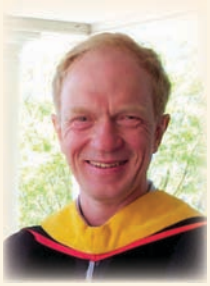
RECKONINGS SPRING 2010

NEWSLETTER OF THE DEPARTMENT OF MATHEMATICAL SCIENCES AT THE UNIVERSITY OF DELAWARE

Chair's Message

Peter Monk



In May 2008, President Patrick Harker unveiled his new strategic plan for the University called the Path to Prominence™. This plan is designed "to engage closely with the critical issues of our day, to increase the global impact of the University, and to raise its prominence in the world." This issue of *Reckonings* features several articles that illustrate the Department of Mathematical Sciences' response to this new strategic vision.

Fulfilling, in part, both the University's "Commitment to Delaware" and the goal of "A Diverse and Stimulating Undergraduate Academic Environment" we continue to develop our Secondary Mathematics Education program. The goal of this program is to prepare students for employment as middle and high school mathematics teachers, an area of critical need in the state. In September 2009 we welcomed a new specialist in this area, Dr. Michelle Cirillo, to the Department. She joins us after a post-doc at Iowa State and, besides teaching in the mathematics education program, she is working on an NSF-funded research project with her colleagues at Michigan State where she is creating professional development materials related to mathematics discourse in secondary classrooms. For more information, an article in this issue by the Director of Mathematics Education and Hollowell Professor, Prof. Alfinio Flores, focuses on mathematics education at Delaware.

Both at the undergraduate and graduate levels, the university is work-

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Mathematical Biology Flourishes at UD

L. F. Rossi

The use of mathematics is not new in the life sciences and applications to life sciences are not new in the field of mathematics. However, the rapid pace of discovery and specialization in the life sciences in recent years has brought the two disciplines together in many new and exciting ways. For example, microarray technology allows biochemists to sample the expression of hundreds of genes simultaneously, but interpretation of this data remains a major challenge. There is no question that this is an exciting time for mathematicians. The life sciences as a field are larger than ever allowing more investigators to participate. This article is not a comprehensive inventory of all life science activity in our department, but I will use our work as a lens through which one can view the challenges and rewards of working on the interface of mathematics and biology.

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Attendees of George Hsiao Conference enjoying a break. See the article on page 19.

The Graduate Experience in the Department of Mathematical Sciences

J. Pelesko, Director, Graduate Program

It's been forty years since the first Ph.D. student received a doctoral degree from the Department of Mathematical Sciences at the University of Delaware. Since then, the department has granted over one-hundred such degrees. And, while the core goal of producing top-quality research mathematicians has remained the same, much has changed in our graduate program. I'd like to take you on a little virtual tour and give you a taste of what the graduate experience is like in our department.

In their first year, new graduate students are invited to campus well before the start of the semester. Students from abroad will participate in the English Language Institute and have the opportunity to practice and strengthen their language skills. Students from the United States, or those who have been studying in the U.S. for a while, will participate in our Graduate Review of Important Problems for Success (GRIPS) program. During GRIPS, students will meet faculty and current graduate students, have the chance to review the mathematics necessary for success in graduate school, and have time to adjust to life in Newark. This adjustment usually includes at least one trip to the Woodside Creamery for a taste of Delaware's best ice cream!

Once the fall semester begins, new students will spend most of their time focusing

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Inside *Reckonings*

Chair's Message, continued from cover

ing towards an assessment strategy for all programs. This doesn't refer to individual student grading, or faculty teaching evaluations. Instead the goal is a formal process for setting educational goals for programs, mapping these goals to courses, and measuring whether students in general are attaining the goals. A final critical step is to use these assessments to improve our programs. Fortunately the department is well ahead in this process having been working on assessment for several years under the guidance of our Assessment Fellow, Prof. Lou Rossi. In the run-up to the Middle States accreditation review for the University next year, we are now concentrating on dissemination of results, and modifying our program to fit the evolving university model.

The second strategic milestone in the Path to Prominence™ is to become "A Premier Research and Graduate University." We have a long-standing commitment to excellence in research and graduate education so the department is enthusiastically working to attain this goal. We have redirected department resources to improve graduate stipends as well as provide fellowships for exceptional students. Under the previous Director of Graduate Studies, Prof. Richard Braun, and the current director, Prof. John Pelesko, we have thoroughly revised the program to tie it more directly to our research strengths and give the students flexibility in pursuing their degree. We have also put in place several special programs to help our students succeed.

First we have the "Graduate Review of Important Problems for Success" (GRIPS) program for new students to help them with the transition from undergraduate to graduate study. This program was started with a grant from the College of Arts and Sciences and invites students to campus in the August before their first semester. A social and academic program then allows students to review mathematics essential for our graduate courses, as well as adapt to life in Newark. Our second program, "Groups Exploring the Mathematical Sciences" (GEMS) is aimed at the critical transition from classroom learning to active research. First year students can apply for summer support to take part in a research team lead by a faculty member and including an undergraduate researcher. This program is made possible by a grant from the University of Delaware's Provost Office, under the "Graduate Program Improvement and Innovation Grants" scheme, and is a big success with no less than nine groups funded for summer 2010. More information can be found on the Web page http://www.math.udel.edu/GEMS/. Finally this year we had our first "Winter Research Review" in which graduate students presented their ongoing projects.

An article in this newsletter by the Director of Graduate Studies, Prof John Pelesko, reflects the excitement we feel for the graduate program. Indeed the only concern I have is with the excessive use of acronyms.

Research in the life sciences is identified as one of the strategic areas for university research in the future. Several faculty in Mathematical Sciences already work in this area (for example Prof. Richard Braun who studies tear films in the eye), and we have taken steps to increase our depth in this important area. In September we welcomed Prof. Pak-Wing Fok, who works on Mathematical Biology, to the faculty. He joins us from a Von Karman Instructorship at Caltech. In addition we have hired a department funded UNIDEL post-doc, Dr. Allison Kolpas, from UC Santa Barbara who is working with Prof. Louis Rossi on his NSF funded projects on modeling swarm behavior. An article in this issue by Profs. Fok and Rossi expands on the topic of mathematical biology at Delaware.

While the University is enthusiastic about multidisciplinary hires and research, we cannot neglect our core research strengths. In January, we were joined by Prof. Sebastian Cioaba, fresh from a post-doc at the University of Toronto, who works on graph theory. In addition we hired a second UNIDEL post-doc, Dr. Tao Feng from Nanyang University in China, who joined us in September and is working with Prof. Qing Xiang on combinatorics. In this issue, Prof Felix Lazebnik has contributed an article on discrete mathematics at Delaware.

In related news, Prof Gary Ebert has announced his retirement. A conference in his honor celebrating his years of research on "Designs, codes & geometries," organized by Prof Qing Xiang and funded by the department, NSA and NSF, took place in April this year.

In other faculty news, I regret that Professors Anja Sturm and Russell Luke have resigned their positions here to take up full professorships at the prestigious University of Goettingen in Germany. We wish them well.

It is with great sadness that I record the death of Emeritus Prof. Cliff Sloyer last year. He made enormous contributions to the department, university and state in mathematics education over his many years at Delaware.

One last piece of news, the College of Arts and Sciences has a new Dean: George Watson, previously the Interim Dean and before that the Senior Associate Dean for Sciences and Mathematics. In his capacity as Associate Dean, I worked closely and effectively with him. He is extremely supportive and has a vision for the future of the college as the center of the university. We look forward to working with him to achieve this goal.

Finally, on a personal note, this is my last year as chair. I'll be returning to mathematics and the chalkboard after a sabbatical. I thank the faculty and staff for their support and hard work during my time in the chairs office, and I wish my successor (at the time of writing undetermined) good fortune in the important task of guiding the department in the years ahead.

From the Editors

Dear Department Alumni, Students, Colleagues and Friends,

It is with great pleasure that we present to you the sixth edition of *Reckonings,* the annual newsletter of the Department of Mathematical Sciences. It would not be an exaggeration to say that 2009 was bursting with activities and events, and this is well summarized in the message from our chairman. Following the tradition of the previous editions, you will find articles describing different areas of exciting research that are being conducted by our faculty. This year, Prof. Rossi's article gives an overview of our department's research and educational interests in the fast-growing field of Mathematical Biology. Prof. Lazebnik discusses the groundbreaking result of T. Tao and B. Green in Number Theory, for which T. Tao was awarded the 2006 Fields Medal. Prof. Colton reports on the collaboration between our Department and the École Polytechnique, France in Inverse Scattering. In addition, we have contributions from Professors Pelesko and Flores who give an update on the recent developments of our graduate program and on Math Education. Other regular features include profiles of new faculty and current students, as well as a list of brief news items highlighting math (and non-math) events, grant activity, awards, etc. of the past year. You will note in particular two conferences that celebrated the lifelong careers and achievements of Profs. Ebert and Hsiao.

Our department is expanding academically and socially, and we hope that this year's newsletter will again keep you updated on our recent achievements and transformations. By the way, something that makes all of us happy — the Mathematician landed the top spot in the 2009 ranking of best jobs in the U.S. according to the *Wall Street Journal*. The study took into consideration the job environment, income, employment outlook, physical demands and stress. The second and third best professions were Actuary and Statistician respectively, jobs that are also highly mathematical in nature. It was a good year to be a Mathematician.

We would like to thank all of the contributors to this sixth edition, as well as Dan Wright from UD's Office of Publications for his help with the design and layout of this newsletter. We also would like to encourage everyone to regularly check the department's web pages (www.math.udel.edu) for current news items, activities and events. Our website is in the final stage of completion and we hope that you will like the new look.

If you have news or other contributions that you would like to share, either on the web pages or in future editions of Reckonings, please feel free to send an email to the Outreach Committee at outreach@math.udel.edu. We look forward to hearing from you.

Sincerely,

Fioralba Cakoni, Pak-Wing Fok and Philippe Guyenne

Outreach Committee of the Department of Mathematical Sciences

Mathematical Biology, continued from cover

The complexity of many of the problems in the life sciences requires the efforts of interdisciplinary teams that can bring many different areas of expertise into focus to illuminate a complex process. For the mathematician working in the life sciences, the challenges are twofold. First, one has to understand the problem enough to develop meaningful mathematics from it. Second, one must find ways to communicate relevant mathematical knowledge back into the life sciences community. These challenges affect not only our research mission, but also our teaching mission as we educate the next generation of mathematicians. In the last three years, our department has seen a spike in activity in mathematical biology on many fronts including new research initiatives, new educational initiatives and new hiring opportunities. This article highlights some of the efforts in our Department to explore these frontiers and resolve scientific, educational and institutional challenges associated with bringing more mathematical reasoning into the life sciences.

The challenge of developing a mathematical understanding of processes in the life sciences is daunting. Biological processes are very complex, and it can be difficult to abstract the dominant effects. This runs contrary to the experience of most undergraduate science majors where the traditional exposure to the life sciences is through simple population dynamics of a single species. In the life sciences significant progress has been achieved by studying the differences between different processes and organisms. The most direct attack on many problems in the life sciences is to categorize all the possible objects for study. This reductionist approach is counter to the culture in the mathematical sciences which seeks to abstract the dominant features in a problem to understand their fundamental properties. If a biologist and a mathematician were trying to build a model airplane together, the biologist would be satisfied with a complete list of all the parts and the mathematician would be satisfied with an understanding of how glue can bond one piece to another.

Often understanding the biology is simply a matter of finding the right collaborator. Prof. Rich Braun, Tobin Driscoll and Pam Cook and former graduate students Alfa Heryudono and Kara Maki have collaborated on a large interdisciplinary grant to study the dynamics of tear films in human eyes during the blink cycle. The tear film is a complex fluid is every sense of the word involving multiple glands supplying different components to the thin layer of fluid that covers the visible portion of our eye. Their research partner is Dr Ewen King-Smith in the College of Optometry at the Ohio State University. In many ways, the collaboration is ideal because King-Smith has a Cambridge Biophysics Ph.D. and expertise in making precise measurements of tear films. Prof. Braun reflects, "He is a perfect contact for our group. He is more mathematically oriented than almost all of the optometrists and ophthalmologists out there; with a classically trained M.D., working at the detailed level of collaboration that we do is more challenging."

Another example of cross disciplinary collaboration is Prof. Edward's work on olfactory receptors with Profs. Don French and Steve Kleene from the University of Cincinnati. French is a mathematician and Kleene is a Biophysicist who runs the "Smell Lab," studying olfactory systems in frog models. Edwards, French and Kleene work together to understand the distribution of ion channels and the transport of charge along cilia in the nasal

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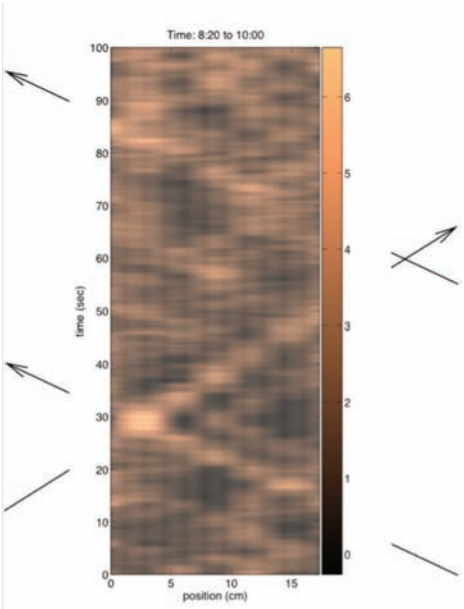
Mathematical Biology, continued from page 3

passages. The cilia itself is a closed channel along which odorant molecules diffuse. The placement of ion channels along the cilia is non-uniform, leading some to speculate that it has been optimized by natural selection to amplify trace concentrations of certain molecules. But understanding this process is impossible without a proper mathematical treatment of coupling of diffusion and surface binding of odorant molecules to ion channels along the cilia. Kleene's role is essential as a check on the physical model and to supply data to match against Edward's and French's calculations. The problem is compelling to Edwards who specializes in exotic, nonlinear reaction diffusion systems, but close collaboration is required to make progress.

My own experiences have been less direct. Some years ago, an undergraduate approached me looking for an undergraduate research experience, and I provided a list of mathematical questions. One of the problems involved whether foraging ants could find globally optimal solutions to the Braess' Paradox and the Knight-Thompson traffic paradox. Our research yielded some surprising results on ant foraging dynamics that eventually led me to find a new collaborator on campus. Prof. Chien-Chung Shen from Computer and Information Sciences studies biologically inspired computer network protocols. When working with complex systems, many scientists and engineers turn to biologically-inspired solutions. The science of using biologically inspired solutions arose from the observation that many technological problems are similar to problems in the natural world. In the natural world, there is no central design process through which solutions meet pre-specified criteria. Instead solutions in the form of successful organisms emerge through natural selection under environmental pressure. Mathematicians and scientists harvest these solutions by modeling and analyzing the natural system, and then modify the model to solve a technological problem. For instance, computer networking protocols based on foraging ants have been enormously successful in situations where the network topology is not known a priori. Of course, mathematical insight is necessary to fully leverage biologically-inspired solutions.

For the mathematician who loves solving certain types of problems that come from the life sciences, it may be difficult to find a collaborator. However, for mathematicians who like to listen and learn, there is no shortage of life scientists looking for mathematical expertise. A little over a year ago, I sought the advice of Dr. William Weintraub and his collaborators at the Center for Outcomes Research at Christiana Care about a faculty search in mathematical biology. After I received the information I was looking for, he asked me my opinion about the problem of vulnerable plaque formation in the human arterial system. I learned that the typical description of heart disease as a slowly evolving plumbing problem had been shown recently to be wrong in most cases. Most "events" (a medical term for a major stroke or heart attack) are caused by ruptured vulnerable plaques, a structure analogous to a bursting blister. The process is more of a mathematical and physical catastrophe than a gradual physical degradation. After this meeting, a group of interested faculty created a Vulnerable Plaque Working Group, tying together Math faculty (Fok, Pelesko, and Rossi), Biology faculty (Ulhas Naik) and physicians from Christiana Care (William Weintraub and Nowwar Mustafa). The aim of this group has been to link together the biochemistry, structure mechanics and fluid dynamic processes to describe the growth and rupture of a vulnerable plaque.



Direct measurements of a standing density wave in an ant foraging trail as predicted by mathematical analysis of a new PDE model of ant foraging trails. The ant nest is on the left and a food source is on the right. The ant density is represented by the brightness.

The challenge of seeking relevance outside of the mathematical sciences is nothing new to interdisciplinary applied mathematics. Working at the interface of two disciplines requires good communication skills. To be effective, the mathematics must be relevant and expressed in a language that is useful to those working in the life sciences. The trouble is that a common unified language for the the biological sciences is still emerging. The subtleties of this challenge were beautifully posed by Y. Lezebnik in his article "Can a biologist fix a radio? — or, what I learned while studying apoptosis."[1]

To have an impact, significant outreach is essential. Biologists will expect any mathematical system to be complicated because biology is complicated. At the same time, mathematicians are trained to strip down processes to the barest essentials that still manage to capture the feature of interest. As our newest hire Prof. Pak-Wing Fok comments, "Finding problems that (i) engage biologists and (ii) satisfy the aesthetic constraint is hard. I would say that many people are content to do one of these, but the rewards are tremendous for someone who can achieve both." Prof. Braun has gone the extra mile to share his results with ophthalmologists and optometrists. In addition to speaking at mathematics and fluids meetings, he regularly attends the more specialized meetings of the Tear Film and Ocular Surface Society. To reach the right audiences, he and his collaborators publish their work both in mathematics journals and medical journals.[2,3,4]

These endeavors highlight the motivation behind these research programs: Buried in these biological processes are unique and intriguing mathematical structures. Where Prof. Kleene sees an olfactory system, Prof. Edwards sees a new nonlinear reaction-diffusion system. Where Prof. King-Smith sees a tear film, Prof. Braun sees thin interacting layers of viscoelastic fluid. By pursuing these problems, we provide physical and technological insight, and at the same time, contribute new mathematical knowledge. As usual, it takes some time for our mathematics curriculum to catch up. Reading an undergraduate calculus or differential equations text, one is led to believe that mathematical biology is synonymous with population dynamics. Ecology remains an active area of research for many, but mathematics in the life sciences now extends into many application domains.

Department research interests have also driven educational changes in both the Mathematical Sciences and the Biological Sciences Departments. Perhaps the most significant of these is the creation of our B.S. in Quantitative Biology program (see *Reckonings*, p. 10–11, Spring 2009), but these larger changes have accompanied some deeper, institutional changes as well. Responding to the need for greater quantitative reasoning skills in their students, our Colleagues in Biological Sciences now require our Math 241 calculus course, originally designed for mathematics and physical sciences majors. In return, we created a new lecture section of calculus for biology majors. This "bio lecture" is open to all majors, but examples and motivation is drawn from the life sciences. As Prof. Driscoll observed, calculus focuses on unifying principles between diverse topics such as rumors, diseases and rabbits. He comments "Newton was inspired by physics when he invented calculus, but the universality of math means that most forms of quantitative inquiry eventually come home to calculus." Prof. Driscoll has also successfully infused new quantitative features into more traditional biology courses. Working with Prof. Bill Cain from Biological Sciences, he wrote a software module for his BISC 413 (Advanced Genetics Laboratory) students to use in creating data that identifies evolutionary relationships in DNA.

Our standard mathematics course offerings benefit as well as well. For instance, true slime mold Physarum polycelphum has been used as an example of a self-assembled, near optimal network in Math 512, one of our capstone courses. The department is also pleased to offer new courses to meet a demand for more specialized mathematical content across the content. This semester Prof. Fiora Cakoni is offering an undergraduate course on the Mathematics of Medical Imaging for the first time. The course is drawing majors in mathematics, electrical engineering and physics who would like to learn more about the mathematical techniques underlying measurement processes such as CAT scan, MRI, as well as diffusion and impedance tomography. The treatment of this material is inherently mathematical and supplements existing courses offered by the College of Engineering that cover issues related to the design of imaging hardware. These and other activities highlight our department's commitment to prepare scientists and engineers who are interested in working in the life sciences.

Mathematics is becoming the dominant language in understanding the living world in this century much as mathematics revolutionized our understanding of the physical world in the 20th century. Then as now, mathematics departments face a choice of whether to play a role in these advances or let the mathematical discoveries come from other disciplines. At UD, we made this choice a long time ago and look forward to maintaining our presence on the exciting and evolving frontiers of mathematical biology. As E.E.Cummings wrote "Always the more beautiful answer who asks the more beautiful question."

1. "Can a biologist fix a radio? — or, what I learned while studying apoptosis," Y. Lezebnik *Biochemistry* 69 (12) Dec. 2004. 1403–1406.
2. "Tear Film Dynamics on an Eye-Shaped Domain I. Pressure Boundary Conditions," K.L. Maki, R.J. Braun, W.D. Henshaw, and P.E. King-Smith. *Math. Med. Biol.* in press.
3. "Tear Film Dynamics on an Eye-Shaped Domain. Part II. Flux Boundary Conditions," K.L. Maki, R.J. Braun, W.D. Henshaw, P.E. King-Smith and P. Ucciferro. *J. Fluid Mech.,* (2010) in press
4. "Contributions of Evaporation and Other Mechanisms to Tear Film Thinning and Breakup," P.E. King-Smith, J.J. Nichols, K.K. Nichols, B.A. Fink and R.J. Braun, *Optom. Vis. Sci.* 85(8):623–630, 2008.

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Graduate Experience, continued from cover

on course work. The flexibility of our new program allows the incoming student to follow their interests' right from the start. While most will take courses in analysis and algebra, in preparation for preliminary examinations, they'll also choose from an array of courses in applied mathematics, applied analysis, probability, discrete mathematics, and computational mathematics. Meanwhile, each week, students will attend our graduate student seminar and begin learning about the research interests of our faculty. Hopefully, students will also take advantage of the numerous other seminar and colloquia offerings in the department and on campus.

While most of their time is spent with course work, many of our new students will be adjusting to life as a Teaching Assistant (TA) at the same time. This too is an important part of the graduate experience. By working closely with faculty members, consulting with university experts on teaching, and spending time in the classroom, our future Ph.D.'s are preparing for life after graduate school — as either an academic or an industrial mathematician. New students are also exposed to the wide variety of fellowship and research assistantship opportunities available to graduate students.

We've been working hard to help more students prepare applications for these opportunities and are proud to say that this year three of our students received fellowships. Congratulations to Michael Cromer, Jiahua Tang, and Chris Castillo, all of whom received one year fellowships from the University of Delaware's Office of Graduate Studies!

During the winter break, most first year students will spend time preparing for their preliminary examinations. These exams, covering aspects of algebra and analysis, must be completed by the start of a student's fourth semester. Many students will also spend part of their winter break talking to faculty members about research projects for our Groups Exploring the Mathematical Sciences (GEMS) program. This program, available only to students in their first summer, gives students an intensive ten-week research experience working with a faculty member and helping mentor an undergraduate research student. This is a competitive program, but we're pleased that this year we'll be able to fund nine excellent projects.

In spring of their first year, students will continue with their course work, submit GEMS applications, and continue preparing for their preliminary examinations. By the end of the spring semester, they'll no longer be a "new student," but will be an integral part of our program, well on their way to a Ph.D. In February, they'll get another glimpse at what this means when they attend our Graduate Student Winter Research Review. This is a symposium, open to the entire university community, where third, fourth, and fifth year graduate students give talks on their thesis research. This new annual tradition ran for the first time in 2010. Seventeen students gave talks on their work to an audience that included students, faculty, and administrators.

Summer is also a busy time for graduate students. Those participating in GEMS will be engaged in intense research. Other students may opt to teach during the summer and get their first experience as the primary instructor for a class. All students are invited to our weekly GEMS lunches where research talks are given by both faculty and graduate students. And, perhaps most importantly, all students are invited to play on our team in our summer softball league. I'm proud to say that last year we handily defeated all teams from the Department of Physics and am planning on a repeat in 2010.

By the start of their second year, our graduate students have completed their preliminary exams, have a good idea of the type of research they wish to conduct, have spent time in the classroom, and have taken a wide range of courses. Their second year is spent finishing the bulk of their course work and getting to know the faculty member who will become their thesis advisor. They are also undoubtedly looking ahead to their

second summer when they'll prepare intensely for their candidacy examination. This is an oral examination, given during the start of their third year, and probes a student's readiness to tackle their thesis project. One bit of advice for any students reading this — bring water, you'll be doing plenty of talking!

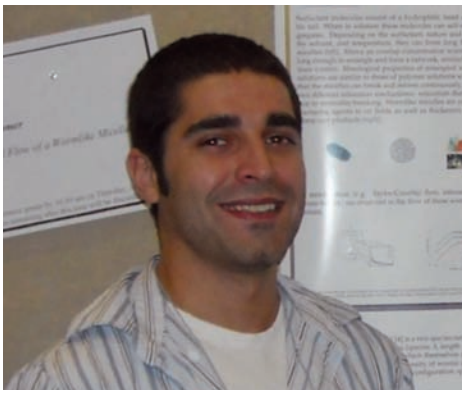
Once a student completes their candidacy examination, the focus switches from course work to research. The next several years are spent creating and applying new mathematics. Many students will publish their first scientific papers during this time. All students will undertake the writing of their dissertation. When they are ready, they'll defend this dissertation to a committee of faculty in a "thesis defense" open to the entire university community. While graduation will still be a few months away, this defense really marks the transition to the doctorate. In fact, once a student has successfully defended, I firmly believe they are ready to be called "Doctor."

Shortly after the defense is graduation, and time to say goodbye. Our students go on to postdoctoral positions, other academic positions, and jobs in industry. They are always welcome back and we always love to hear from them. No matter where they end up, or what path they take, they'll always be a valued part of the Department of Mathematical Sciences at the University of Delaware.

Featured Graduate Students:

Michael **Cromer**

Michael Cromer grew up in Linthicum, Maryland. He graduated *magna cum laude* from York College of Pennsylvania in May 2005. Mike received a Bachelor of Science in Mathematics with a minor in Quantitative Management. While at York, he played soccer and was a tutor for math, physics and business statistics.



Mike has always enjoyed math and solving problems, and as mathematics became more complicated the more it really piqued his interest and the more he gained a true appreciation and passion. Upon deciding to pursue an advanced degree and researching graduate programs, the math department here at UD was an easy choice for him. With strong curriculum and faculty and a close-knit student community, Mike has enjoyed every minute of his ensuing time at Delaware.

Coming into graduate school Mike did not know which specific area of mathematics he wanted to pursue. He spent his first summer learning about transonic flow from Prof. Pam Cook and Prof. Gilberto Schleiniger and gained a real appreciation for applied mathematics and fluids. Mike's research has taken a similar direction and now, with his advisor, Prof. Pam Cook, in collaboration with Prof. Gareth McKinley and his group at MIT, is focused on the analysis and simulation of a constitutive model, the VCM model (developed by UD math dept. alumnus Dr. Paula Vasquez [2007, currently at UNC] with Profs. Cook and McKinley) for wormlike micellar solutions. They have many industrial applications; among others they are used as fracturing agents in oil recovery and as thickeners for home care products, such as shampoo. The VCM model is a two-species, network model, which includes the scission of a long species and the reforming of two short species in order to capture properties of wormlike micelles undergoing flow deformation. In his work, "Extensional Flow of Wormlike Micellar Solutions," which appeared in Chemical Engineering Science in 2009, with Profs. Cook and McKinley, they examine the model in extensional flow and show that it, unlike several other models, can simulate the unique phenomenon of rupture of wormlike micellar filaments. Mike is currently simulating the one-dimensional pressure-driven shear-flow through a channel using a self-developed adaptive spectral method and intends to adapt this method to the simulation of two-dimensional flows.

Mike has presented his work at many conferences including the XVth International Conference on Rheology in Monterey, the national Society of Rheology meeting in Madison and the SIAM annual meeting in Denver. In addition to his research, Mike has served as the treasurer for the UD SIAM student chapter and as the graduate student seminar coordinator. He has also participated in the Graduate Student Mathematical Modeling Camp as well as the Workshop on Mathematical Problem in Industry. Mike recently spent a semester, designed around complex fluids, at the Institute for Mathematics and Its Applications.

Outside of his studies, Mike is an avid gym-goer with aspirations of being a personal trainer as well as amateur bodybuilder or powerlifter; one of his goals being to join the "1000 club" (squat+deadlift+bench press) before he graduates. He has dedicated countless hours to the study and practice of fitness and health, and has dreams of someday owning and operating his own gym. He is also a sports fanatic with the goal of not only learning but also being able to effectively play every sport.

Mike is considering careers in both industry and academia in hopes of continuing work on the modeling and simulation of non-Newtonian fluids. While he has been influenced by a great deal of people both inside and outside of academia, it has always been the love, support and dedication of his parents and his brother that continually drives him and motivates him to strive to great heights.

Zunlei **Xiao**

Zunlei Xiao grew up in Harbin, China, and did his undergraduate work at Peking University in Beijing, China. In July 2005, he received his Bachelor of Science in Mathematics. Subsequently, he was a graduate student in the Department of Mathematical Sciences at the University of Delaware, after he attended a Gaussian Processes summer school given by Prof. Wenbo Li in Peking University. Currently, he is a PhD candidate in Mathematics and is due to receive a Masters in Statistics this August.

Zunlei remarks that he has always enjoyed the subject of mathematics. He spent his first summer working with Prof. Anja Sturm on simulations of branching processes. In summer 2007, he worked with Prof. John Pelesko on a diffusion model in a lens capsule under a Howard Hughes Medical Institute (HHMI) grant. Neither research topic became the focus of his thesis although he benefitted greatly from their study. After two years, he

focused on his research interest in probability and statistics. He ultimately settled on pursuing probability theory and will soon complete his thesis on "Lower Tail Probabilities for Gaussian and Iterated Processes" under the supervision of his advisor Prof. Wenbo Li. Calculating lower tail probabilities is a theoretical problem, but it has a variety of applications; it is a probability estimate of small values or deviations. The approach he takes in the thesis is to use mainly Gaussian techniques, inequalities and analysis.

He attended a series of probability seminars and workshops during his graduate study, where he met many famous people working in his fields and gained valuable research experience. He is going to attend

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Brief News Items from the Math Department

Professor Qing Xiang receives a three-year NSF grant from by the combinatorics program in the Division of Mathematical Sciences of NSF.

Qing Xiang has been awarded a new three-year grant starting July 1, 2010. This grant will support Professor Qing Xiang and his collaborators to study a diverse set of problems concerning incidence matrices, additive combinatorics, difference sets and Hadamard matrices. Incidence matrices are basic mathematical objects which are frequently encountered in various branches of mathematics, computer science and engineering. Difference sets and Hadamard matrices are important objects in combinatorial design theory, which have found many applications in radar, spread-spectrum communications and cryptography.

Mathematics department faculty Rossi and Seraphin continue tradition of college service

Department of Mathematical Sciences faculty members **Louis F. Rossi** and **Anthony Seraphin** continue the tradition of department leadership on the College of Arts and Sciences Faculty Senate. Professor Seraphin will serve as President-Elect for the 2010–2011 academic year and President for the 2011–2012 academic year. Professor Rossi will serve as chair of the Committee on Committees and Nominations for the 2010–2011 academic year. We congratulate them on their recent elections and thank them for the leadership in these important positions.

Mathematics Major Patrick Devlin chosen as Goldwater Scholar

Congratulations to mathematics major **Patrick Robert Devlin** who has won a prestigious Goldwater Scholarship. The scholarship program, honoring the late U.S. Sen. Barry M. Goldwater of Arizona, is designed to encourage outstanding students to pursue careers in the fields of mathematics, the natural sciences and engineering. The Goldwater Scholarship is the premier undergraduate award of its type in these fields and students compete nationally for the award.

Graduate Student Nicholas Brubaker awarded NSF Graduate Research Fellowship

We would like to extend special congratulations to Department of Mathematical Sciences graduate student **Nick Brubaker** on receiving a very prestigious NSF Graduate Research Fellowship Award. This is a three-year fellowship and one of NSF's oldest and most prestigious programs. In existence since 1952, the program has fielded over 500,000 applicants and made only 42,000 awards. More than twenty of these have gone to future Nobel Laureates. In recent years, fellows have included Sergey Brin (Google co-founder), Steven Levitt (co-author of Freakonomics) and Steven Chu (1997 Noble Prize for Physics, U.S. Secretary of Energy).

Prof. Cai elected to serve as Co-Chair of SIG/RME

Professor Jinfa Cai has been elected to serve as the New Co-Chair for the Special Interest Group on Research in Mathematics Education (SIG/RME), affiliated with the American Educational research Association. SIG/RME is the primary organization for research in mathematics education in the United States. The purpose of SIG/RME is to promote and to disseminate research, development, and evaluative efforts in mathematics education, and to promote and encourage scholarly and productive exchanges among members of all the constituencies that affect, or are affected by, research on the learning and teaching of mathematics.

It is a two-year term as co-Chair (2010–2012, the first year as Junior Co-Chair and the second year as Senior Co-chair). The major responsibilities of the co-chair include organizing annual meetings for American Educational Research Association's annual meeting on Research in Mathematics Education and the National Council of Teachers of Mathematics Research Pre-session, overseeing junior scholar award and senior scholar award in Research in Mathematics Education, and communicating with various constituencies concerning the research related to the learning and teaching of mathematics.

Professor Cirillo receives Knowles Research Fellowship

Michelle Cirillo has been awarded a Knowles Science Teaching Foundation (KSTF) Research Fellowship. Two fellowships were awarded this year, one in science and one in mathematics. Through this grant, Doctor Cirillo will pursue a study of second year high school teachers teaching proof. She is interested in learning about the proof-related discourse practices of beginning geometry teachers. She is also interested in studying the ways in which a professional development experience provides teachers with tools designed to engage students in proving mathematical statements. KSTF Research Fellowships support early career scholars engaged in critical research relevant to the mentoring and retention of high quality mathematics and science teachers.

Graduate students Michael Cromer, Jiahua Tang, and Chris Castillo receive fellowships

Department of Mathematical Sciences graduate students **Michael Cromer, Jiahua Tang,** and **Chris Castillo** have all received competitive fellowships from the University of Delaware's Office of Graduate and Professional Education. All three fellowships provide financial support allowing these students to focus entirely on coursework and research. Michael Cromer, a student of Professor Pamela Cook, has received a University Dissertation Fellowship and will spend the year completing his dissertation on complex fluids. Jiahua Tang, a student of Professor Richard Braun, has received a University Graduate Fellowship and will spend the year working on tear films. Chris Castillo is completing his first year and will spend next year as a University Graduate Scholar. Congratulations to all of these students — we look forward to great things from them in the future!

Where they are now — recent grads head to Oxford, U of M, etc. . . .

Recent years many students received their Ph.D. in Mathematics or Applied Mathematics from the Department of Mathematical Sciences. Graduates from our program have gone to prestigious postdoctoral and tenure track positions at research Universities.

Derek Moulton is heading to Oxford following a postdoctoral position at the University of Arizona. **Kara Maki** is working as an IMA postdoc at the University of Minnesota whereas **Liwei Xu** as a postodoc at the Rensselaer Polytechnic Institute. **Noam Zeev** received a tenure track assistant professor position at Old Dominion University right after his degree. **Rodrigo Platte** holds a tenure track assistant professor position at Arizona State following a successful completion of his postdoctoral research at the University of Oxford. **Craig Culbert** is currently a Visiting Assistant Professor at Franklin and Marshall College. **Todd Gutekunst** is an Assistant Professor at Kings College and **Zeying Wang** is a Postdoctoral Fellow at Ohio University. **Paula Vasquez** is now on a postdoc in the Department of Mathematics at the University of North Caroline at Chapel Hill. **Ang Wei,** Visiting Assistant Professor, University of Rochester.

Many other graduates hold academic positions worldwide and work in industry, commerce and government.

CONGRATULATIONS to all of our GRADS!

Prof. Xiang organizes BIRS workshop in 2011

After successfully organizing a BIRS workshop on "Invariants of Incidence Matrices," **Professor Xiang** is teaming up with **Saieed Akbari, Richard Brualdi, Willem Haemers, Hadi Kharaghani,** and **Behruz Tayfeh-Rezaie** to organize another BIRS workshop on linear algebraic techniques in combinatorics and graph theory during Jan. 30 – Feb. 4, 2011, in Banff, Canada. The main aim in organizing the workshop is to bring together the large and diverse collection of researchers who have made substantial contributions using linear algebra techniques in combinatorics and graph theory, or using combinatorial and graph-theoretic ideas to investigate matrices. It is expected that there will be considerable cross-fertilization of ideas leading to people learning new problems and new applications of linear algebra techniques, and that this will lead to new collaborations and breakthroughs.

Graduate Student Qiang Chen receives travel award from the Finnish Center of Excellence in Inverse Problems

Our graduate student **Qian Chen** is supported by the Finnish Center of Excellence in Inverse Problems Research to participate in the International Workshop on Computational Solution of Inverse Problems to be held at the University of Helsinki, Finland, on June 28 – July 2, 2010. The workshop is aimed at international graduate students and postdoctoral researchers in the fields of mathematics, physics or engineering with an interest towards inverse problems.

Secondary Mathematics Education Program receives National Recognition

The National Council for Accreditation of Teacher Education (NCATE) gave the Secondary Mathematics Education Program at the University of Delaware the status of National Recognized as part of the NCATE 2009–2010 accreditation process for the University of Delaware's teacher education programs. The National Council of Teachers of Mathematics (NCTM) serves as the specialized professional association for this process. National Recognition implies that standards for the preparation of secondary mathematics teachers developed by NCTM have been met to a very high degree by our secondary mathematics education program. The program is recognized through the year of the University's next NCATE accreditation decision seven years from now. Having NCATE accreditation for our teacher education programs allows our students not only to meet the requirements to teach in Delaware, but also to easily meet the requirements to teach in almost any other state in the country.

Prof. Cook re-elected SIAM Secretary

Pam Cook was re-elected Secretary of the Society for Industrial and Applied Mathematics (S.I.A.M.) for a two-year term 2010–2011. S.I.A.M., an international society which "fosters the development of applied mathematical and computational methodologies needed" in application areas, has more than 12,000 individual members and over 500 institutional members including universities and corporations. The (nonprofit) Society oversees and publishes 14 peer-reviewed research journals and as well publishes over 25 research books each year.

UD Team spends fall at IMA

Four department members received support to spend the fall at the IMA (Institute for Math and its Applications), two faculty as long-term visitors (**Rich Braun** and **Pam Cook**), one of our recent Ph.D. students who received a competitive IMA postdoctoral fellowship, **Kara Maki,** and one of our graduate students **Mike Cromer**. The activities for this academic year at the IMA are focused on Complex Fluids and Complex Flows. One of our faculty, Pam Cook, is a member of the organizing committee for the year and was the lead organizer for the first Workshop.

UD student society receives funding from SIAM

The University of Delaware Student Chapter of the Society for Industrial and Applied Mathematics (SIAM) has received a $500 grant from SIAM to support its activities in the 2009–2010 academic year. The SIAM Student Chapter focuses on furthering the application of mathematics to industry and science,

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Mike Cromer, Rich Braun, Kara Maki and Pam Cook will attend the IMA this fall.

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promoting basic research in mathematics, providing an environment in which to socialize and to exchange mathematical ideas, and sponsoring activities that foster interaction between mathematics students and professionals in other fields. Any person interested in mathematics and its applications is eligible for membership, including undergraduate, graduate, and continuing education students. No dues are charged, and members are eligible for free student memberships in SIAM.

Math Education alumna named Delaware Teacher of the Year

Congratulations to Math Education alumna **Mary Pinkston** who won the

Delaware Teacher of the Year title. Mary Pinkston, a former student of our Department, was awarded the title of the Delaware Teacher of the Year. She was chosen out of 20 district teachers of the year. Mary Pinkston teaches mathematics at Brandywine High School and has 17 years of teaching experience. She earned her BA in Secondary Mathematics and Master of Education in Curriculum and Instruction from the University of Delaware.

Prof. Cakoni named to the editorial board of the Journal of Integral Equations and Applications

Congratulations to **Professor Fioralba Cakoni** for having been named an associate editor Journal of Integral Equations and Applications. This is a leading international journal devoted to research in the general area of integral equations and their applications. This journal, founded in 1989, endeavors to publish significant research papers and substantial expository papers in theory, numerical analysis, and applications of various areas of integral equations, and to influence and shape developments in this field.

NSF grant to study mathematics teacher education

A team of mathematics educators across campus received a $2,000,000 grant from the National Science Foundation through the Research and Evaluation on Education in Science and Engineering (REESE) program. The team is formed by **Dawn Berk** (PI), **James Hiebert** (Co-PI), **Tonya Bartell**, **Amanda Jansen**, and **Anne Morris** from the School of Education; **Alfinio Flores** (Co-PI) from the Department of Mathematical Sciences; and **Jon Manon** from MSERC. The five-year project will study two cohorts of teachers from their last year of their teacher preparation program through their first three years of their teaching careers. The purpose of the study is to determine to what extent and under what conditions does the knowledge and teaching skills learned by mathematics teachers prepared at the University of Delaware have an impact on their own students. The insights gained by the study may have an impact on teacher preparation programs as well as induction and professional development programs.

Flores to participate in validation committee for Common Core Standards

Governor Jack Markell, Co-Lead of the Common Core Standards, National Governors Association, invited **Alfinio Flores** to participate in the validation committee for the Common Core Standards Initiative. The validation committee will provide an independent expert review of the college- and career-readiness, and K–12 common core standards. The Common Core Standards Initiative is developing a common core of state standards in English-language arts and mathematics for grades K–12. The first step was to develop the college- and career-readiness standards.

Prof. Rossi teams up with Prof. Shen from CIS to investigate underwater swarming

Prof. Lou Rossi and **Prof. Chien-Chung Shen** from Computer and Information Sciences have recently been awarded a Network Science and Engineering grant from the National Science Foundation to study underwater swarming problem. Social animals (such as packs of wolves, flocks of birds, and schools of fish) that travel in groups often rely on social interactions among group members to make collective movement decisions. In contrast, the integration of advanced computation, wireless communications, and control technologies has facilitated the creation of swarms of wirelessly networked autonomous vehicles (WNAVs), including swarms of aerial, land, or underwater autonomous vehicles, which are envisioned to carry out critical civilian as well asmilitary tasks. Many of the issues unique to autonomous underwater vehicles (AUVs), including low or irregular communication quality and low quality localization information, remain unresolved because of the current high cost of underwater vehicles. However, if underwater vehicles are following the same trendas ground and aerial vehicles, we can expect that AUVs will be ubiquitous in the next decade so effective coordination of AUV swarms is a critical emerging technology that needs to be developed.

Profs. Rossi and Shen have been working together for the last two years on the analysis and design of swarm algorithms for mobile and static communication networks, and have successfully bridged the gap between realistic network features and simplified mathematical models that identify key dynamical features. The aim of this project is to gain a deep understanding of biologically inspired algorithms in noisy environments through mathematical analysis and detailed network simulations. In this project, Profs. Rossi and Shen focus on the design, rigorous analysis and validation of bio-inspired algorithms to control AUV swarms. As case studies for this project, Profs. Rossi and Shen will explore leadership in swarms, swarming in background flows and level set detection, but the mathematical methodology and underlying design principles are generally applicable to a wide class of problems. The $440,000 grant will support an interdisciplinary team consisting of Profs. Rossi and Shen with graduate students from both Mathematical Sciences, and Computer and Information Sciences for the next three years.

Rossi joins Peta-scale cloud computation team

Prof. Lou Rossi has joined forces with a large interdisciplinary team at UD and the National Center for Atmospheric Research (NCAR) to develop new algorithms to perform multiscale computations of cloud physics. The team hopes to achieve computational speeds in the Peta-Flop (10^15 floating point operations per second) regime on some of the

world's fastest computers. The team leader is Prof. Lian-Ping Wang from Mechanical Engineering. In addition to Prof. Rossi, team members include Wojciech W. Grabowski, senior scientist in the Mesoscale and Microscale Meteorology Division at NCAR, Prof. Guang R. Gao, from Electrical and Computer Engineering; Prof. Chandra Kambhamettu from Computer and Information Sciences; Prof. Xiaoming Li, from Electrical and Computer Engineering and Andrzej A. Wyszogrodzki, scientist in the Research Application Laboratory at NCAR. This project will be funded by a $1,000,000 NSF grant and a separate $300,000 grant to NCAR.

The specific aim of this proposal is to capture the essential physics of droplet coalescence coupled to the large-scale fluid dynamics of a turbulent cloud. This type of investigation requires resolving flow features from over lengths scales traversing many orders of magnitude. Performing this type of science requires advances in algorithms and computing hardware. Historic studies covering the last few decades have shown that improvements in scientific computation can be attributed in equal parts to improvements in algorithms and hardware. Prof. Rossi and his graduate student Claudio Torres will bring their expertise on fast algorithms, parallel computing and computational fluids to boost the performance and efficiency of the existing cloud physics model. The team members will work together to take advantage of new hardware paradigms including the use of graphical processing units (GPUs) to boost performance.

Professors Gilbert and Guyenne receive collaborative research grant from NSF

The aim of this proposal, in collaboration with Yvonne Ou at the Oakridge National Laboratory and Mathew Lewis at the University of Texas Medical School, is to provide a mathematical background for understanding the use of ultrasound methodology for osteoporosis diagnosis and to begin the investigations of the dynamics of osteoporosis. To understand exactly what mechanical information of cancellous bone can be extracted from ultrasound measurement, especially in the lower frequency range (< 100 kHz) where effective theory applies, this project proposes to 1) develop accurate both low (< 100 kHz) and high (1–2 MHz) frequency ultrasound models for the isonification of cancellous bone, 2) test these models by solving the inverse acoustic model for the e ective bone parameters and compare with experimental results and 3) correlate microscopic bone parameters with macroscopic parameters using the methods of dehomogenization. Two different mathematical approaches are applied in order to go beyond periodic microstructure: one by variant of Tartar's method of oscillating test functions, the other by stochastic-two-scale homogenization.

Professor Monk inducted as member of Phi Kappa Phi

On May 8, 2009, **Professor Peter Monk** was inducted as a member of the Phi Kappa Phi Honor Society. The Honor Society of Phi Kappa Phi is the nation's oldest, largest, and most selective all-discipline honor society. The University of Delaware's chapter was the fifth chapter founded. Now, the society boasts over 300 chapters worldwide.

Professor Cook gives Lighthill Lecture

Pam Cook, Prof. of Mathematics, Associate Dean of Engineering with a secondary appointment in Chemical Engineering, gave the I.M.A. Lighthill Lecture at the British Applied Mathematics Colloquium this April in Nottingham, UK. Her talk was titled "Steady and Transient Flows of Entangled Fluids" This lecture, supported by the I.M.A. (Institute for Mathematics and its Applications) in the UK is given each year at the BAMC in memory of its founding President, Sir James Lighthill. The British Applied Mathematics Colloquium is the premier multidisciplinary annual applied mathematics meeting in the UK attracting over 300 participants each year. Originally founded as the British Theoretical Mechanics Colloquium in 1958 by Sir James Lighthill, the meeting has broadened to cover all aspects of interest to applied researchers." Sir James Lighthill followed Dirac and preceded Hawking as the Lucasian Professor of Mathematics at Cambridge, later becoming Provost of University College London. Lighthill's contributions were to the areas of airfoil theory, supersonic flow, aeroacoutstics and especially kinematic waves.

Ivar Stakgold and Pam Cook elected as SIAM Fellows

The Department has not one but two SIAM fellows! **Professor Emeritus Ivar Stakgold** and **Professor Pam Cook** are newly elected fellows.

According to the SIAM press release "The Society for Industrial and Applied Mathematics (SIAM) is pleased to announce the SIAM Fellows Class of 2009 and the inauguration of the SIAM Fellows Program. Fellowship is an honorific designation conferred on members distinguished for their outstanding contributions to the fields of applied mathematics and computational science. During this inaugural year of the program, SIAM will confer Fellows status on 183 noteworthy professionals who will be recognized during the 2009 SIAM Annual Meeting in Denver, Colorado. Many faculty in the Department of Mathematical Sciences are actively pursuing research in applied mathematics. This has been a hallmark of the Department since at least 1975 when Ivar Stakgold became chair. Under his leadership, the Department expanded in applied mathematics and gained a strong reputation in this area. During his final years as chair, Ivar was elected President of SIAM in 1988 and served as President for two years from 1989–90.

As Chair from 1992–2000 Pam Cook continued the emphasis on applied mathematics in the Department, but with the added goal of promoting ties with industry. Pam is now Secretary of SIAM and also served as the editor in chief of the SIAM Journal on Applied Mathematics for a number of years. This journal is one of the premier journals in applied mathematics.

In view of the Department's reputation for excellence in applied mathematics research, it is wholly appropriate that members of the Department occupy leadership roles in the applied mathematics community. The Department is delighted to see that Pam and Ivar's excellent service contribution has been recognized by SIAM.

Pam Cook to be the 2009 E. Arthur Trabant award winner

Mathematical Sciences faculty member **Pam Cook** is the 2009 E. Arthur Trabant Award for Women's Equity winner. Prof. Cook has been working on diversity issues with the College of Engineering, as well as on women's issues campus wide in part in her part-time role as Associate Dean of Engineering. Prof. Cook served as Chair of the university's Commission on the Status of Women for a number of years and more recently, along with Michael Chajes (Dean, College of Engineering), Tom Apple (Dean, College of Arts

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and Sciences) and Kate Scantlebury (Prof. Department of Chemistry and Biochemistry) is a co-PI on an NSF ADVANCE grant focused on improving the climate for women faculty in STEM fields. She was also a member of the UD President's Task Force on Diversity.

According to the UD web page "The E. Arthur Trabant Award for Women's Equity is given annually to any individual, department, administrative unit, or committee who has contributed to equity for women at the University. The Commission defines "contributions" broadly to encourage as wide a range of nominations as possible, but examples might include developing exemplary programs or curricula, implementing innovative policies and procedures related to women's equity, and enhancing existing services to women."

The Department strives to be a welcoming environment for women and Minorities, and we congratulate Pam on her award.

President Patrick Harker, Pam Cook and E. Arthur Trabant

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the Seminar of Stochastic Processes in Orlando, Florida this spring. He has gained lots of teaching experience during his time at UD as well, both as a teaching assistant and a lecturer. In spring 2009, he enrolled in the statistics program and started pursuing his minor degree in Statistics.

During his time in graduate school Zunlei has picked up playing basketball as a hobby. He is considering careers in both academia and industry, where he can be a problem solver using his knowledge in probability and statistical analysis. When asked about role models that have influenced his interest in Mathematics, Zunlei enthuses about his adviser, Prof. Wenbo Li: "I look to him as a role of model for his diligence, passion and dedication to his work."

The **Mathematical Problems** in **Industry** Workshop 2009

Pak-Wing Fok

The 25th Annual Mathematical Problems in Industry Workshop (MPI09) was held June 15–19, 2009 at the University of Delaware. Participants in the workshop came from all over the United States, the United Kingdom, Canada and India. Oxford University, Rensselaer Polytechnic Institute, Louisiana State University and, of course, University of Delaware were especially well represented.

The workshop presents an opportunity for scientists in Industry to present problems to the Applied Mathematics community. It also provides a way for companies to obtain cost-effective consulting and to gain access to scientists from universities and national labs. In return, academics get a glimpse into the problems that workers in industry must face under practical, non-ideal conditions. This year, five problems were presented by representatives from Industry. The problems were mathematically diverse and were drawn from medicine, engineering and computer science.

John Abbot from Corning Incorporated presented a problem involving the flow of viscoelastic ceramic pastes. Dr. Uwe Beuscher from W. L. Gore and Associates presented a filtration problem described in terms of fluid flow through a regular network of tubes. Ferdinand Hendriks from Hitachi Global Storage Technologies presented a fluid mechanics problem that was important in the engineering of hard drives. Dr. Fern Hunt from the National Institute of Standards and Technology presented an optimization problem important in regulating Internet traffic. Finally Dr. Nowwar Mustafa from Chistiana Care Health System discussed the need for a mathematical model of atherosclerotic plaques.

During the first morning, the five presenters outlined their problems. The participants divided themselves into five working groups, each headed by the presenter. The brainstorming sessions were punctuated by regular coffee breaks. Lunch was provided for all participants and the first day ended with a banquet in a local Chinese Restaurant. At the end of each day, one member of each group informally reported the progress of his/her group to all the workshop participants. At the end of the fifth day, proposed solutions were presented in slideshow format for each of the five problems. After the workshop, written reports are submitted to the presenters. More Information about MPI09 can be found at www.math.udel.edu/MPI.

A Brief History of Our Department

The origin of what is now the Department of Mathematical Sciences certainly is coincident with the emergence of the University of Delaware itself from the original Newark Academy. Through the Second World War and into the 1950s the University remained, like the town of Newark itself, a relatively small institution. The University had less than 4,000 undergraduates, with small graduate programs and only a handful of Ph.D. programs. Main Street and Delaware Avenue had two-way traffic; Delaware's connection with New York, Philadelphia and Washington was then Route 40.

At the time, we were called the Department of Mathematics and Astronomy. We were housed, along with Biology and Psychology, in Wolf Hall, and were primarily a service department. Our responsibility was to provide instruction in mathematics and statistics to the university community and, particularly, to the College of Engineering. Graduate instruction was confined to Master's level courses, and the graduate students in that program came primarily from what were then small regional colleges. A handful of students from local industry and from Aberdeen Proving Ground in nearby Maryland took graduate courses at night.

Between the World Wars, the Department was led by Carl J. Rees who served as Chair for ten years and then held, simultaneously, the positions of Dean of the College of Graduate Studies and Provost of the University. He received an honorary D.Sc. from Franklin and Marshall College in 1950 and was awarded the Medal of Freedom by General H. H. (Hap) Arnold for his service to the country during both World Wars, having made significant contributions to what is now known as Operations Research.

From 1951 to 1965 G. Cuthbert Webber led the Department and oversaw its growth from a handful of faculty, essentially one faculty member in each of the areas of Algebra, Analysis, Differential Equations, Mathematics Education, Numerical Analysis, and Topology, complimented by two statisticians, one "theoretical" and one "applied." At this point, the department had been renamed the Department of Mathematics, the astronomers having left the group to join the Department of Physics.

As well, the Department moved to the newly constructed Sharp Laboratory, sharing that building with what had become the Department of Physics and Astronomy. That proximity led to many productive exchanges and even to joint seminars.

Sputnik went up in 1957, and, along with the University, the Department expanded. Teaching loads, typically four courses in the early part of the decade, were reduced to accommodate the increasing emphasis on research. Teaching loads for those active in research were reduced to two, one typically a large lecture with some as large as 200 students. At that time, there were significant contacts with both industry and with research programs at the Aberdeen Proving Grounds.

In 1965 the statisticians left the Department to join the newly formed Department of Statistics and Computer Science. It was in that year that Bert Weber stepped down and Russell Remage Jr., our sole topologist at the time, became Chair. It was at this time as well that the major effort of the first half of the 1960s to develop a Ph.D. program came to fruition. With a small although growing faculty (typically one or two new junior appointments each year) it was necessary to concentrate effort, and so emphasis in the doctoral program was placed on Complex Analysis and Applied Mathematics.

The budding doctoral program received a great boost when Remage negotiated with the Unidel Foundation to establish the Department's first Unidel Professorship, which was held, first, by a distinguished complex analysis, Malcom Robertson, who came to Delaware from Rutgers. He, together with the complex analysts already on the staff, quickly established a widely recognized center for the study of univalent functions.

In 1968 Ralph Kleinman joined the Department as an Associate Professor, having worked at the Radiation Laboratory of the University of Michigan. Others from the University of Michigan soon joined him and became the kernel of a major research interest in Acoustic and Electromagnetic Scattering Theory, a departmental research interest, which continues to the present day. Ralph's many contacts in government laboratories contributed greatly to the idea that external connections with government and industrial programs could be of great benefit to the overall research program of the Department.

Willard Baxter became Chair in 1970 and the Department and its programs continued to flourish under his leadership. Despite the demands of duties of the chairmanship, including some tough tenure decisions, Will managed to continue his research program and supervise Ph.D. students. He also put together a young team of algebraists around whom our current program in Algebra and Combinatorics was built.

Pictured are, from left to right, Ed Bloch (SIAM Manager), Ivar Stakgold, Dean Helen Gouldner, and Ralph Kleinman (deceased, Professor of Mathematical Sciences).

The year, 1975, was another year of big change in the history of the Department. That year, Robertson retired, Baxter stepped down as Chair, and Robert P. Gilbert, an expert in complex variables and partial differential equations, was hired to replace Robertson as Unidel Chair. Ivar Stakgold, then Chair of the Department of Engineering Sciences at Northwestern, came to Delaware to replace Will Baxter. As part of the nego-

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tiations, he persuaded the University to add an as yet unplanned fifth floor to what was to be Kirkbride Hall, and to move the department out of Sharp Laboratory. That move worked well for our colleagues in Physics and Astronomy, as they were able then to persuade the Bartol Foundation, previously at the Franklin Institute in Philadelphia, to move to the University.

Bob Gilbert came to the Department from Indiana University. Besides his prolific research output, Bob brought with him the journal he had founded, Applicable Analysis. Soon after, he founded the Journal of Complex Variables: Theory and Applications and remains an editor of both journals today.

The appointment of Ivar Stakgold as Chair coincided with the push at the University for significant increases in outside funding. During his tenure as Chair, research funding did increase significantly and several other notable developments took place. In the late 1970s senior faculty were hired, notably Adi Ben-Israel, who helped to initiate the Operations Research Program, David Colton, and Zuhair Nashed, who all increased the profile of the Department.

Gilbert founded the Institute of Applied Mathematics within the Department and served as its director. In 1982, a comprehensive rating of Graduate Programs in Mathematics by the Conference Board of Associated Research Councils recognized the significant improvement in the quality of our graduate programs and ranked the faculty's scholarly quality just above that of Georgia Tech.

In 1977 we moved to the fifth floor of the new Kirkbride Office Building (later renamed Ewing Hall), along with History and the Department of Anthropology. Soon, we overflowed and some members of the Department had to be housed in other buildings on campus. Eventually we all returned to Ewing Hall when the departments of History and Anthropology moved out.

In the early 1980s, Ivar proposed the creation of a Division of Mathematical Sciences to be composed of the two existing departments of Mathematics and of Statistics and Computer Science, together with the program on Operations Research. While Computer Science remained a separate department, the statisticians rejoined us and we became the Department of Mathematical Sciences better to reflect the breadth of the programs that we offered. It was at this time that the well-known probabilist Marcel Neuts joined our department.

These years were also a period of increased contacts with national and international research mathematicians and statisticians. Likewise, we saw an increase in graduate students from abroad as well as post-doctoral students and visiting faculty from Africa, Asia, Australia, New Zealand, and Europe, particularly with Holland, Denmark, Germany, France and Italy. Some gave lecture series that were published under the auspices of the Institute of Applied Mathematics.

Ivar Stakgold stepped down from the chairmanship in 1991 and L. Pamela Cook, who had come to the Department in 1983, served as our first female Chair, holding that position from 1992 to 2000. She continued the emphasis on Applied Mathematics but with the added goal of reestablishing and expanding ties with industry. Several of the appointments to the faculty at the junior level were made with this goal in mind. She and Ivar (who, after his tenure as Chair became the President of the Society for Industrial and Applied Mathematics) have been recently recognized by SIAM for outstanding contributions to the applied and computational science community and were named Fellows of the Society.

The Department continued, and continues, to grow and change with the advent of new programs for students and the evolving research interests of the faculty. The Department has been led into the 21st century first by Philip Broadbridge and now by Peter Monk. The newest program in Quantitative Biology is but one of the changes in our teaching and research programs that continue to evolve. We believe that they are built on a strong historical commitment of the Department to interaction with other disciplines and other institutions.

— Tom Angell

Acknowledgment: This short history relies heavily on a previous version prepared by Richard Weinacht. I have borrowed liberally from his manuscript. I take full responsibility, however, for any errors.

Mathematics Education: Educating the educators

Alfinio Flores

Mathematics Education is an important endeavor and component of the Department of Mathematical Sciences. The department has a long tradition of excellence and innovation in undergraduate mathematics, for example, the incorporation of electronic technology as part of the regular teaching of mathematical courses. One of the traits of the department is not only its focus on research but also close attention of faculty to undergraduate teaching.

The department has also a tradition of involvement of both tenure-track and continued-appointment faculty in schools and in the professional development of mathematics teachers, mainly at the high school level. In addition, tenure-track faculty members in mathematics education carry out their nationally-recognized scholarly and research programs in mathematics education. Dr. Jinfa Cai focuses on national and cross-national studies of teaching and curriculum. He is also interested in cognitive studies of teaching and learning mathematics, mathematical assessment, problem solving, and teacher education. Dr. Michelle Cirillo's interests are on issues related to teachers' development, focusing on classroom discourse and proof (see an expanded description of her work in the new faculty hire section). Dr. Alfinio Flores focuses on teacher preparation, use of technology in the teaching of mathematics, and issues of diversity. In addition to being highly productive individually, faculty in mathematics education have common interests that propitiate collaboration among them. Also, their work has relevance for the undergraduate program.

The undergraduate program in mathematics education has grown in the last few years, and is now the biggest in the department; almost half of the majors in the department are future secondary mathematics teachers.

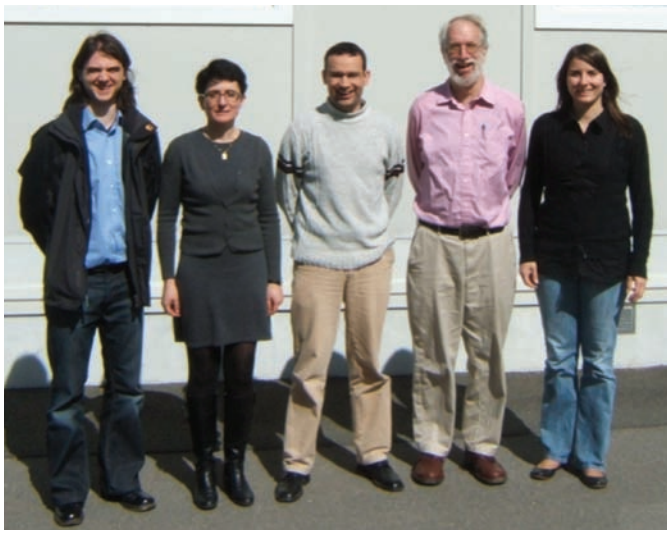
Faculty in mathematics education also collaborate closely with colleagues housed in the School of Education in joint research projects and course development. We expect these collaborations to become more institutionalized in the near future through joint mathematics education programs.

Research Alliance formed with **École Polytechnique, France**

David Colton

A collaborative program has recently been established between research teams in the Department of Mathematical Sciences at the University of Delaware and the Department of Mathematics in the Ecole Polytechnique in Paris, the premier scientific institution in France. This program will focus on the use of qualitative methods in electromagnetic inverse scattering theory and will last for five years with funding being provided by the French "Institut National de Recherche de Informatique en Automatique" (INRIA). In particular, funding will be available for the exchange of graduate students, postdoctoral students and faculty members during this period. The research team at Delaware is headed by Professor Fioralba Cakoni and at the École Polytechnique by Dr. Houssem Haddar.

The collaboration between the inverse scattering group of F. Cakoni, D. Colton and P. Monk at the University of Delaware and H. Haddar at INRIA was initiated by the appointment of Dr. Haddar to a Post-Doc position at t he University of Delaware in 2001 followed by continuous collaboration since then. This collaboration has been intense and fruitful: it has led to the development of the linear sampling method in inverse electromagnetic scattering theory, the introduction of the gap reciprocity method for the detection of buried objects and an investigation of the basic theory of transmission eigenvalues and their application in electromagnetic inverse scattering theory. The research team at Delaware together with Dr. Haddar at INRIA has now become recognized as among the leading researchers in the world in the emerging field of qualitative methods in electromagnetic inverse scattering theory. The present program between the research groups at the University of Delaware and the Ecole Polytechnique is designed to encourage further progress in this field as well as to facilitate interaction with the active optimization group at the Ecole Polytechnique.



"The Usual Suspects": Members of Ecole Polytechnique–University of Delaware team: A. Lechleiter (EP), F. Cakoni (UD), H. Haddar (EP), D. Colton (UD), A. Cossonniere (EP)

Under the auspices of this collaborative program, University of Delaware graduate student Qiang Chen has visited Ecole Polytechnique twice and Anne Cossonniere from Ecole Polytechnique has visited the University of Delaware once. In addition there has been frequent exchange visits between Delaware and Paris by professors Cakoni, Colton and Haddar. In March 2010, there will be a workshop at Ecole Polytechnique devoted to inverse problems in wave propagation which is organized by the leaders of the research team together with Dr. Armin Lechlester at Ecole Polytechnique.

In Memoriam . . . **Clifford W. Sloyer, Professor Emeritus**

Clifford Sloyer, who became the Assistant Chairperson and Acting Chairperson of the Department of Mathematical Sciences several times during his tenure at the University of Delaware, passed away on November 4, 2009. He came to the department in 1964 continuing his research in Topology with an interest in sheaf theory. He also worked in the areas of complex analysis and non-Hausdoff compactifications. Later, he turned to secondary mathematics education to which he devoted most of his efforts in recent years. He organized several national and international conferences and wrote many articles and texts about education. His book, Fantastiks of Mathematiks: Applications of Secondary Mathematics is considered a representative work on mathematical modeling in secondary mathematics. The proceeds from the calculus text, Calculus and Probability, written with W.E. Baxter, enabled the funding of the Baxter-Sloyer Graduate Teaching Award. In both teacher professional development and development of teaching materials, his unique perspective made challenging mathematics meaningful for both students and teachers. Many of his students (now teachers) recall how his problems "seemed impossible to solve, and yet you were compelled to spend hours on them until you found an 'eloquent' solution." From his course on "Proof" to his well-known "Snowplow" and "Lawn Mower" problems, his students remember his high standards and continuing influence on their classroom instruction. In 1997, he was awarded the G. Cuthbert Webber Award for Achievement in Mathematics Education. He is fondly remembered by many faculty, former students and alumni.

— Bettyann Daley

Thanks for all the contributions to this article by faculty and alumni.

A **Long-Standing Math Problem Solved**

The Green-Tao Theorem

Felix Lazebnik

The last twenty years lavished mathematics with incredible presents: many oldstanding problems were solved. The most famous of them are Fermat's Last Theorem and Poincaré's Conjecture. Among other victories is the problem described below. I never thought it would be solved in my lifetime.

A positive prime number is a positive integer greater than 1 whose only positive divisors are 1 and the number itself. The first nine positive primes are:

$$2, 3, 5, 7, 11, 13, 17, 19, 23$$

Questions about properties of primes have fascinated people from the inception of mathematics, and many of them are still not answered. A question which was answered recently relates to primes forming arithmetic progression.

Consider an arithmetic progression (AP):

$$a, a + d, a + 2d, \ldots, a + nd, \ldots n \geq 0.$$

In this note we assume that a and d are positive integers.

Once someone asked: **can all terms of an AP be prime numbers?**

It is not hard to argue that one cannot have an *infinite* AP with all terms being prime numbers. Therefore we consider only finite APs. For some small number of terms the answer is yes:

$$2$$
$$2, 3$$
$$3, 5, 7$$
$$5, 11, 17, 23$$
$$5, 11, 17, 23, 29$$
$$7, 37, 67, 97, 127, 157$$
$$7, 157, 307, 457, 607, 757$$
$$\ldots,$$

but longer examples are hard to find:

$$5749146449311 + 26004868890 \cdot n : n = 0, \ldots, 20$$

$$11410337850553 + 4609098694200 \cdot n : n = 0, \ldots, 21$$
(Moran, Pritchard, Thyssen (1995))

$$56211383760397 + 44546738095860 \cdot n : n = 0, \ldots, 22$$
(Frind, Underwood, Jobling (2004))

At this stage the existence of APs with even 24 prime terms is not clear. Nevertheless, based on very few initial examples and some heuristics, it was conjectured at least a century ago that

Conjecture 1: *There are arbitrarily long APs of primes. In other words, the set of all positive primes contains arbitrarily long APs.*

Conjecture 1 should not be confused with a famous result of Dirichlet (1837): any infinite AP with a and d having the greatest common divisor 1 contains infinitely many primes. Dirichlet's theorem can be considered as a generalization of a great theorem of antiquity: there are infinitely many primes ($a = d = 1$).

Though Conjecture 1 withstood a century, several results on APs in certain subsets of integers were obtained. In order to discuss these results we need the notion of density.

Let A be a subset of positive integers. The density of A, $d(A)$, is defined as

$$d(A) = \lim_{n \to \infty} \frac{|\, A \cap [1, n] \,|}{n}$$

if the limit exists. The fraction $|\, A \cap [1, n] \,|/n$ represents the proportion of members of A among the first n integers. For example, if A is the set of all odd (or all even) positive integers, $d(A) = 1/2$. Moreover, if A is an infinite AP with common difference d, then $d(A) = 1/d$. If P is the set of all positive primes, $d(P) = 0$. This nontrivial result was first obtained by Legendre in 1798. About a century later, it was shown by de la Valle-Poussin, and by Hadamard, that for large n, $|\, P \cap [1, n] \,|/n$ behaves like $1/\ln n$, which also implies that $d(P) = 0$.

In 1927 van der Waerden proved that if the integers are coloured using finitely many colors, then one of the color classes must contain arbitrarily long APs. Which color class? Though it is reasonable to suspect that it should be one of positive density (such class must exist), van der Waerden's theorem did not imply it. In relation to APs of primes, Van der Corput (1939) proved that there are infinitely many APs of primes of length 3. A theorem of Roth (1956) extended Van der Corput's result to all subsets of integers of positive density, and Szemerédi, using combinatorial ideas, extended Roth's result to APs with 4 terms in 1969. Finally, in 1975, Szemerédi proved that any subset of integers of positive density contains arbitrarily long APs. This was achieved by an ingenious and complicated extension of his previous combinatorial argument. Unfortunately, as the density of primes is 0, Szemerédi's theorem does not imply Conjecture 1. What was needed is the extension of Szemerédi's theorem to sparse sets, in particular to some sets of density 0. Such an extension had to wait until 2004.

Green-Tao Theorem (2004): *The set of all primes contains arbitrarily long APs.*

Actually they proved a more general statement, that not only do the primes contain arbitrarily long APs, but so does every sufficiently dense subset of primes. The proof is hard, and is based on the ideas and results from several areas of mathematics, e.g., analytical number theory, combinatorics, pseudorandomness, harmonic analysis, ergodic theory. The paper was published in *Annals of Math.* 167 (2008), 481–547.

As we all know, the existence of an object in mathematics does not imply that its explicit construction is known. Though Green-Tao theorem does not tell us how to find long APs of primes, it encourages one to keep looking for such a method. So far, the only progress in this direction was a construction of APs of primes of length 24 and 25:

$$468395662504823 + 205619 \cdot 223092870 \cdot n, n = 0, \ldots, 23$$
(Wróblewski (2007))

$6171054912832631 + 366384 \cdot 223092870 \cdot n, n = 0, \ldots, 24$
(Wróblewski, Chermoni (2008))

We finish this note with another beautiful conjecture of Paul Erdős of 1936.

Conjecture 2: *Any set of positive integers whose sum of reciprocals diverges contains arbitrarily long APs.*

As the sum of the reciprocal of positive primes diverges (Euler, 1737), this conjecture implies the Green-Tao theorem. At this time Conjecture 2 is totally open: it is not even known if such a set must contain an AP with three terms!

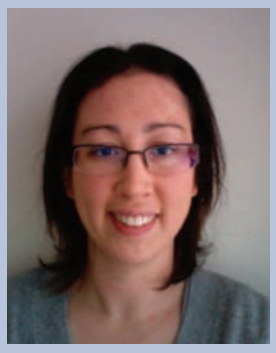
New Hires

Pak-Wing Fok joins us as a tenure track assistant professor. He received his Ph.D. from MIT in 2006. He did his undergraduate degree at Imperial College London. Before joining the University of Delaware, he held joint positions at Caltech as a Von Karman Instructor in Applied and Computational Mathematics and at UCLA as a postdoctoral scholar in the Department of Biomathematics.

Pak-Wing's interests are in Mathematical Biology and mathematical aspects of Materials Science. He is currently working on a wide range of problems in quantitative biology including kinetic models of protein folding and phenomenological models of so-called Vulnerable Plaques. Vulnerable Plaques (VPs) are atherosclerotic plaques that are prone to mechanical rupture. When this occurs, thrombogenic agents are released into the bloodstream, often resulting in a heart attack. Being able to diagnose and predict the behavior of VPs is therefore an important medical problem and a quantitative description of them is currently lacking.

In his free time, Pak-Wing enjoys performing and listening to classical music. He is particularly keen on playing Chopin and Rachmaninov on the piano. He also likes to participate in choral groups and spent several years as a member of the MIT Concert Choir and the Caltech Glee Club.

Dr. Michelle Cirillo joins us as a tenure track assistant professor. She received her Ph.D. from Iowa State University in 2008. Michelle's research interests include proof, classroom discourse, and teachers' use of curriculum materials. She is especially interested in the space where these three areas intersect. As a co-PI on a collaborative NSF Discovery Research K–12 (DRK12) grant, Michelle is working with researchers from Michigan State University to develop materials to help secondary mathematics teachers improve their classroom discourse. A goal of this work is to help teachers facilitate reasoning, argumentation, and proof in their classrooms. Michelle is a co-editor and contributor of the book "Promoting Purposeful Discourse." Last semester, Michelle's publications included an article in the proof focus issue of "Mathematics Teacher" as well as a series of three co-authored articles related to mathematics curriculum vision. She has an article about teachers' framings of mathematicians coming out in "School Science and Mathematics" this year. Her personal interests include traveling and outdoor activities.



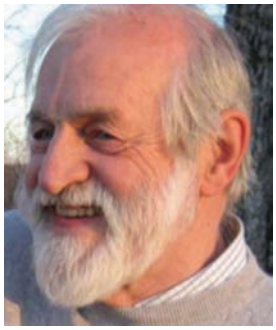
Dr. Allison Kolpas joined the department as a Unidel Postdoctoral Fellow. She did her undergraduate work at U.C. San Diego and received her Ph.D. from U.C. Santa Barbara, in 2008. Before joining the University of Delaware, she was a researcher in the department of Ecology, Evolution, and Marine Biology at U.C. Santa Barbara. Allison Kolpas' research interests are in mathematical biology with an emphasis on modeling and numerical methods for swarming and population dynamics. Her thesis work focused on the development of coarse-grained numerical methods to efficiently characterize population-level processes from individual-based models of swarming. In her free time, Allison enjoys traveling, music, movies, and cooking.

Tao Feng joins us as a UniDel Postdoctoral Fellow. He received his Ph.D. degree in 2008 from Peking University, China. He was a research fellow at Nanyang Technological University, Singapore before he joined the Department. His research interest is mainly on algebraic design theory, which is the study of combinatorial objects with algebraic tools. The Difference Set is the central object in the study of algebraic design theory, and Tao has made some progress on the multiplier conjecture about difference sets in his thesis. In his spare time, Tao enjoys music and sports.

Chester Weatherby, a recent Ph.D. graduate, joins us as a visiting assistant professor. Chester completed his graduate work at Queen's University in Kingston, Ontario, Canada, in June 2009 under the supervision of M. Ram Murty. Before Queen's, he attended Mount Allison University which is located in Sackville, New Brunswick, Canada. Chester's research is in Number Theory where he studies special values of certain functions, including the Riemann zeta function, and L-functions. In his first year at UD, Chester taught courses from the Calculus sequence and is slotted to do so again in 2010–11.

Professor Murray delivered the **Carl J. Rees Lectures**

Gilberto Schleiniger



Professor James D. Murray of the University of Oxford (UK) and the University of Washington (USA) was the lecturer for the Department of Mathematical Sciences Carl J. Rees Distinguished Lecture Series in the fall of 2009.

Professor Murray is a distinguished mathematician whose pioneering work in mathematical biology, including mathematical modeling in medicine, psychology, ecology, epidemiology and developmental biology has earned him many accolades. Prior to coming to the University of Washington, he was Professor of Mathematical Biology and Director of the Centre for Mathematical Biology at the University of Oxford. An endowed chair, the James D. Murray Chair of Applied Mathematics in Neuropathology, in perpetuity, was established 2006 at the University of Washington in his honor.

In 2009 he was awarded the Bakerian Medal and Prize Lecture, the London Royal Society's premier lecture in the physical sciences. It originated in 1775 through a bequest by Mr. Henry Baker FRS, of £100 for an oration or discourse which was to be spoken or read yearly by one of the Fellows of the Society 'on such part of natural history or experimental philosophy, at such time and in such manner as the President and Council of the Society for the time being shall please to order and appoint'. Among his many other honors are: Guggenheim Fellow 1968; Fellow of the Royal Society (Edinburgh) 1979; Fellow of the Royal Society (London) 1985; Fellow of the Institute of Biology (Great Britain) 1988; Foreign Member of the Academy of Sciences (France) 2000; London Mathematical Society Naylor Prize for Applied Mathematics 1989; President, European Society for Mathematical and Theoretical Biology 1991–1994; invited speaker, ICIAM 1991; Okubo Prize 2005; Honorary Member, Edinburgh Mathematical Society 2008; Institute of Mathematics and its applications (IMA, UK) Gold Medal 2009 Summer Lecture. Honorary degrees: D.Sc. University of St. Andrews 1994, D.Sc. University of Strathclyde (Scotland) 1999, Dott. Mat. Laurea Honoris Causa, University of Milan (Italy) 2004, D. Maths. University of Waterloo 2006. Honorary Fellow, Corpus Christi College, University of Oxford 2000. Visiting Professorships: National Tsing Hua University 1975; University of Florence 1976; University of Utah 1979; Massachusetts Institute of Technology 1979; University of Heidelberg 1980; California Institute of Technology 1983; Los Alamos National Laboratory 1985; University of Angers, 1993; University of Paris, 1994, 1995, 1996 and others.

As part of the Rees Lecture Series, Professor Murray delivered two lectures that attracted a diverse audience of students, faculty and other members of the University community. His first lecture, "The Marriage Equation: A practical theory for predicting divorce and a scientifically based marital therapy," addressed the issue of predicting marriage success or failure, and how effective therapies can be developed for marriage counseling. It was attended by mathematicians, psychologists and other scholars, and it was very well received. His second lecture, "On the Growth of Brain Tumors: enhancing imaging techniques & highlighting inad-

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International Conference Honoring **Gary Ebert**

The international conference on Designs, Codes and Geometries took place during March 28 to April 2, 2010. The conference featured nine invited 50-minute talks, and 20 contributed talks, covering a wide range of topics in designs, codes and geometries. Many important research advances were reported in the talks and the informal discussions have been fruitful. We are especially glad to see many young researchers from many different countries, such as, Canada, China, Belgium, Italy, and the U.S., during the conference. We also used the conference as an opportunity to honor the scientific work of Gary Ebert, who has made important research contributions to the three areas mentioned above. The conference was financially supported by NSF, NSA and the Department of Mathematical Sciences of University of Delaware.

2010 Student Award Recipients

The **Baxter-Sloyer Graduate Teaching Award** presented graduate teaching assistants in mathematical sciences who have demonstrated superior effectiveness in teaching and in the performance of their responsibilities was awarded to ***Matthew Zumbrum.***

The **Stephen J. Walf Memorial Scholarship** awarded to a student entering the senior year majoring in mathematics who has demonstrated both love and talent for the subject was awarded to ***Patrick Devlin.***

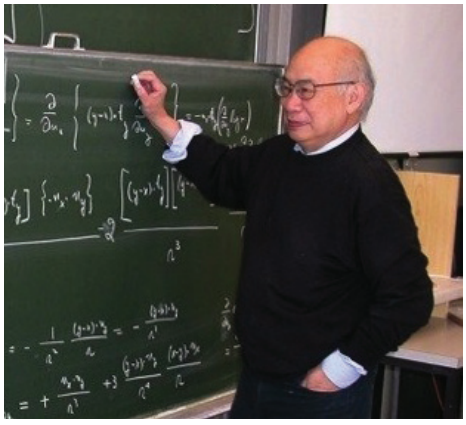
The **William D. Clark Prize** presented only when a senior majoring in mathematics has unusual ability in the area is awarded to ***Michael Tait,*** who is acknowledged by the Department as the best graduating senior.

The **Faculty Recognition Award** given to a graduating senior who has excelled in mathematics and has contributed valuable service to the department is awarded to ***Michael Bauer.***

Celebrating the **75th birthday** of **Prof. G. C. Hsiao**

The conference "Advances in Boundary Integral Equations and Related Topics" was held at UD from Aug. 7–9, 2009 in honor of the 75th birthday of Prof. George C. Hsiao. More than 50 mathematicians attended this international event to celebrate his career achievements and pioneering contributions to the analysis of boundary integral equations. The speakers and organizing committee members represented at least 10 countries, including world-renowned experts such as Weng Cho Chew (Hong Kong/USA), Vladimir G. Maz'ya (UK/Sweden), Jean-Claude Nédélec (France) and Wolfgang L. Wendland (Germany).

George C. Hsiao received his master's degree in civil engineering from the Carnegie Institute of Technology and his Ph.D. in mathematics from Carnegie-Mellon University. He joined UD in 1969 where he is now the Carl Rees Professor of Mathematics. In addition to being the author of more than 150 papers in mathematics, applied mechanics, oceanic environment and biomedical engineering, he has also received a large number of prestigious awards, ranging from the UD's Alison Award to the Humboldt Fellowships. George C. Hsiao is also recognized



as an outstanding teacher and mentor, having supervised 11 Ph.D. students at UD, some of whom have become well-established academics as well.

Emeritus Professor Tutors **High School**

Gary Ebert

Willard Baxter was hired into the Department of Mathematics in 1958. He was then first Ph.D. student of the eminent algebraist I. N. Herstein, and his mathematical work centered on non-associative rings with involution. Most of his research papers were joint work with Jerry Martindale. However, Dr. Baxter's contributions to the department, university, and mathematical community as a whole were extremely diverse and far-reaching. He would probably say that his life-long passion for teaching, and education-related endeavors, drove most of these activities.

Willard was promoted to full professor in 1967 and was department chair from 1970 to 1975, during which time he hired Robert Gilbert as the department's first Unidel Chair Professor. During this same time frame he served for two years as President of the Delaware Council of Teachers of Mathematics (DCTM), a position that introduced him to Bill Geppert, who was the state Superintendent of Mathematics. With Bill's help he obtained sufficient funding from the Dupont Company to start the state's Senior High Math League, an institution in which he remained incredibly active for the rest of his career, and for which he was honored by a DCTM Award in 1992. After stepping down as departmental chair, he became chair of the University Committee on Committees, and was instrumental in writing and getting passed the University Faculty Bylaws, which are still in effect today. At about the same time he took charge of the Delaware Science and Humanities Symposium, which he ran for 10 years. This was a program to encourage high school students to become math and science majors, and was partly supported by Willard's fund-raising activities at both the Dupont and Gore companies. Willard was also AAUP President at the University of Delaware for two years, and was the first President of the Arts and Science Faculty Senate. And all this is in addition to his in-service and pre-service work in math education, for which he received the Webber Award in 1993. These are only a few highlights of his remarkable list of service activities at the university and throughout the state.

Together with Cliff Sloyer, Willard wrote a probability-based calculus book for the biological and managerial sciences. This novel approach made it a popular textbook throughout the country for a number of years. The royalties from its use as a textbook at the University of Delaware were donated to the Department, and these monies were used to endow the Baxter-Sloyer Award, which is given annually to some graduate student in the department for outstanding teaching performance. Willard was also very active in the EPADEL section of the MAA, and held almost every position possible over a 15-year period. These efforts made him the first recipient of the MAA Distinguished Service Award for work in one of the MAA sections.

Upon retirement from the University of Delaware in 1994, he did volunteer work first at the Delaware Museum of Natural History and then at the Tristate Bird Refuge. For the last twelve years he has been volunteering his time, from 7:30 a.m. to 2:30 p.m Monday through Thursday every week of the school year, as a math tutor at Newark High School. During this time he has helped innumerable students pass their high school math courses, and was recently honored by the Delaware *News Journal* in its "25 Who Matter" series. The full *News Journal* article can be found in its February 7, 2010 issue.

Professor Murray, continued from page 18

equacies of current therapies," addressed the issue of therapies for brain tumors based on current imaging techniques, and it was also very well received and attended by a large and diverse audience. In addition to his lectures, Professor Murray met with students in the UD Quantitative Biology major, and with students and faculty of the Delaware Chapter of the Association for Women in Mathematics. His interactions with students and faculty were lively and highly valuable — his engaging personality and genuine interest in interacting with everyone were a treat for everyone who had the pleasure of meeting with him.

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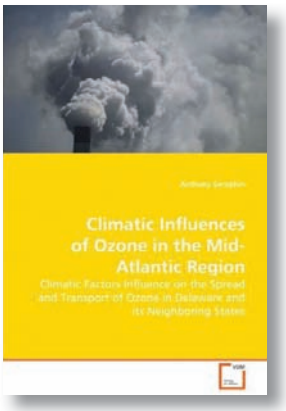
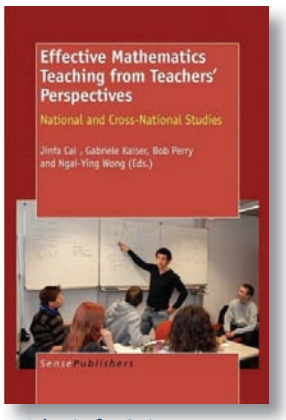
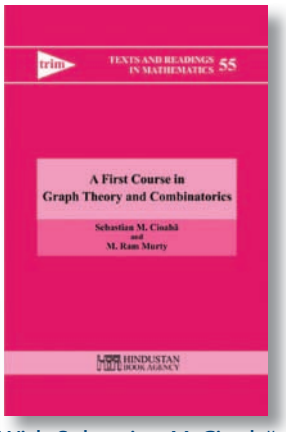
Recently Published Books by Math Department Faculty



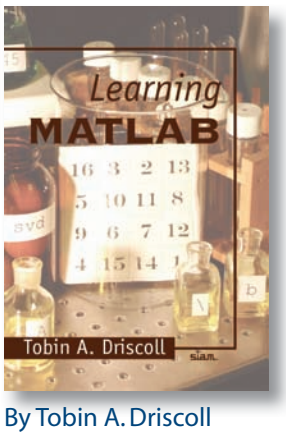
By Anthony Seraphin



With Jinfa Cai



With Sebastian M. Cioabă



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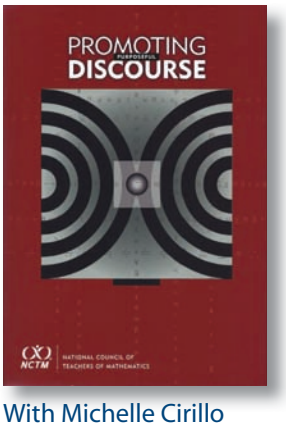

With Michelle Cirillo