New York University

HOLIDAY NEWSLETTER 2005
Volume 3 – Number 1

Courant Institute of Mathematical Sciences

Letter from the Director

Dear Alumni, Colleagues and Friends,

I am writing to you in place of Chuck Newman, who is enjoying a well-earned one-semester sabbatical break; he will be back at the helm as Director this spring semester. He and I thank you all for your interest in and growing support of the Institute.

Faculty recruiting this past year proved very successful. Nine outstanding new faculty are joining us; five have arrived this fall and the remaining four will arrive next fall. Profiles of the newly arrived faculty can be found on Page 4. Their interests span the range of Courant activities, from core disciplinary work to the interdisciplinary uses and applications of Mathematics and Computer Science. Our Core Math group is notably enhanced by the arrival of Scott Sheffield and Yuri Tschinkel this fall and the anticipated arrival of Jinho Baik and Akshay Venkatesh next fall. In the Computation in Science area we have gained Weiqing Ren in Mathematics and Richard Bonneau as an assistant professor of Biology and Computer Science. Daniel Stein is our other interdisciplinary appointment as professor of Physics and Mathematics. Finally, next fall, Jinyang Li and Lakshmi Subramanian will be joining the Computer Science Department, enhancing the systems group by establishing a significant presence in networking.

In a more cautionary vein, I want to mention our concern at the downward trend in federal funding of basic research. While this has not had a significant impact to date, we foresee increasing pressure on our ability to maintain the size of our current Ph.D. student and postdoc cohorts. Of course, this is not affecting the Courant Institute alone; it is a national phenomenon. Why does this matter? Nationally, it reduces the pool of talent that is vital for the continued well-being of advanced industry and science, be it in finance or bio-engineering or a myriad of other industries. Locally, it threatens to stress our programs and research activity.

What can you do? In the long run, achieving and maintaining supportive public opinion is key. Lively opinion pieces in your newspaper can be very effective. It is also important to let legislators know you think support of science is important. More locally, if, as I hope you do, you feel your Courant training was and is valuable, I urge you to support the Institute to the extent you can. To our former Ph.D. students and postdocs, let me say that if you have prospered since your time here, you might consider supporting a current student or postdoc in whole or in part.

While on the topic of fundraising, I would like to mention a couple of activities enabled by your past generous support. Film professionals associated with NYU's Tisch School of the Arts are presently making a documentary about the Institute's history based on interviews with some of our giant figures, currently emeritus faculty, who followed the founders of Richard Courant's generation. We are also finishing the refurbishment of the Commons (a.k.a. the lounge) with new furniture on its way and a new sound system in the planning stages.

Finally, I invite you to stay in touch and let us know what you think, be it by e-mail, mail, or in person. I wish you a joyous holiday season.

Sincerely,

Richard Cole

RICHARD COLE
Acting Director, Courant Institute

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Fall 2005 Puzzle: Professor Hercules and the Hydra Herd

Joel Spencer, Professor of Mathematics and Computer Science, is the author of *The Probabilistic Method* and an expert in random structures and applications of randomness. In his spare time, he is also a puzzle designer; from 1987 to 89 he wrote the puzzle column, "Brain Bogglers" for *Discover Magazine*. Now, he offers you the following brain teaser.

The hydra herd is a formidable enemy for Prof. Hercules. Each hydra has some number of heads. At the first sword stroke ("deletion" for short) a hydra loses one head and then duplicates (starting with a k-headed hydra, yields two (k-1)-headed creatures). The regenerative powers then strengthen; on the next deletion a hydra loses a head and then triplicates. On the n-th deletion a hydra loses a head and then n extra copies of it appear. Moreover, the deletions are counted for the entire herd. Only when a one-headed hydra is deleted does it simply die. Prof. Hercules always deletes a head of the hydra with the least number of heads.

For example, faced with two single-headed and two double-headed (let's write it 2211), Prof. Hercules disposes of the two singles with deletions one and two but deletion three turns a 2 into four 1's, giving 21111. Deletions four through seven leave just 2 standing and deletion eight turns the last 2 into nine singles. These are destroyed one by one. Prof. Hercules's labors end with his seventeenth deletion.

On December 20, 2005 Prof. Hercules walks into his Courant office at 9 a.m. and is confronted with a single four-headed hydra. He applies one deletion every nanosecond. When does he destroy the hydra herd?

Puzzle Solution:

4 becomes 33 which becomes 3222. When Hercules uses his x-th deletion on a two-headed hydra, it becomes $x + 1$ ones which require deletions $x + 1$ through $2x + 1$ to delete. So the first two-headed hydra takes deletions 3 through 7, the second 8 through 17 and the third 18 through 37, leaving one three-headed hydra. Deletion 38 leaves 39 two-headed hydra. The first takes deletions 39 through 79, the second 80 through 161, the third 162 through 325. When is the 39th destroyed? Mathematically, what is the 39th term in the pattern 79, 161, 325, . . .? Each term is double the previous term plus three. Here's a good estimate: the numbers roughly double each time so that would make the 39th term 79 x 2^{38}. But you might think (having taken the right courses at Courant!) of adding three to each term giving 82, 164, 328, ... Now each term is precisely double the previous term so the 39th term is 82 x 2^{38} and therefore the 39th-term of the original sequence is three less, or 22, 539, 988, 369, 405. At a deletion a nanosecond this takes Prof. Hercules roughly 22, 540 seconds, which is six hours, fifteen minutes and forty seconds, leaving time for afternoon tea.

WOWinC a Success for Women in Computing

For more than five years, the United States has experienced a worrying and mysterious decline in the percentage of women studying computer science. To show female students the rich variety of careers in computing, and to provide a venue in which students and professionals with interests in computing could meet and learn from one another, the Courant Institute hosted a workshop called "WOWinC" (Work Opportunities for Women in Computing) on September 23.

The daylong event was coordinated by faculty from nearby universities—Julia Hirschberg (Columbia), Margaret Wright (NYU), Andrea LaPaugh and Jennifer Rexford (Princeton), and Barbara Ryder (Rutgers)—and also by Courant alumna Susan Puglia and Susan Malaika, both of IBM. The approximately 60 participants included students from an array of local universities and colleges as well as women working in academia and industry. WOWinC was sponsored by IBM with additional support from Google.

Caroline Kovac (General Manager, IBM Healthcare and Life Sciences), Jan Cuny (University of Oregon and the National Science Foundation), and Julia Hirschberg (Columbia) spoke about their careers and offered strategic advice on a variety of topics. In lively discussions among themselves and in response to questions from the audience, two panels of current students and recent graduates talked about their widely differing backgrounds and their common enthusiasm for their work. Many informal conversations took place during the extended lunch and an ice cream social at the end of the day.

WOWinC participants were uniformly positive about their experiences. Margaret Wright commented, "As hoped, WOWinC provided exposure to the breadth of opportunities in computing, a chance to meet other women with related scientific interests, and an extraordinary sense of energy." NYU students have already taken the initiative and started to arrange further, smaller events, and to connect with sister organizations at other schools.

Alumna Evelyn Berezin, Computer Science Department Chair Margaret Wright and Carol Kovac of IBM, who was a plenary speaker.

Team of Scientists Under Courant's Bud Mishra Develops Algorithm to Evaluate Genomic Studies of Diseases

The completion of the human genome project opened doors on a whole new generation of genomic studies of diseases like cancer, but it also generated a non-biological quandary: how do we analyze the data from these studies in which tens of thousands of data points may be produced in a single experiment?

Biologists are turning to computer scientists, mathematicians, and statisticians for the answer, and they are particularly keen to have an algorithm that would be statistically robust, efficient, and widely applicable. It is a tall order, but a team of scientists under the direction of Bud Mishra, professor of computer science and mathematics at NYU's Courant Institute of Mathematical Sciences and also professor of cell biology at the NYU School of Medicine, believe it has made progress in developing such an algorithm. The algorithm is particularly useful for scientists studying cancer who are trying to analyze genomic aberrations known as copy number variations. The concept of a copy number variation is very similar to that of a point mutation, which occurs when a single base is either deleted or incorrectly inserted into DNA that is being replicated. A copy number variation is much the same, except that it involves an entire segment of DNA instead of a single base.

Imagine DNA as a book that is being photocopied; the desired outcome is an exact duplicate of the book with all pages arranged in the correct order. If an individual page is accidentally copied two or three or 10 times, there is no change to the text itself, but there is a change in the number of copies of that page. Alternatively, a page might not get copied at all, or a page might be copied once but then get inserted into the wrong chapter. These same mistakes happen in DNA replication as well, with whole segments of DNA being copied a wrong number of times or being copied once but inserted into the wrong location.

The effect of these copy number variations is very interesting to scientists because the changes often amplify or dampen the effects of a gene. Too many copies of a DNA segment will usually result in increased activity of that gene. If the gene is one that promotes cell replication, an increase in copy number might cause the cell to begin dividing excessively, as usually happens with cancer cells. Alternatively, deleting a segment of DNA might result in diminished activity of a gene.

Scientists taking this genomic approach to studying cancer usually use a technique called a microarray, which enables them to compare the entire genome of a cancerous cell to the genome of a normal cell and thereby locate segments of the DNA with copy number variations. However, the data generated from microarrays is voluminous and prone to slight inaccuracies, known as "noise," making statistical analysis necessary.

The algorithm that Mishra's team developed is meant to deal with both the large volume and the slight inaccuracies, using statistical techniques that eliminate the noise and generate very robust and accurate results. It can also be used to compare normal cell genomes to other normal cell genomes, so that scientists can identify copy number variations that are benign, and therefore unrelated to cancer and other diseases.

This is all a part of a trend that Mishra finds very promising. Mathematicians have historically gravitated to subjects like physics and engineering but avoided the life sciences, but the Courant Institute is part of a movement in the opposite direction, toward working more frequently with biologists.

"Biology can use the mathematical sciences to make it much more quantitative and solid," says Mishra, and in an effort to promote this collaboration among computer scientists, mathematicians, and biologists, the statistical software developed by his team will be publicly available to researchers, "because the more people can look at this data and analyze it well, the more everybody benefits."

Article written by Cecilia Dobbs.
Orginally published in *NYU Today*

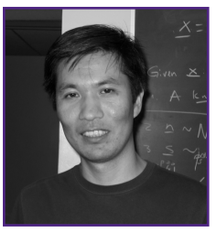
Editor's note: The positive potential of Prof. Mishra's work has been recognized by the National Institutes of Health, with a $585,000, two-year R21 grant to develop faster and cheaper methods of DNA sequencing.

Caroline Kovac addresses a plenary session of WOWinC on September 23. (See opposite page for article.)

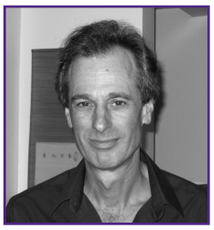
New Faculty Profiles

Richard Bonneau, assistant professor of Biology and Computer Science. Dr. Bonneau's Ph.D., in Biochemistry, Biomolecular Structure and Design, is from the University of Washington in Seattle (2001). He comes to NYU from the Institute for Systems Biology, also in Seattle. His research concerns developing and implementing methods for modeling global regulatory circuits, and he has also played a critical role in developing "Rosetta," one of the most successful programs for predicting protein folding, a present day grand challenge.

Scott Sheffield, assistant professor of Mathematics. He received his Ph.D. from Stanford in 2003. He was a postdoc in the Microsoft Research Theory Group from 2002 to 2004, and an NSF postdoc at Berkeley in 2004-05. His research interests include probability theory, statistical mechanics, and conformal invariance.



Weiqing Ren, assistant professor of Mathematics. He is one of our own, having gained his Ph.D. here at the Courant in Mathematics in 2002. Since then, he has been a visiting member at the Institute for Advanced Study (2002-03) and an instructor at Princeton University (2003-05). His research concerns theory and numerical methods for the study of energy landscapes and rare events with application to problems in material science, chemistry, and biology. He is also interested in mutiscale modeling of complex fluids and micro-fluidics.



Daniel Stein, professor of Physics and Mathematics, and Provost Faculty Fellow. He joins us from the University of Arizona, where he had been Head of the Department of Physics since 1995. He also serves on the Science Board and the External Faculty of the Santa Fe Institute. Dr. Stein's current research focuses on randomness and disorder in condensed matter systems, with an emphasis on random magnetic materials called spin glasses and on stochastic processes leading to rare nucleation events. Dr. Stein is a Fellow of the American Physical Society, a recipient of the University of Arizona College of Science Distinguished Teaching Award, and received the Commission on the Status of Women Vision 2000 Award.

Yuri Tschinkel, professor of Mathematics. Previously, he held the Gauss Chair of Pure Mathematics at the University of Goettingen, Germany. Dr. Tschinkel received his Ph.D. from MIT in 1992. He has been a Junior Fellow of the Harvard Society of Fellows (1992-5), a Leibniz Fellow of the European Community at the Ecole Normale Supérieure in Paris (1995-6) and a Clay Mathematics Institute Fellow (2001-2). His research concerns number theory and algebraic geometry. He intends to pursue his recent work on Galois groups of function fields, rationally connected varieties over function fields and homomorphic symplectic fourfolds.

Courant Initiative Seeks to Impact Quality of Mathematics Education

For about 5 years, a group of Courant faculty have been involved in issues of K-12 mathematics education, as part of a national grassroots mathematics education advocacy association called NYC HOLD. These include Director Chuck Newman and Professors Sylvain Cappell, Fred Greenleaf, Jonathan Goodman, Alan Siegel, Arthur Goldberg, Al Novikoff, Mel Hausner and Edmond Schonberg. Activities have included one-on-one mentoring of younger students, collaboration with colleagues at the Steinhardt School in teacher training programs, and advocacy.

Driven in part by a shared concern—one likely understood by many of you who have school-age children—that the traditional goal of imparting a specific set of mathematical skills has been lost in favor of more subjective pursuits such as "discovery learning," some of these faculty together with Elizabeth Carson of NYC HOLD and Courant Librarian Carol Hutchins have launched the Courant Initiative for Mathematical Sciences in Education (CIMSE). The CIMSE mission is to help foster excellence in school mathematics education.

The issues involved are national ones and are certainly apparent in the tri-state region in particular. The first CIMSE organized event was a forum on October 2 at Courant that focused on the effects of mayoral control on the math and reading curricula in New York public schools and featured a presentation by Diane Ravitch, the noted expert on the history of education from the Steinhardt School.

Lax and Nirenberg's Eightieth Birthdays Celebrated

The 2005-2006 academic year marks a major milestone in the lives of two iconic figures within the Courant community, as both Peter Lax and Louis Nirenberg reach the venerable age of eighty. Both came to Courant during the 1940's, and went on to serve as director, forming part of the so-called "Second Generation" – the immediate successors to the founders Richard Courant, Kurt Friedrichs, and James J. Stoker.

While Peter Lax was the subject of a feature article in the last issue of this newsletter, Louis Nirenberg's brilliant career may not be as well known to all of our readers. We are therefore pleased to reprint the following summary, written by Allyn Jackson, which appeared in the April 2002 edition of *Notices* of the American Mathematical Society:

"Louis Nirenberg is one of the outstanding analysts of the twentieth century. He has made fundamental contributions to the understanding of linear and nonlinear partial differential equations and their application to complex analysis and geometry.

"He was born on February 28, 1925, in Hamilton, Ontario, Canada. After receiving his bachelor's degree from McGill University in 1945, he went to New York University as a graduate student, obtaining his M.S. in 1947 and his Ph.D. in 1949, under the direction of James Stoker. Nirenberg then joined the faculty of NYU and was an original member of the Courant Institute of Mathematical Sciences. After spending his entire career at Courant, he retired in 1999.

"Nirenberg received the AMS Bocher Prize in 1959 for his work on partial differential equations. In 1982 he was the first recipient in mathematics of the Crafoord Prize, established by the Royal Swedish Academy of Sciences in areas not covered by the Nobel Prizes. In 1995 he received the National Medal of Science, the United States' highest honor for contributions to science."

The Department of Mathematics at the Courant Institute honored the occasion of Lax and Nirenberg's birthdays by hosting a symposium featuring visiting speakers from Princeton, UCLA, Rutgers, and Hebrew University. The two-day event culminated with a banquet on October 29. Those wishing to honor Professors Lax and Nirenberg with a special gift to the Courant Institute should contact Mark Hansen, Development Officer, at (212) 998-6775 or mark.hansen@nyu.edu.

Courant Spearheads NYU's Acquisition of the Fastest Computer in New York City

Last May, New York University installed a new IBM eServer BladeCenter system capable of peak performance of 4.5 TeraFlops. According to the TOP500 List, a ranking of supercomputers, NYU's supercomputer is the fastest in New York City and the 117th fastest supercomputer in the world. The acquisition of this supercomputer was made possible by a gift from IBM and federal funding.

The installation of the UNIVAC computer at NYU by the Atomic Energy Commission in the 1950's led to the creation of the Courant Mathematics and Computing Laboratory.

The new system will support NYU research with heavy computational requirements. Among the research enterprises that will be early beneficiaries of the new system are Courant's Center for Atmosphere-Ocean Science, which is developing sophisticated models to study the behavior of the Earth's atmosphere and oceans, and a collaborative effort between Courant and the Center for Comparative Functional Genomics on genomics and bioinformatics.

David McLaughlin, NYU's provost, said, "The Courant Institute of Mathematical Sciences is world-renowned for the strength of its scholarship in mathematics and computer science. NYU had an important and prominent role in the development of computers from their initiation. This technology will not only be a tremendous resource for a number of our faculty in areas of scientific research at the University, but also help build on our role as an important center for computation in science and society."

Coming a half-century after NYU's acquisition of the pioneering UNIVAC computer, the recent addition of IBM's latest technology has inspired a year-long Golden Anniversary observance sponsored by the NYU Office of Information Technology. In particular, any of our readers who may have witnessed any aspect of the history of computing at Courant are encouraged to share their recollections with the wider community by visiting **www.nyu.edu/about/techtimeline.**

Produced by the Courant Institute of Mathematical Sciences
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The Courant Institute recognizes with gratitude the following alumni, faculty, and friends who made gifts for fiscal year 2004–2005 since our last edition went to print:

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Last year, 308 donors contributed $95,276 of unrestricted funds to the Institute – 47 more donors than the year before. Our goal for the current year is $110,000, with a similar increase in new donors. Don't forget: every donor and every dollar counts!