

Department of Mathematics and Statistics

Newsletter

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DEPARTMENT HEAD'S MESSAGE *by George Avrunin*

Dear Alumni and Friends of the Department of Mathematics and Statistics:

My first year as Department Head has been, to say the least, a very interesting one. The campus has had serious budget cuts and significant administrative changes that will be continuing during the next academic year. But the Department has come through in vigorous and healthy condition, even if a little bit smaller.

Before describing some of the changes, I want to thank **Eduardo Cattani** for all of his work as Department Head during the last three years. Eduardo's leadership has been enormously important to all of us, and I hope that I don't fall *too* far short of his standard. Eduardo will be retiring in December, but will do some teaching on a post-retirement appointment. We all hope to keep him fully involved in the activities of the Department for a long time.

Last summer, **George Langford**, the Dean of the College of Natural Sciences and Mathematics, left to take a position at Syracuse University. As a result, the Department got a new Head

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PROFILES

Peter Costa '84: Mathematical Biology in Industry

When asked why he went into mathematics, Peter Costa says that it came down to a choice between two possibilities. "I always say there are two things I can do well, mathematics and guitar. Somehow I chose a career in mathematics."

The guitar world's loss is our gain, for today Costa is a distinguished applied mathematician in industry with a long and productive career replete with mathematical contributions from signal processing and software design to teaching and mathematical biology.

In the first third of his career Costa developed radar-application algorithms at the MIT Lincoln Laboratory and the Raytheon Company. After this, he became the Director of the Center for Applied Mathematics at the University of St. Thomas. Since then, he has focused on scientific computing with an emphasis on mathematical biology. In an early project Costa applied the Kalman filter in a novel way to detect the outbreak of infectious respiratory disease based on admission data from the emergency department of Children's Hospital



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Barry Randall '86: Mathematics in Asset Management

From an early age Barry Randall knew that he was good at math. "I always had a head for numbers and did well at math. In my family, I was the go-to guy for math."

Randall is proof that hard work in mathematics pays off. Today he is a highly successful portfolio manager with 14 years of experience in the financial industry.

Upon entering UMass Amherst after high school, Randall planned to study electrical engineering. But EE wasn't a good fit for him, and he quickly switched to mathematics and took a track that involved a concentration in computer science.

Randall's favorite course in the department was a course in ordinary differential equations taught by Professor Jon Sicks. "It was the most demanding course I took at UMass Amherst," says Randall. "I don't think I want to reveal my final grade." The course involved a computational component that was novel in the early days of the personal computer and that developed a mathematical model of traffic flow. "The course really nailed down both sides of math for me, computational and theoretical. It stays with me even today."

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BIOLOGICAL CONTROL OF INVASIVE SPECIES: EXPERIMENTAL STUDIES AND MATHEMATICAL MODELING

by Robert Gardner

Lake Victoria is one of the world's largest lakes. To historians, the name might evoke associations of Stanley, Livingston, and the race to find the source of the Nile. To ecologists, it had once been a symbol of resplendent tropical biodiversity and was particularly renowned for having the largest number of native species of cichlid fish in the world. Today, "Lake Victoria" is heard by ecologists as a cautionary tale and as a rallying cry.

During the 1950s, the Nile perch, a large exotic predator, was introduced in an effort to relieve pressure on native species caused by excessive fishing. The population of Nile perch remained low until the early 1980s, at which point the population experienced explosive growth. The population explosion of Nile perch decimated other fish species at all levels of the food chain, and some of these species are now believed to be extinct. This triggered a cascade of adverse consequences for many other of the lake's native plant and animal species. Today, the Nile perch constitutes roughly 80% of the lake's fish biomass.

The lake has also been devastated by the water hyacinth, a notoriously invasive plant species brought to the region by Belgian settlers for their gardens. The plant was accidentally released into the lake in about 1988. Water hyacinths grow on the water's surface, and plants double their area every one to three weeks. Accumulations of the plant deprive other plants of light and oxygen and have created massive dead zones in the lake. A partial remedy was found through the intentional release of several types of weevil, a natural enemy of the water hyacinth that feeds on it. However, both the Nile perch and the water hyacinth continue to cause serious environmental damage to the lake.

Exotic species are responsible for levels of habitat destruction and a loss of biodiversity that are second only to deforestation. The damage to Lake Victoria illustrates the devastation that can follow in the wake of an exotic species' sudden acquisition of decisive competitive advantages in its feeding and reproductive abilities over native species, and the absence of checks that occur in its native habitat due to the action of natural enemies. Under such conditions, such species are more accurately described as invasive.

After a brief window of opportunity, the risks and expense of the eradication of an exotic pest through chemical and mechanical controls become prohibitive. The introduction of natural enemies as a biological controls may be an attractive alternative, albeit one with its own risks, since an exotic enemy species may itself pose an invasive threat. Species that target a single host or prey are called *specialists*. The introduction of a specialist enemy increases the likelihood of curtailing the growth of its target population while having a minimal impact on native species. Accordingly, species selected for use as biological controls are often specialists.

Specialist populations aggregate in spatially segregated *patches* where the organism it feeds upon is located due to the likely starvation faced by foraging specialists in search of new food patches, and their tendency to resist leaving a food patch until the risks attendant to overcrowded conditions within their present patch rival those associated with inter-patch dispersion. Immigrants in recently discovered patches are often weakened by the search and are small in number. The high intrinsic growth rates typical of specialists reduce the risk of extinction in recently discovered patches. The set of such biological and behavioral evolutionary adaptations of specialists to the constraints imposed by the availability of their energy supply produces a characteristic local patch dynamics consisting of a phase of rapid growth to the point of saturation of local resources, followed by a crash phase due to starvation and the onset of inter-patch dispersion. Local *growth-crash cycles* occur as deterministic process. However, stochasticity becomes more significant during the low-density initiation and terminal phases preceding and following a deterministic growth-crash cycle. The duration of intervals of low-density fluctuations are of unpredictable length.

Inter-patch dispersion can bring about a synchrony of the phase of local growth-crash cycles within subregions of the global arena. When such a synchrony of phase extends globally over all food patches, there is a significant risk of a *global* annihilative crash of the specialist species and also of the species that it consumes as food. It is difficult to predict if and when such catastrophic annihilations will occur, making this is one of the more problematic strategic issues arising in the use of natural enemies as a biological control. The global annihilation of the control species creates the chance, if not the likelihood that the invasive target will eventually return to a phase of explosive and unconstrained population growth.

Experimental Studies

The population dynamics of specialist predators and parasites is a fundamental problem of theoretical biology, but one which can be difficult to investigate in controlled experiments with exotic species due to their size and to the environmental risks. Another intensively investigated area of application concerns the biological control of insect and arthropod crop pests by their natural enemies. The patchy arrays of small numbers of plant species

typical of agricultural environments attract specialist species that can include both herbivore and (predatory) carnivore species. The predator-prey dynamics of interacting mite populations in agriculture, in particular, is used by population biologists both as a theoretical and experimental paradigm for the predator-prey dynamics of specialist populations. The small size and short generation times of mites make it possible to perform controlled experimental studies of interactions within large, spatially distributed arrays of patch populations. Sampling data obtained from months, and in some cases, years of observation have provided fundamental theoretical advances about predation among specialist populations, and to a limited extent, have led to the more effective use of specialist predators and parasites in the biological controls of invasive pests.

Modern research in this general area of population biology has its origins in the work of C. F. Huffaker. In a series of experiments performed in the 1950s, Huffaker devised an ingenious laboratory model of predator-herbivore-host plant interactions in a complex environment consisting of 120 periodically replaced food patches. Using the biotic potential and spacing of food patches as experimental parameters, Huffaker eventually discovered a configuration in which the co-action was able to persist for about 8 months. In preceding trials, the predator species was globally annihilated after relatively brief interactions typically lasting from 4 to 6 weeks.

tal studies that persisted for one or more years nevertheless experienced an abrupt global annihilation of the predator species, while the interaction in replicate experimental populations persisted until the experimenter terminated the study. The connection between biology, the environment, and the unpredictable dynamics typically seen in experimental populations is still not well understood, and the early promise of developing a rigorous scientific methodology in connection with the biological control of invasive pests has not as yet been brought to fruition.

Mathematical Modeling

Huffaker theorized that persistence occurs when a balance can be achieved between the dispersive pressure on each species and the rhythm of local growth-crash cycles. Thus predator and prey survive through a sort of “hide-and-seek” dynamics in which the prey is always somewhat ahead, but not too far ahead, of the predator in establishing themselves on new patches. There are two distinct approaches that have been taken in the formulation of mathematical models suitable for simulating such dynamical behaviors.

Mathematical models formulated by biologists consist of discrete stochastic systems that model the dynamics of homogeneous, interacting populations within a discrete network of patches. Dispersion is modeled as migration between patches over each time

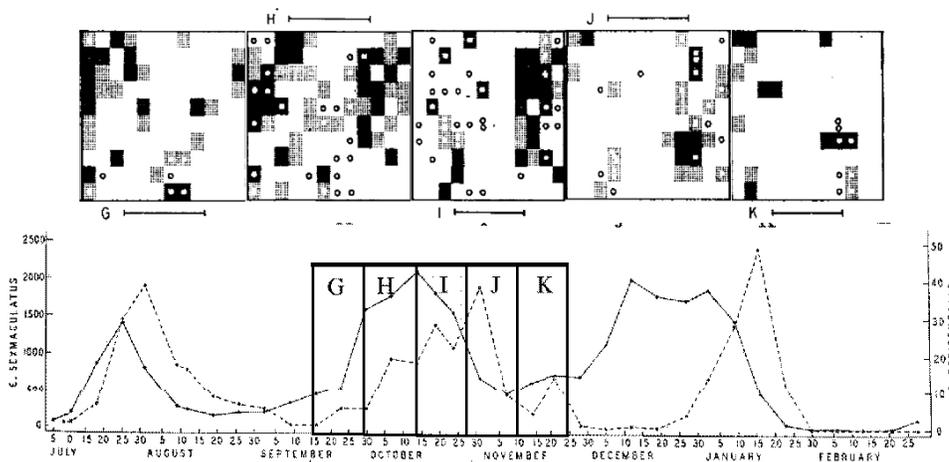


Figure 1. (upper) Sampling data for arena of 120 patches over time sequence from G to K in the mean-data graph. Higher prey densities are indicated by darker rectangles, and predator densities are indicated by circles. **(lower)** Huffaker’s mean prey data (dark line) and predator data (dotted line) over an 8 month interval.

step. Such model accurately portray local dynamics within patches since biologists can obtain accurate information about the rate functions and parameters that determine local birth and death rates. Such microlocal models are less reliable with regard to the attributes of dispersive behavior as it occurs in large, multipatch arenas. The numerical data generated by stochastic-patch models have many attributes of the qualitative phenomena seen in experimental data, but there is little quantitative correlation between numerical and experimental data.

Huffaker’s foundational research has influenced the course of this intensively investigated area of population biology over the last 50 years. Scores of successive studies have improved upon and expanded the scale of Huffaker’s original model and, on a practical level, have significantly advanced biologists’ understanding of how to prevent short-term extinctions in the predatory control of crop pests and other invasive species. However, some experimen-

In my research I have been formulating and analyzing deterministic population models over spatial continua that take the form of systems

of reaction-diffusion (R-D) equations. Such macroscopic models have strengths and deficiencies that complement those of the micro-local stochastic models favored by biologists. The most important strength of R-D models is their ability to predict the spontaneous generation waves and patterns, their stability and bifurcations, and the attendant set of phenomena associated with complex interactions of waves.

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NEW LECTURE SERIES IN HONOR OF MEL BERGER

When Peter Costa came to UMass Amherst in 1980, he had just finished a Master's degree program in applied mathematics at the University of Illinois in what he today calls a "less than promising fashion." His plan was to turn his back on applied math and to earn a Master's degree in statistics. But after taking a yearlong course in applied math under Mel Berger, his instructor asked a question that changed his life. "Peter," Berger said, "why don't you work with me on a Ph.D. in applied mathematics?"

Costa reluctantly explained his hesitation, but as he puts it, "Professor Berger would have none of it." According to Costa, Berger said, "Whatever they told you at Illinois does not match what I've seen. Are you going to let them decide what you're capable of, or will you let me help them prove you wrong?"

Berger must have known what he was doing, for today Costa has built a distinguished career as an applied mathematician in industry with many significant accomplishments (see the article "Peter Costa '84: Mathematical Biology in Industry" on page 1).

A Fortuitous Meeting

Two years ago, while vacationing on Cape Cod, Peter and his wife Anne ran into George and Mary Knightly. George, a Professor Emeritus in the department, is also an applied mathematician, and he also played an important role in Costa's graduate days.

After reminiscing with the Knightlys about the department, Berger, and the role he played in Costa's life, Costa realized he had to do something to honor Berger's memory, who died in October 2005. "I came to realize how different my life would have been had Berger not taken me under his wing. He was gracious and light-hearted, he encouraged me, and he even helped me to meet Anne, my guiding light. Today Anne and I have a great life, and we wanted to give something back."

A New Lecture Series

In order to show their gratitude, the Costas established a new lecture series in the department, the Distinguished Lecture in Applied Mathematics in honor of Professor Melvyn S. Berger. This colloquium lecture brings in a world-renowned applied mathematician to give a general lecture to the whole department. Instead of a focused lecture on a narrow research topic, the speaker gives a presentation highlighting the interconnections between applied and pure mathematics and statistics. Currently Professor Bruce Turkington coordinates the Center for Applied Mathematics and Computation, which Berger himself established over 25 years ago. According to Turkington, "Mel Berger had a broad vision of mathematics and its applications, which he communicated especially well through his widely read books. The Distinguished Lecture in Applied Mathematics sustains that approach to research and its dissemination. It is a highlight of each academic year for the group of faculty who make up Center for Applied Mathematics and Computation. Given its broad appeal, it also attracts graduate students and faculty from all the fields represented by the department. We are very grateful to the Costas for their initiative and generous support."

Last year's inaugural lecture was given in October by Professor Christopher Byrnes of Washington University, a UMass Amherst Ph.D. whose career was profiled in last year's newsletter. He spoke on novel connections between control systems and geometry, and his talk was warmly received.



Peter and Anne Costa

PARTING WORDS

In his introductory remarks at the first lecture, Costa summarized Berger's impact on his life by relaying some of Berger's wisdom to the audience:

"Be honorable people, succeed humbly, and encourage one another."

"For the students in the audience today, I ask you to do your best and a little more. The faculty may ask a great deal of you, but that is because they want to tap into your talents."

"To the faculty, I ask that you show enthusiasm for your work. Encourage your students, and help them to find their path and place in this discipline. Professor Berger did all this and more for us [his students] with alacrity."

CHANGES IN UNDERGRADUATE ADVISING

In September 2008 Robin Young took over as the Chief Undergraduate Advisor in the Department of Mathematics and Statistics. Having been the Undergraduate Program Director, Professor Young has extensive experience with the undergraduate affairs of the department. As Chief Undergraduate Advisor, he is the primary point of contact for all our undergraduate majors and minors.

One of Professor Young's first contributions has been to make several structural changes in the advising office. A central aim of these changes is to make the rules for the major accessible and understandable and to rationalize some of the more arcane rules.

The most obvious change is that a web page dedicated to advising has been set up. This is intended to be a storehouse of information regarding the major, easily accessible to all students as well as parents, prospective students, and faculty advisors. A work in progress, the web page includes the following:

- an online version of the Undergraduate Handbook;
- copies of advising worksheets;
- links to career information;
- announcements of current events, including undergraduate conferences and opportunities for jobs and internships.

Many other changes are now currently in progress. These include setting up a small advising database linking students with their advisors, making the process of scheduling an appointment during advising week more efficient, and consolidating information about course offerings, equivalences, and substitutions in one place. There are now over 300 Math majors, and as the program grows, these changes become more important. An extensive revision of the Undergraduate Handbook is also planned; a central focus of this effort is to make it more web-friendly so that both web and printed versions will be easier to read and navigate.

The Advising Office is also in regular contact with the current Undergraduate Program Director, Professor Farshid Hajir, who is working together with Professor Young to evaluate and modify the undergraduate program to provide the best possible experience for our majors.

We are continually looking for advice and suggestions for improvements to the advising process. All interested parties are urged to peruse the web page by navigating through the Undergraduate/Advisors tabs from the departmental page or by going directly to www.math.umass.edu/~advise/. We would welcome any comments and suggestions, preferably by email to advise@math.umass.edu. We look forward to hearing from you.

WILLIAM LOWELL PUTNAM COMPETITION 2008 *by Jenia Tevelev*

The Putnam Competition is widely regarded as the most prestigious mathematical competition for undergraduate students in the U.S. and Canada. It has been administered by the Mathematical Association of America annually since 1938. The test is held on the first Saturday in December and consists of two three-hour sessions separated by a lunch break. There are twelve problems, which are formulated using only the most basic college mathematics, but solving them requires extensive creative thinking. Here is an example of a Putnam problem from 2008.

Alan and Barbara play a game in which they take turns filling the entries of an initially empty 2008 by 2008 array. Alan plays first. At each turn, a player chooses a real number and places it in a vacant entry. The game ends when all the entries are filled. Alan wins if the determinant of the resulting matrix is nonzero; Barbara wins if it is zero. Which player has a winning strategy?

While this problem is clearly about linear algebra (matrices, determinants, etc.), the setting is unusual. What does linear algebra have to do with games? Here is a solution found by one of the UMass Amherst participants, Keaton Burns. In fact, he found it soon after he learned about determinants

in the Math 235 course on linear algebra taught by our Visiting Assistant Professor, Sukhendu Mehrotra.

Keaton's idea is to pair each entry in the first row with the entry directly below it in the second row. If Alan ever writes a number in one of the first two rows, then Barbara writes the same number in the other entry in the pair. If Alan writes a number anywhere other than the first two rows, then Barbara does likewise. At the end, the matrix will have two identical rows, and so its determinant will be zero. Elementary, my dear Watson, elementary.

A total of 3627 students from 545 colleges in Canada and the United States participated in the Putnam Mathematical Competition 2008. The test was as intellectually hard and as brutally graded as usual, with half of all the students scoring 0. The University of Massachusetts Amherst was represented by seven students, and five of them

— Keaton Burns, Nate Harman, Alex McAvoy, Ilya Scheidwasser, and Albert Tsou — scored in double digits. Our team was ranked 38th nationally, which is up from 43rd last year and 143rd the year before. The best individual result was achieved by Nate Harman, who ranked 133rd nationally. We congratulate our students for this excellent achievement.



Nate Harman, Jenia Tevelev

SOLUTION TO LAST YEAR'S CHALLENGE PROBLEM

Last year's challenge problem was the following:

Let $P(x)$ be a real polynomial with distinct real zeros a, b, c , where $a < b < c$. Let d be the critical value satisfying $a < d < b$ whose existence is guaranteed by Rolle's theorem. Prove that d is nearer to a than it is to b .

A number of you pointed out, via counterexamples, that one important condition was omitted: $P(x)$ should have been restricted to third degree polynomials. We'll assume this and give the solution.

We may assume without loss of generality that P is monic. Then P has the form $P(x) = (x-a)(x-b)(x-c)$.

Computing the derivative, we find $P'(x) = (x-a)(x-b) + (x-c)((x-a) + (x-b))$.

Since d is a critical point, the quantity $P'(d) = (d-a)(d-b) + (d-c)((d-a) + (d-b))$ vanishes, which gives us $0 = (d-a)(b-d) + (c-d)((d-a) - (b-d))$. Since $(d-a)(b-d)$ and $(c-d)$ are positive, we must have that $(d-a) - (b-d)$ is negative. Thus $d-a < b-d$, and so d is nearer to a than it is to b .

Thanks to all who sent in solutions.

Department Head's Message *continued from page 1*

in September at the same time as the campus got a new Chancellor, **Robert Holub**, and the College got an Interim Dean, **Jim Kurose** from the Department of Computer Science. A few weeks into the fall semester, the University was hit with the first of a series of mid-year budget cuts resulting from the financial crisis and the resulting decline in state tax revenues. Many of the things we were planning to do had to change — for instance, in September the Department was planning on hiring at least three and possibly four new faculty, but we were able to hire just one — and a lot of time and effort has had to go into making those adjustments.

Among the biggest adjustments is the reorganization of the campus that the Chancellor proposed, partly to save money and partly to provide new research and educational connections. While some of the proposals are still under discussion, the big change for us is that the College of Natural Sciences and Mathematics (NSM) and the College of Natural Resources and the Environment (NRE) are being closed. All of the NSM departments and most of the NRE departments, along with the Department of Psychology, are being combined into a new College of Natural Sciences. (Unfortunately, Mathematics is being dropped from the name and will no longer be visible in the list of colleges!) This new College will bring together the physical, mathematical, computational, and life sciences in one unit. It will have 15 departments, almost 400 faculty (counting research faculty), 5,800 undergraduate majors (25% of the undergraduates at UMass Amherst), and nearly 1,100 graduate students (38% of the Ph.D. students at UMass Amherst), and it will account for two-thirds of the campus's external funding. The Dean of the new College of Natural Sciences will be **Steve Goodwin**, who has been Dean of NRE. The campus is also getting a new Provost, **James Staros**, who has been the Dean of Arts and Sciences at SUNY Stony Brook.

Within the Department, **Daeyoung Kim** and **Hongkun Zhang** joined our faculty this year. Short profiles of them appear elsewhere in this newsletter. **Alexei Oblomkov**, a representation theorist and algebraic geometer who was hired last year, stayed at Princeton University this year and will officially join the Department in September. Also arriving in September will be **Paul Hacking**, another algebraic geometer who is coming to UMass Amherst from the University of Washington. Three members of our faculty, **Erin Conlon**, **Mike Sullivan**, and **Tom Weston**, were awarded tenure and promotion to Associate Professor. We also have two new staff members. **Alan Boulanger** joined our Research Computing Facility staff last summer after **Steve Ball** became Facilities Manager for the College, and **Sarah Willor** became our receptionist in December, replacing **Connie Milne** who left to take a position in the Department of Economics. Three of our Visiting Assistant Professors, **Adrián Espínola-Rocha**, **Zhigang Han**, and **Sudhenku Mehrotra**, are also completing their appointments and moving on to positions at other institutions.

Our Distinguished Lecture Series entered its second year with a new addition, a Distinguished Lecture in Applied Mathematics supported by a very generous contribution from **Peter and Anne Costa** in memory of Peter's Ph.D. advisor, **Mel Berger**. Peter is also the subject of a profile in this newsletter. The inaugural Distinguished Lecture in Applied Mathematics was given by **Chris Byrnes**, who received his Ph.D. from our department in 1975 and is now the Edward H. and Florence G. Skinner Professor of Systems Science and Mathematics at Washington University, where he was Dean of the School of Engineering and Applied Science for fifteen years. Our other Distinguished Lecturers this year were **Gregory Lawler** (University of Chicago), **Wilfried Schmid** (Harvard University), **Carlos Kenig** (University of Chicago), **Tomasz Mrowka** (MIT), and **Paul Marriott** (University of Waterloo), who was the Connecticut Valley Colloquium lecturer. Thanks again to **Weimin Chen** for his outstanding work arranging these lectures and the rest of the colloquium talks.

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APPLIED MATH MASTER'S DEGREE PROGRAM: MODELING CLIMATE CHANGE

by Bruce Turkington

Each academic year the students in the Master's Program in Applied Mathematics engage in a group project, in which they investigate a topic from science or engineering that poses challenges for mathematical modeling. The topics change every year. In the past they have ranged from predicting the yield curves of bonds using neural networks to modeling the spread of cancer tumors using partial differential equations. This past year we chose a topic that is much in the news: global climate change.

The students involved in this year's project were Andrew Aumick, Hugh Enxing, Abhinav Guliani, Cathy Ho, Chris Hoogeboom, Maksim Kuksin, Yannan Shen, Nadiah Wah, and Caitlin Worth. They presented their results at a departmental colloquium on May 8, 2009.

At first sight, there is no easy entry point for mathematical modelers into the extremely complex subject of climate dynamics. State-of-the-art climate predictions are based on elaborate numerical models that attempt to include all relevant physical processes in the entire Earth system. These numerical simulators, which grew out of weather-prediction technology, are generically called GCMs, meaning General Circulation Models, although nowadays perhaps Global Climate Models is a more appropriate term. Their governing equations incorporate the circulation of the atmosphere as well as its radiative physics and chemistry (carbon dioxide, ozone, aerosols), the circulations of the oceans and coupling through the hydrosphere (water vapor, clouds, glaciers, sea ice), and even aspects of the biosphere (forests, soils, marine biota). Models with this level of complexity take decades to develop, test, and tune, and they are very expensive to run. Moreover, the results and predictions that they produce are often quite hard to interpret, especially if the goal is to identify a particular mechanism and its effects.

In our initial investigations we located the user-friendly EdGCM made available through Columbia University. It is based on a famous GCM developed by NASA called Model II, which it invokes through a graphical user interface for inputs and outputs. We dedicated a workstation to running this code for many hours at a time in order to see how particular "forcings" resulted in climate changes. For instance, we did a century-long simulation with doubling of atmospheric carbon dioxide, which is the classic global-warming scenario. We also considered the opposite regime in which the solar radiation is continually decreased, leading to increased glaciation and eventually to a so-called snowball Earth that is almost completely covered by ice.

However, because our main goal was to design some models ourselves, we needed to adopt a different approach. Our strategy was to select a few variables that represent the bulk or average quantities of greatest interest to our climate dynamics and to define differential equations governing these variables. The most basic models of this

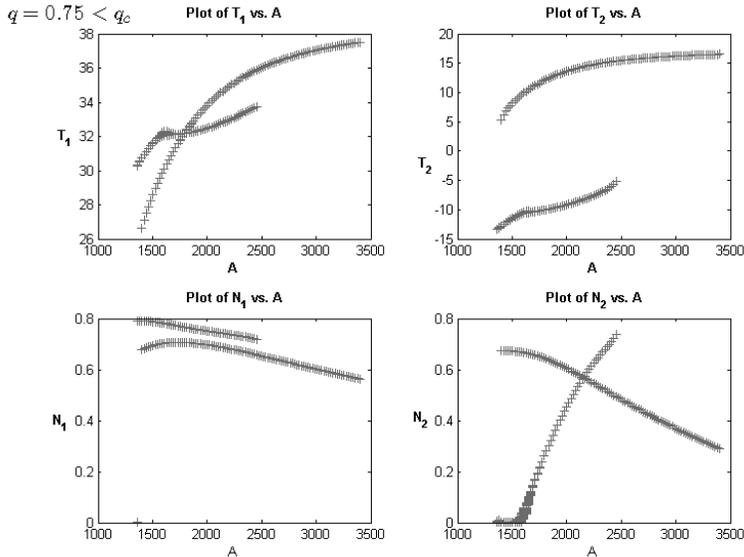
kind are called energy-balance models. They determine the surface temperature through an equation that balances the incoming solar radiation, outgoing infrared radiation, albedo properties of the surface, and greenhouse effect in the atmosphere. The albedos measure the fraction of radiation reflected as opposed to absorbed, the most important case being the coverage by ice or snow in contrast to ground or ocean. Traditionally, simple energy-balance models with ice-albedo effect have been used to explain ice ages; namely, as temperature decreases, ice advances and hence more radiation is reflected, leading to further temperature decrease, and so forth. Our project took the energy balance concept as the basis on which to build models that also include a carbon cycle through the biosphere or the oceans.

Our biosphere model consists of two boxes that represent the tropics (within 30 degrees of the equator) and the high latitudes (above 30 degrees). In each box we have a temperature and a carbon content of the biosphere. In this way we represent the effects of a tropical forest and a boreal forest on the carbon cycle through the atmosphere, where carbon dioxide contributes to greenhouse forcing. Heat is transferred between the boxes by linear flux proportional to temperature difference. The governing equations are a system of four differential equations of first order. Specifically, for each box there is an energy-balance equation, with albedo depending on ice and forest coverage, and a vegetation-growth equation, with productivity depending on temperature and the concentration of carbon dioxide.

With this model we obtained a number of interesting, and even surprising, results. For instance, in the process of adjusting the heat conductivity to achieve realistic temperatures in the two boxes, we discovered that its tuned value was near to a critical value. As the conductivity is decreased below this critical value, the climate equilibrium undergoes a bifurcation. In physical terms this means that, as the thermal flux from equator to pole is weakened, the model Earth system suffers an abrupt climate change. Temperature in the high latitudes drops, glaciers advance, and the boreal forest declines, while the tropics remain relatively unchanged. From this state, we then considered the effect of systematically increasing carbon dioxide in the atmosphere. After a sufficient increase another bifurcation occurs, in which temperature jumps back to a non-ice-age value, glaciers retreat, and forests return. The entire cycle forms a hysteresis loop, meaning that the equilibrium state of the system for given forcing depends on the path followed to arrive at that state. Besides this fascinating result, the model also shows how the carbon uptake by the vegetation can partially regulate climate. The accompanying figure displays the bifurcation diagram, showing the temperatures and carbon content in each region for equilibrium solutions depending on the total carbon content of the system.

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Modeling Climate Change *continued from page 7*



The bifurcation parameter A represents the total carbon content in the model Earth system. The four plots show how temperature T and vegetation N in each box vary with A . The tropical box is number 1 while the polar box is number 2. Each cross denotes an equilibrium solution for the dynamic climate model. There are two branches of equilibrium solutions for a range of A , and both are stable. The parameter q represents heat conductivity between the boxes. If A is increased above a critical value, then the cold climate in the polar box jumps to a warm climate. If A is decreased along this branch, then below a critical value the warm climate drops back to a cold climate.

We also constructed a model in which the carbon cycle through the biosphere was replaced by the transfer of carbon dioxide between the atmosphere and oceans. The purpose of this model was to simulate the oscillations of climate that Earth has experienced over the past million years. These quasi-periodic changes are thought to be caused by small variations in the incoming solar radiation that result from variations in Earth's orbital parameters, specifically its

eccentricity, obliquity, and precession. By analyzing ice core data from Antarctica and Greenland, geoscientists have documented a sawtooth oscillation with a period of approximately 100,000 years, in which there is a rapid warming followed by a very slow cooling. Carbon dioxide is found to follow temperature through these cycles, and so it is viewed as a likely candidate for the enhanced feedback that supports these major climate variations.

For our simulation of the glaciation cycle we again used a two-box model. But now the model imposed a quasi-periodic solar forcing with small amplitudes and included a term in the carbon balance equation that mimics the effect of ocean outgassing as temperature rises — cold water dissolves carbon dioxide more readily than warm water. This simplified mechanism had been introduced by Hogg in 2006 in a model with only one box and without ice-albedo feedback. Once we tuned our model parameters appropriately, we obtained the desired glacial/interglacial oscillations with agreement in shape, amplitude, and period. These results were gratifying, but if we had had more time, we would have liked to improve the model by adding some more variables and understanding the ocean- CO_2 feedback better.

These climate modeling exercises opened our eyes to the difficulties of making useful simulations and reliable predictions. Much depends on knowing how to encapsulate very complex, multiple-scale phenomena in a few bulk variables. And when such variables are chosen, there remains the so-called parameterization problem. This refers to tuning the various parameters in the model equations to fit data when those parameters are not constrained by physical arguments. For reasons of this kind, we recognize that simplified models are most useful when they produce qualitatively robust behavior, such as the bifurcations of climate equilibria in our biosphere model or the recurrent climate changes of our glaciation model. Making quantitative predictions of more detailed features may require the large GCMs. But even for those sophisticated numerical models the parameterization of unresolved processes, such as cloud properties, remains an ongoing challenge.

Peter Costa *continued from page 1*

Boston. Presently he is a senior applied mathematician at the Hologic Corporation in Marlborough, Massachusetts, a medical device company. "In addition to traditional statistical work for the FDA," Costa explains, "I work on algorithm development for identification and classification problems in medical imaging. The goal is to write software that helps lab samples be analyzed consistently and accurately and that guides pathologists to look at areas of concern."

In May 1984 Costa earned a Ph.D. in our department in applied mathematics under the direction of Mel Berger. Although his dissertation was on nonlinear partial differential equations, a field somewhat remote from his current concerns, he brings much from UMass Amherst to his workplace. "In my job today I use the broad palette of tools, from differential equations and statistics to numerical analysis and linear algebra, that I learned at UMass Amherst. I also constantly use methodology I learned at UMass Amherst when confronted with problems."

Costa speaks glowingly of working with Berger. "Professor Berger was colorful, gracious, and inspirational. He encouraged unconventional ways of looking at problems, an approach I continue to use today." Berger's impact on Costa's life was so profound that when Berger passed away in 2005, Costa and his wife Anne decided to establish a lecture series in the department in Berger's honor (see the article "New Lecture Series in Honor of Mel Berger" on page 4). "My father once told me that when a good man dies, you shed a tear and say a prayer, but when a great man dies, you do something."

Peter Costa was born and raised in Buffalo, New York. Before coming to UMass Amherst, he did his undergraduate work at SUNY Binghamton and received an M.S. degree in applied mathematics from the University of Illinois. Currently he and his wife Anne live in Hudson, Massachusetts.

Barry Randall *continued from page 1*

After graduation Randall worked as a programmer until 1991. He became interested in finance and returned to school to pursue an MBA at the University of Texas. During his subsequent career as a distinguished analyst and asset manager he's supervised the growth and exceptional performance of funds totaling over \$800 million.

But despite his background in mathematics, Randall doesn't consider himself to be a "quant" in the financial industry. "Finance uses a nice mix of mathematics and cumulative experience," Randall says. "Mathematical modeling plays a key role, but history teaches us that looking for the perfect mathematical model for the stock market is not necessarily the best way to go." Instead of applying the most esoteric mathematical models he can to the stock market, Randall primarily uses a set of parameters he's developed over his career to identify outperforming stocks. "One should be quantitative when it's appropriate, but one shouldn't fall into the trap of believing in 'mathematical certainty.' It's more important to build a good track record."

For many years Randall has been a consistently generous donor to the Department of Mathematics and Statistics. When asked why, he cites two reasons. First, when he switched from engineering to mathematics, the department went out of its way to welcome him and to make him feel at home. "I've always appreciated that Professor Lorraine Lavallee, who was the Chief Undergraduate Advisor when I transferred from the School of Engineering, made me feel welcome and supported in the department."

Second, Randall is a firm believer in public higher education and the opportunities it provides. According to Randall, his academic performance in high school was "sub-par," but his SATs showed promise, and UMass Amherst recognized that potential: "I have always felt there was an implicit message in my acceptance to UMass Amherst: 'work hard and show us what you have to offer.' And since then, I believe that UMass Amherst, remains a place where a highly motivated though somewhat ordinary student can go to shine, to prosper, to learn, to mature and prepare himself or herself to move on in life, ready for what's next."

Barry Randall was born in Quincy, Massachusetts, and grew up in Quincy and Winchester, Massachusetts. He graduated from UMass Amherst in 1986 and earned an MBA with a concentration in finance from the University of Texas in 1993. Today he runs his own company, Crabtree Asset Management, which manages the Crabtree Fund. In addition to finance, he is also a licensed commercial pilot, a skill he first began learning at the Northampton Airport near Amherst. Today he lives in St. Paul, Minnesota with his wife Lisa and their two children.

NAHMOD AWARDED RADCLIFFE INSTITUTE FELLOWSHIP

Professor of Mathematics and Statistics Andrea R. Nahmod has been awarded a fellowship at the Radcliffe Institute for Advanced Study at Harvard University for the academic year 2009-2010. Professor Nahmod will spend the year in residence in Cambridge, MA. As the appointment letter states, she "will join a class that included fellows of extraordinary breadth and accomplishment. They come from across the country and abroad, women and men at different stages of their careers representing different academic, professional and artistic fields."



The Radcliffe Institute fosters transformative works in the arts, humanities, sciences, and social sciences. Each year approximately fifty men and women from all over the world arrive at Cambridge to undertake research and creative work as Radcliffe Institute Fellows. The Institute is an integral part of Harvard University and "serves as an intellectual convening force across Harvard's schools and as a site for interdisciplinary collaboration." The mission of the Radcliffe Institute is the creation of new knowledge and an academic community where Fellows can pursue advanced work. The work that Radcliffe Fellows do while in residence lies at the very heart of the institute's endeavor. Within that broad purpose, it sustains a continuing commitment to the study of women, gender and society.

Professor Nahmod's research focuses on the analysis of nonlinear dispersive wave phenomena. Dispersive partial differential equations (PDEs) model certain wave propagation phenomena in nature. Dispersive waves are those that spread in space as time evolves while also conserving energy. Probably the most well known equation within the class of dispersive PDEs is the nonlinear Schrödinger equation. During the last fifteen years enormous progress has been made in settling fundamental questions on the existence of solutions, their long time behavior, and the formation of singularities. It is fair to say that so far the thrust of this body of work has focused mostly on deterministic aspects of wave phenomena. Sophisticated tools from nonlinear Fourier analysis and geometry have played a crucial role in the employed methods of research.

The aim of Professor Nahmod's project at the Radcliffe Institute is twofold. First, it is concerned with the behavior of solutions of a nonlinear dispersive PDE arising in ferromagnetism and nonlinear optics. Nahmod will study a spin-model known as the Ishimori system in the hyperbolic setting. This system arises in connection with theories of ferromagnetism and of vortex filaments. Second, Professor Nahmod's project seeks to understand the role of data randomization and the existence and invariance of the associated Gibbs measures to obtain, respectively, sharper results on local well-posedness and global existence for "generic data"; i.e., almost surely in the sense of probability. The focus is on certain periodic nonlinear PDEs for which there remains a gap between the local well-posedness results and those that could be globally achieved for all solutions.

Professor Nahmod will conduct collaborative research on these and other topics with Professor Gigliola Staffilani of MIT, who is also a Radcliffe Fellow during the academic year 2009-2010.

There is an analogy one could make with solid-state physics. A sparse subset S is like a gas, with large distances between molecules, and a dense subset is more like a solid, with molecules clustered closely together. In this analogy an arithmetic progression is like a little crystal, where the molecules have all been lined up regularly. Certainly we expect to find more crystalline structure in a solid than in a gas. But is there a way to quantify this?

Erdős's Conjecture

Our analogy with physics indicates that it should be hard to pick a large subset of numbers that does not contain long arithmetic progressions if one is forced to choose a dense set. One way to make this precise is via a conjecture of Paul Erdős (1913–1996). In mathematics, a *conjecture* is a precise mathematical statement supported by evidence. Unlike *theorems*, conjectures are not presented with a proof. Instead, conjectures serve as motivational yardsticks by which mathematicians measure progress in their fields. Typically conjectures represent major goals of a given subject.

Paul Erdős made many conjectures over his colorful life, and in many cases even offered a cash reward for their solutions. (If you've never read about Erdős, there are several good popular biographies about him available today.) The conjecture we have in mind — for which Erdős offered \$3000 for a solution — states that if an infinite set S of numbers is sufficiently dense in the set of all numbers, then S should contain arbitrarily long arithmetic progressions. The conjecture is too technical to state here, but what we can say is that it gives a recipe to compute a number A attached to S . If this recipe yields an actual number A , then S is not dense enough. But if in the computation of A the process yields infinity instead of a number, then S is believed to be dense enough to contain arbitrarily long arithmetic progressions.

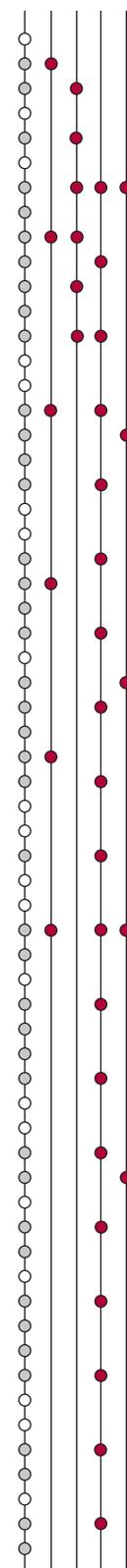
For instance, consider the sequence of squares $1, 4, 9, 16, 25, 36, 49, \dots$. Certainly the squares are not very dense in the set of all numbers; in fact there are far fewer of them than there are primes. Erdős's conjecture predicts that the squares do not contain arbitrarily long arithmetic progressions. Indeed, this is plausible, since it seems unlikely that the squares even contain any arithmetic progressions of length 3. After all, the differences between successive terms increase quite rapidly. Experimentation with a computer mildly contradicts this intuition. There *are* apparently infinitely many arithmetic progressions in the squares of length 3, and you can actually see one of them in the data here. On the other hand, there are apparently none of length 4 and higher (at least up to 300^2), which is compatible with the conjecture; in this case the number A is $\pi^2/6 = 1.64493\dots$, which is definitely not infinite.

What about the primes? The primes *do* satisfy the conditions of Erdős's conjecture, and so the conjecture predicts that for any k , the primes contain at least one arithmetic progression of length k . One can see a progression of length 3 in the short list of primes above. There is a progression of length 5 starting with 5 and with common difference 6. The longest known arithmetic progression in the primes has length 24 and was found in 2007 after a sophisticated computer search; the initial member is 468,395,662,504,823 (yes, it's a prime).

The Green–Tao Theorem

Thanks to the groundbreaking work of Ben Green and Terence Tao, we now know that there exist arithmetic progressions in the primes of length k for any k . This settles the most important example of Erdős's conjecture. Remarkably, the proof of the theorem does not use any deep properties of the primes themselves. In fact, all the number theory used in the proof was already known over 100 years ago. Rather, their work gives a significant new understanding to the nature of regularity and randomness in sets.

It should be emphasized that the Green–Tao result, like many in modern mathematics, is non-constructive: we know that arbitrarily long arithmetic progressions in the primes exist, yet the proof of the theorem gives no method to find them. Perhaps one method could be to fire up the Arecibo radio telescope, beam a few big progressions of primes into space, and then sit back and await the response.



A random sequence of integers with four arithmetic progressions

Department Head's Message *continued from page 6*

I would like to leave space for the rest of the newsletter, and so I will mention only one other significant development in the Department. When Bruce Turkington was Department Head, we were able to convert a large faculty office into a small common room in which faculty and graduate students could discuss mathematics and other things in an informal setting. That room was really too small and never worked very well. This year, we have converted the former Geometry, Analysis, Numerics, and Graphics (GANG) laboratory into a new common room (see A New Common Room on page 16). A group of faculty and graduate students removed most of the partitions, which we will reuse elsewhere, and we bought some new furniture with money donated by alumni. The room opened in the spring semester and has been extremely successful and well-used. The old room is being used as for seminars and other small presentations, and our Undergraduate Lounge, across from the Advising Office, continues to be a very popular spot for our undergraduate majors. In the summer, we are also using the new common room as a place for the students in our Research Experiences for Undergraduates program to work. The REU students are math majors who are working on research projects with faculty during the summer and their stipends come from alumni donations. This summer we have seven REU students working with faculty.

As I write this in June, we have just received a message from the Chancellor noting that Massachusetts, like many other states, has chosen to “front-load” the Federal stimulus money. This means that we might be able to avoid severe budget cuts this coming fiscal year, which starts July 1. However, the stimulus money will mostly have run out by the following year, and the campus will then face a very substantial budget deficit from the already diminished budget. The Chancellor has asked the Provost and the Faculty Senate to work with him in making curricular reforms and other changes to achieve savings, keeping in mind “our common desire to emerge from the current downturn in a position to move rapidly into the highest ranks of public research institutions in the country.” These are very challenging times for the campus and, we know, for many of our alumni and friends. We are extremely grateful for your support. It is an essential component in our efforts to make the Department of Mathematics and Statistics a great place for our students to learn and for our faculty to teach and do research.

Biological Control of Invasive Species *continued from page 3*

Earlier and simpler experiments with short-lived transient behavior were often seen as having failed to produce long-term persistence. However the transient phenomena in this simpler setting often have the aspect of a single simple wave in the absence of the complicated phenomena that obscure such behaviors in larger experiments. Such data provides an important measure of the macroscopic aspects of the overall dispersive environment. Such data may also provide an important benchmark with which to calibrate system parameters to the global dispersive environment. The mature state of development of the analytical aspects of nonlinear wave stability can be brought to bear, and many tools are available in connection with fitting experimental data to wave solutions of model equations. There are also likely to be many tractable problems relating to the analysis of interactions and instabilities of elementary waves.

Experimental and mathematical modeling are both still a long way from achieving a sufficient level of reliability for use in the formulation of tactical and strategic programs of biological

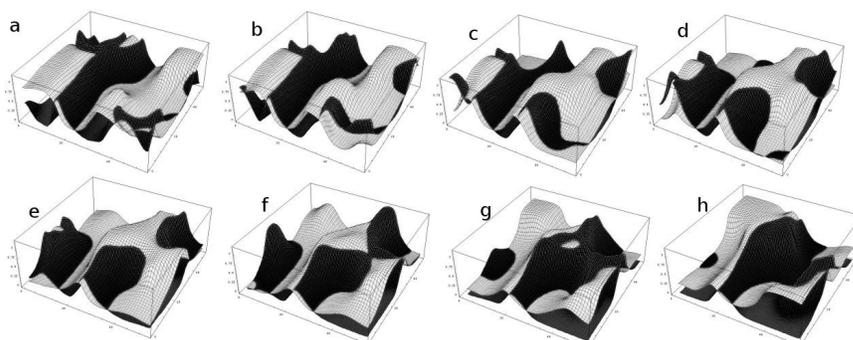


Figure 2: Data from numerical solution of RD-system: Prey (light graph) and predator (dark graph); the time sequence follows alphabetical order. The sequence illustrates how wave-like behaviors can lead alternatively to annihilation (e.g., lower left corner) and regeneration (e.g., upper left corner) of rectangular spatial domain.

control of invasive pests. A more realistic objective towards this end would be to determine a combination of experimental and mathematical paradigms that generate predictable wave-like phenomena in both experimental and numerical data. A correlation between such data would provide an important benchmark of population dynamics in terms of measurable biological and environmental parameters.

TEACHING GRADUATE MATHEMATICS IN CAMBODIA



Cattani and his students

Last spring most professors in the Department of Mathematics and Statistics didn't have to overcome broiling heat, regular power outages, and commuting to work in a trailer pulled by a motorcycle to teach their courses. But Professor Eduardo Cattani did, as a foreign instructor in an intense mathematics program in Cambodia, and he loved it: "It was a fantastic experience, and I can't wait to do it again."

From mid March until the end of April, Cattani was one of several mathematicians from the U.S., Europe, and Japan who volunteered to give advanced graduate courses to a select group of Cambodian students at the Royal University of Phnom Penh. He served in a program administered by the Centre International de Mathématiques Pures et Appliquées and the U. S. National Committee for Mathematics of the National Academy of Sciences. The goal of this program is to help rebuild scientific infrastructure in Cambodia, infrastructure that was essentially wiped out by Pol Pot and the Khmer Rouge in the late 1970s.

The total number of people killed by the Khmer Rouge is unknown. The best estimates are that by the end of their reign two million Cambodians, out of a total population of eight million, had died from executions, overwork, starvation, and disease. Many who died were professionals and intellectuals, and the effect on the Cambodian educational system was profound. "Ph.D.s in science are almost unheard of in Cambodia," Cattani says. "Most university faculty have only an undergraduate degree, and most students have never had any contact with a research mathematician."

Teaching in Cambodia

Cattani taught a course in real analysis, the theoretical underpinnings of advanced calculus, and covered material very similar to that found in our own department's Math 523. His goal was to convey how a professional mathematician looks at the material. "I tried to show the students that every mathematical argument has a core idea, that proofs can be beautiful."

Teaching in Cambodia presented Cattani with unique communication challenges. "The students' written work is excellent, exceptionally neat and clear," says Cattani, "but their skills in oral English are very weak." Cattani's wife Mary, who accompanied him on the trip, had an idea to help draw the students out on the first day. "I

sketched a map of the U.S. and showed them where Massachusetts is, to explain where I was from," says Cattani. "Then I invited the students to tell me about their homes." But instead of telling him, the first student approached the board, silently drew a map of Cambodia, then marked the location of his village. "One by one, the other students stepped up to the board and did the same."

Life in Phnom Penh

Perhaps the most overwhelming feature of daily life in Cambodia is the climate. "People say there are two heat classifications in Cambodia," says Cattani, "High Discomfort, which takes place five months of the year, and Extreme Discomfort, which takes place the rest of the year." Daily high temperatures of 95° F with high humidity are common in March. The Cattanis coped by drinking copious amounts of bottled water, up to 1.5 gallons per day, and by doing their walking and sightseeing before 9:00 am.

After one learns to cope with the heat, there's plenty to enjoy in Cambodia. Cambodian food, for instance, is a unique blend of Thai, Vietnamese, Indian, and French cuisine, with a variety of exotic curry and fish dishes. "It's not typical Asian food," says Cattani. "They don't use chopsticks, because of the Indian influence." The Cattanis were also able to visit the magnificent temples of Angkor Wat, the 12th century temple complex famous for its grandeur and extensive bas-reliefs.

But by far the most memorable part of Cambodian life wasn't the heat, food, or sightseeing, but was the people. Despite the trauma they've been through on a national scale, Cambodians remain enthusiastically friendly and welcoming. "People always treated us with warmth and kindness, just as if we were long lost family members."

A Rewarding Experience

Teaching in Cambodia gave Cattani a chance to reflect on the good fortune of his own professional life. "The facilities for the entire Department of Mathematics at the Royal University of Phnom Penh would easily fit into our department's mailroom, and their institute library is far smaller than my own personal library."

In many ways Cattani felt a kinship with the students and their precarious circumstances, and he felt humbled by his experiences. "I was so lucky myself in my own education. Being in Cambodia and seeing what these students are up against made me think of how it was basically by chance that I succeeded and became what I am today." Perhaps, through his efforts in Cambodia, Cattani has given that same chance to one of his eager students.



Commuting by tuktuk

NEW FACES IN THE DEPARTMENT

Daeyoung Kim joined the Department in September. Professor Kim is a statistician who works on mixture models, which are used for density estimation and model-based clustering. In particular, he has studied finite mixture models where the sample sizes are not large relative to the separation of clusters. In addition to methodological issues, he is interested in applications in such areas as biology, medicine, ecology, and image segmentation, and he has broad experience in statistical consulting. Professor Kim received his Bachelor's and Master's degrees from Korea University and his Ph.D. in 2008 from Pennsylvania State University under the direction of Professor Bruce Lindsay. His hiring is an important part of our efforts to rebuild the statistics group, which was hit especially hard by the retirements in 2002–2003.



Hongkun Zhang came to UMass Amherst from Northwestern University, where she was a Visiting Assistant Professor for the 2007–2008 academic year. She received her Bachelor's and Master's degrees from the University of Inner Mongolia in China and her Ph.D. from the University of Alabama at Birmingham, where she worked with Nikolai Chernov. After receiving her Ph.D. in 2005, she returned to China and worked as an associate professor at North China Electric Power University for two years before going to Northwestern. Professor Zhang works on the statistical and chaotic properties of dynamical systems with singularities, in particular on the “billiard models” used to study motion in systems with deep potentials, such as classical molecular dynamics or the motion of a cold atom in optical traps.

SUMMER CONFERENCE ON TRANSFORMATION GROUPS *by Weimin Chen*

The Department of Mathematics and Statistics hosted an international conference on transformation groups July 14–17, 2008. The major funding came from the National Science Foundation with additional support from the department. It was also co-sponsored as the 2nd Group Action Forum Conference by the Group Action Forum. This international mathematical association was founded in 2002 to be a scientific interdisciplinary forum for mathematicians interested in branches of mathematics in which transformation groups appear and in which the notion of group and concepts of symmetry play important roles.

At the July international conference there were about 40 participants from the U.S. as well as from Canada, Finland, France, Germany, Hong Kong, Japan, Korea, Norway, and Poland. The topics discussed during the conference included the following: geometrization of finite group actions on 3-manifolds; locally linear topological, smooth, or symplectic symmetries of 4-manifolds; transformation groups of higher dimensional manifolds; and group actions on algebraic varieties or in symplectic geom-

etry. Particular efforts were made to encourage the participation of women, young researchers, postdocs, graduate students, and undergraduate students. The success of this effort is seen in the fact that among the 40 participants there were 3 women, 8 young researchers and postdocs, 5 graduate students, and 1 undergraduate student. The organizing committee of the conference consisted of Weimin Chen (UMass Amherst), Slawomir Kwasik (Tulane University), and Reinhard Schultz (UC-Riverside). More details may be found at the conference website www.math.umass.edu/~wchen/gafc-2.html.

The last comprehensive conference on transformation groups in the U.S. took place a quarter of a century ago at the conference Group Actions on Manifolds, which was held at University of Colorado in Boulder during June 26 – July 1, 1983. The last time UMass Amherst hosted a conference on transformation groups was in 1971; it was the Second Conference on Compact Transformation Groups, which took place June 7 – June 18, 1971.

NEW CHALLENGE PROBLEM

This year's challenge problem is taken from the Henry Jacob Mathematics Competition.

Suppose that $f(x)$ and $g(x)$ are real polynomials, with $f(x)$ having degree three and $g(x)$ having degree two. Let $a < b$ be real numbers, let $c = (a+b)/2$, and suppose that $f = g$ at the three points a, b, c . Then prove that

$$\int_a^b f(x) dx = \int_a^b g(x) dx.$$

Please send your solutions to
Challenge Problem 2009
c/o Paul Gunnells
Department of Mathematics and Statistics
University of Massachusetts Amherst
Amherst, MA 01003-9305
or send email to gunnells@math.umass.edu

MINI-CONFERENCE FOR PROSPECTIVE MATH PH.D. STUDENTS *by Eyal Markman*

The Graduate Admissions Committee of the Department of Mathematics and Statistics has completed an extremely successful recruiting season. The highlight of this season was the second annual mini-conference for prospective math Ph.D. students, held on March 27, 2009. All thirteen applicants who were admitted into this program and reside in the U.S. were invited to attend the event. Of the eight prospective students who attended, five accepted our offer, preferring it over other competitive offers. The incoming class for fall 2009 will also consist of three additional international students. The recruitment ended on April 15, the deadline for the admitted students to respond to our offer. For the first time in memory we did not have to go to our waiting list to fill all the available positions.

There are undoubtedly many factors contributing to the success of our recruitment this year. Some people emphasize the hiring, during the last few years, of faculty members with highly visible research programs. Others point to the hard work of our Graduate Program Director, Professor Siman Wong, whose efforts have helped create a constructive atmosphere for our graduate students, which in turn led to their active participation in the mini-conference and their positive interactions with the visitors. The members of the Graduate Admissions Committee are convinced that the mini-conference was one of the major contributors to the success of this year's recruitment. When I amusingly told a colleague the different opinions about the reasons for our success, he told me the Indian parable of the six wise but blind men who each feel a different part of an elephant's body and reach different conclusions about what an elephant is.

The mini-conference was extremely effective in presenting the many strengths of our department, academic and otherwise. The visiting students witnessed a united team consisting of dedicated graduate students and faculty members who worked hard to make them feel welcomed. This by itself, I believe, was an extremely forceful argument for their choosing to come to UMass Amherst.

Two current graduate students, Allison Tanguay and Jason McGibbon, agreed to join Professor Richard S. Ellis, Professor Siman Wong, and myself as the organizing committee for the event. Allison and Jason were terrific. They were perfect hosts, organized three social events for graduate students — two dinners and the afternoon activities of the mini-conference — recruited other students for dinners and lunches, found graduate students to host the long-distance travelers, and participated in the panel discussion. We are very fortunate to have such committed graduate students, willing and able to demonstrate such leadership.

Our academic strengths were emphasized in the welcoming remarks by Professors Rob Gardner, our Associate Chair, and by Professor Siman Wong. Three perfectly pitched talks were then delivered by Prof. Richard S. Ellis, Professor Farshid Hajir, and



our graduate student Laura Hall-Seelig. The talks were followed by an informal panel discussion, which was moderated by Allison Tanguay and in which Jason McGibbon, Professor Hans Johnston, and Professor Michael Sullivan participated. The panel responded to questions raised by the visitors such as how to choose an advisor and what reasons each panel member had for choosing to come to UMass Amherst. The relaxed discussion was dotted with humorous remarks and demonstrated the supportive environment that we provide for our students' academic success.

The event ended with dinner at a local restaurant, which twenty-two people attended including seven of the visitors and a group of our graduate students. The visitors' responses were uniformly positive, indicating how thoroughly they enjoyed the event. One even said that he was "sad to leave."



A NEW COMMON ROOM *by Michael Sullivan*

Alumni who visited their math and stats instructors' offices may remember how the department is spread over a number of floors in the Lederle Graduate Research Tower. For example, a student may visit Professor Hajir's Math 411 office hours on the 11th floor, and then trudge up five flights to pick up his or her paycheck for grading.

This lack of centralization has an effect on the graduate students and junior faculty as well. Established faculty have their own research programs with collaborators around the world, presenting their work at the UMass seminars. Graduate students and junior faculty, however, directly benefit from mathematical interactions with other department members beyond the seminars.

This semester, with the help of generous contributions from alumni, the department has established a Faculty and Graduate Research Room in LGRT 1535 for the express purpose of creating a nexus for collaborative mathematical activity. This informal interaction within the department is both horizontal and vertical in nature: department members discuss topics with their peers, and graduate students consult with their professors. The comfortable alumni-funded couches ensure that there are always people around to pursue these discussions.

continued on page 18

RESEARCH PROJECTS BY UNDERGRADUATES *by Farshid Hajir*

During the past summer the Department of Mathematics and Statistics continued its long-standing tradition of funding research projects for undergraduates. These projects are made possible by a combination of generous donations to the department by alumni and of grants from the National Science Foundation and other agencies funding the research of the supervising faculty members.

As in previous years, a number of students engaged in one-on-one projects with individual faculty members. Adam Rose worked with Professor Hans Johnston on speeding up computational N-body problems by implementing the algorithms on graphics processors; Steve Sarasin worked with Professor Robin Young on numerical algorithms for solving and visualizing the evolution of a nonlinear elastic string; under the direction of Professor Tom Weston, Olivia Simpson investigated elliptic curves over finite fields that have just as many solutions as there are elements of the field; and Zach Vinyard worked with Professor Eric Sommers on computing Kazhdan-Lusztig polynomials.

This past summer's program also had a new component. In addition to individual projects, seven students worked on a large group project called "Asymptotically Good Families" under my direction. There is a class of optimiza-

tion problems in various branches of mathematics that can be understood in terms of a search for families of objects having rare and desirable properties. For example, in the graph theory of networks, one seeks graphs which are highly interconnected so that information can pass quickly from one node to a distant one, but where each node has a direct connection to only a restricted number of other nodes so that the network is not too expensive to build. The basic question investigated in this project was the following. What are the restrictions on achieving maximum intercon-

nectivity for a fixed number of edges per node as the number of nodes goes to infinity? It turns out that this problem has deep connections with other branches of mathematics such as number theory and algebraic geometry.

The seven students in this group project studied asymptotically good families in the context of algebraic number theory, algebraic curves, linear codes, and graphs, with an emphasis on the interrelations among these different branches of mathematics. Specifically, Arthur Baines and Jake Mitchell studied the asymptotic properties of codes derived from certain simple families of graphs; Tommy Boucher and Justin Mitchell learned about codes attached to curves over finite fields; Elyse Dostie and Peter Krafft examined properties of graphs attached to codes; and Elizabeth Rosso-limo studied codes attached to unramified towers of number fields.



Olivia Simpson, George Avrunin



**Arthur Baines, Farshid Hajir,
Jacob Mitchell, Peter Krafft**

GRADUATE PROGRAM NOTES *by Siman Wong*

Patrick Boland attended the Joint Mathematics Meetings in Washington, DC in January 2009 and part of the Cornell Topology Festival in the spring.

Jennie D'Ambroise attended the Fifth International Conference of Applied Mathematics and Computing in Plovdiv, Bulgaria in August 2008, and her paper appeared in the conference proceeding. She also attended the Joint Mathematics Meetings in Washington, DC in January 2009, the AMS Sectional Meeting at Worcester Polytechnic Institute in April 2009, and the Conference on Lie Theory and Its Applications in Physics in Varna, Bulgaria in June 2009.

Adam Gamzon attended the Arizona Winter School in March 2009 and the Park City Mathematics Institute summer program on Arithmetic of L-functions.

In April 2009 **Elena Giorgi** gave a contributed talk at the 16th HIV Dynamics and Evolution conference in Oxford, UK. Her talk was entitled "Analysis of T-cell Responses and Viral Escape in Early HIV-1 Infection." She also submitted an abstract entitled "Age-structured Stochastic Model of Intrapatient HIV Evolution" for the Third q-bio Conference on Cellular Information Processing in Santa Fe, NM in August. In addition, four of her joint papers have been accepted for publication, and she has submitted three more.

Laura Hall-Seelig was nominated for a University Distinguished Teaching Award. Last fall she attended the WIN: Women in Numbers Workshop in Banff, Canada. She also gave talks at the Bi-College Mathematics Colloquium at Haverford College in Haverford, PA and at a student research seminar at Bryn Mawr College.

Anna Kazanova attended the MSRI Summer Graduate Workshop on Toric Varieties in June 2009.

In March 2009, **Kody Law** presented a talk in the Spring School on Evolution Equations in Berlin, Germany. He also spoke at the Sixth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena in Athens, GA, where he won a "best student paper" award. Kody gave a talk at the SIAM Conference on Nonlinear Waves and Coherent Structures in Rome, Italy; a seminar at the Center for Nonlinear Studies at Los Alamos National Laboratory; and a talk at Journées de Physique Statistique at ESPCI in Paris, France. Two of his papers have been pub-

lished in *Physical Review A*, a third paper has been published in *Physical Review E*, and a fourth paper has been submitted to *SIAM Journal on Applied Dynamical Systems*.

Chris McDaniel gave an invited talk at the American Mathematical Society Southeastern Sectional Meeting at North Carolina State in April. His talk was entitled "The Strong Lefschetz Property for Coinvariant Rings of Finite Reflection Groups." His trip was funded in part by a travel grant from UMass Amherst.

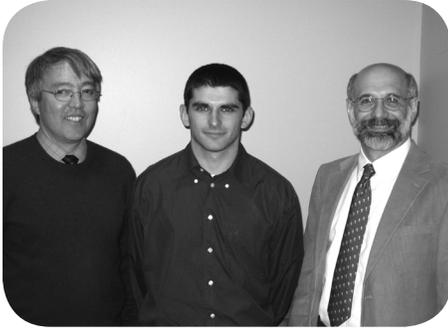
In August 2008 **Jason McGibbon** attended the Conference on Holomorphic Curves at Stanford University and the MSRI Workshop on Low Dimensional Topology. He also attended the FRG Workshop on Strings, Fields and Topology at University of California at Berkeley in January 2009, the Third Japan-US Workshop in Knot Theory in Washington, DC in January 2009, and the Georgia International Topology Conference at the University of Georgia in May 2009.

In March 2009 **Chenyu Wang** attended the Sixth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena in Athens, GA. Her trip was funded in part by a travel grant from UMass Amherst. Along with Professor Panos Kevrekidis and Professor Nathaniel Whitaker and other people outside the department, she also published the following three papers: "Two-Component Nonlinear Schrödinger Models with a Double-Well Potential" in *Physica D*, "Spinor Bose-Einstein Condensates in Double-Well Potentials" in *Journal of Physics A*, and "Collisionally Inhomogeneous Bose-Einstein Condensates in Double-Well Potentials" in *Physica D* (in press).

The following students are expected to receive a Ph.D. degree in mathematics this year: **Patrick Boland**, **Amit Datta**, **Laura Hall-Seelig**, **Omer Kucuksakalli**, and **Meng-Shiou Shieh**. In September 2008 **Viktor Grigoryan** and **Brett Milburn** received a Ph.D. degree in mathematics.

The following students are expected to receive an M.S. degree this year: **Diego Belfiore** and **Kathryn Sansom** in mathematics; **Abhinav Guliani**, **Maksim Kuksin**, **Yannan Shen**, and **Nadiah Wahi** in applied mathematics; and **Amy Beresky**, **Jian Chang**, **Nicole Herdina**, **Cathy Ho**, **Enrique Schulz**, **Xinyu Wang**, and **Yufeng Zhang** in statistics.

OUTSTANDING UNDERGRADUATES HONORED



This spring the Mathematics and Statistics department hosted a banquet to honor achievements of our top undergraduates. Participants in undergraduate research projects (see the article by Farshid Hajir in this newsletter) and in the William Lowell Putnam Competition (see the article by Jenia Tevelev in this newsletter) were recognized, along with the winners of the M. K. Bennett Geometry Award and the Henry Jacob Mathematics Competition. Special recognition was also given to Michael Kranin, a former winner of the math competition, for winning a prestigious Goldwater Scholarship. We were delighted to host alumnus Roy Perdue '73 and Dean Jim Kurose of the College of Natural Sciences and Mathematics.

Jim Kurose, Michael Kranin, George Avrunin

M. K. Bennett Geometry Award

The M. K. Bennett Geometry award was founded by a group of alumni led by Robert and Veronica Piziak to honor the memory of Professor Mary Katherine Bennett. In 1966 Professor Bennett earned the first Ph.D. from the department under the direction of Professor David Foulis. After teaching at Dartmouth, she returned to UMass Amherst for the rest of her career, where she encouraged interest in geometry and high school teaching among undergraduates. Each year the award is presented to the students with the strongest performance in Math 461, Geometry. This year's winners were Andrew Havens and Katherine Murdock.



Andrew Havens, Peter Norman,
Katherine Murdock

Henry Jacob Mathematics Competition

The Henry Jacob Mathematics Competition honors the memory of Professor Henry Jacob, who encouraged interest in mathematics among undergraduates through an annual mathematics contest. The contest is open to all first and second year students who do not have a close affiliation with the department. The competition is sponsored by Roy Purdue '73 (Solutions by Computer) and James Francis '86 (Deutsche Bank). This year first prize, a \$1600 cash award, was earned by Nate Harmon, a mathematics major. Second prize (\$1000) went to Keaton Burns, a mathematics/physics double major, while third prize (\$600) went to Boxuan Cui, a mathematics major. Fourth prize (\$200) went to Anton Medvedev, a pre-engineering major, and mathematics major Jinlong Tan won an honorable mention award.

Paul Gunnells, Nate Harmon,
Boxuan Cui, Eleanor Killam,
Haskell Cohen, Roy Perdue



A New Common Room *continued from page 16*

With a Monday deadline for this article, this author decided to pay a visit to 1535 on Saturday morning for inspiration. Used to an abandoned department on the weekend, he was quite surprised to find the room filled with at least a half-dozen graduate students working on Real Analysis. The room had already succeeded in generating a sustainable critical mass of activity.

"I have found that I collaborate more with people because of the room. For instance, if I go up there just to eat lunch . . . I might find someone working on Lie groups or complex, and we end up discussing the material and figuring things out together," said one PhD student. She continued, "I end up coming into school on days when I would have stayed and worked at home."

Since the department is on six floors, it is unlikely to run into people by coincidence. But as two first-years point out: "I've found that the room has been a major catalyst in terms of getting to know my fellow graduate students"; "I've met a lot of new people I probably wouldn't know otherwise."

THE FOLLOWING ALUMNI AND FRIENDS HAVE MADE CONTRIBUTIONS

The following alumni and friends have made contributions to the Department of Mathematics and Statistics during the past year. We greatly appreciate your generosity. It is through this generosity that we are able to improve and enrich the educational experience of our students.

Giving to the Department of Mathematics and Statistics supports initiatives in an array of areas, including the following:

- A gift of \$100 or less helps support the Math Club, the Awards Dinner, and other student functions.
- A gift of \$100 – \$500 provides funding for awards for outstanding undergraduate majors and graduate students to help honor their achievements.
- A gift of \$500 – \$1000 helps support student travel to conferences and workshops, and could sponsor a prize in the mathematics competition.
- For \$1000 – \$3000 your gift could provide funds to support increasing classroom technology such as tablet PCs and projectors. You could fund a seminar series or a distinguished lecture.
- For \$3,000 – \$5000 your gift could fund the summer research of REU (Research Experience for Undergraduates) students. You could provide summer support for graduate students so that they could concentrate on their dissertation research, or provide support for junior faculty.

To make a gift to the department, please use the enclosed gift envelope or visit our gift page on the department's website: www.math.umass.edu/Donate/donate.html. The website www.umass.edu/development/ offers more information about donating to the campus and gives you the opportunity to make your gift online.

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