

Neurobiologist Joshua C. Brumberg, right, and honors student Harold Gomes study the function of brain neurons.

on the eddies, or rings, which are torrents up to 1,000 meters deep and hundreds of kilometers across that break off randomly from the Gulf's Loop Current, a warm-water branch of the Gulf Stream.

"The swell speeds of these rings are so fast that oil companies can't dig while they're passing their rigs. They'll bend the drill," Poje said. Writing in Yale's *Journal of Marine Research*, his team detailed the life cycle of three potentially devastating rings, which go by names like Juggernaut and Millennium.

familiar directions.

But near heavy stars and black holes, space curves in a phenomenon called gravitational lensing. Direction isn't quite what it seems to be and, due to curvature, there is more than one shortest distance between two points. The universe becomes what mathematicians call a Riemannian manifold that can exist in far more than three dimensions.

Sormani studies the Ricci curvature of Riemannian manifolds, that is, how the volume of a multidimen-

Poje uses nonlinear dynamics and chaos theory to understand the rings' geometry. "If you plotted tracer trajectories driven by these eddies you'd get a spaghetti plot. I try to make sense of the spaghetti." Constantly moving, frequently splitting, the eddies get squashed and ripped apart. "I want to know what factors are responsible for the disintegration, as well as the most dangerous place to crash your oil tanker. Can a model predict where the oil will go if I dump a million gallons to the left of some line you can't see?"

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Think of the shape of a candle flame as it flickers, with constantly changing corners, surface, tips and curvature. Knowing a flame's dimensions can be important in a factory or spacecraft, where its position and shape are critical.

The same notion of curved surfaces applies to the universe. Near the Earth, explained Lehman College associate professor Christina Sormani, the universe looks like everyday, three-dimensional Euclidean space.

Forward-backward, left-right and up-down are the

sional manifold differs from the volume of a comparable region in Euclidean space. (Einstein popularized Ricci curvature in his theory of general relativity.) She is also interested in mirror symmetry and string theory, which help explain particle physics and cosmology, as well as manifolds. "It is very abstract," Sormani said.

More comprehensible is her work as principal investigator of Lehman's new Math Teacher Transformation Institute. Funded by the National Science Foundation, it focuses on better equipping Bronx junior high and high school teachers to teach algebra, geometry and other areas of mathematics. The institute also seeks to assess the best instructional practices, as measured by New York State Regents Exams.

Sormani teaches geometry to the first cohort of 40 state-certified math teachers. Geometry had faded from the classroom when many of them were in high school themselves, because the Regents kept changing the curriculum. With the state now reverting to a more traditional approach to algebra, geometry and trigonometry, the teachers have turned to the institute to expand their knowledge and skills.

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Does the shape of a neuron, or nerve cell, determine how it functions in the brain? Queens College neurobiologist Joshua C. Brumberg can learn only so much by examining tissue. But with mathematical models, "We can test hypotheses that we might not be able to do in a living system."

"Computational neuroscience gives us a leg up," said Brumberg, an associate professor and director of the Graduate Center's neuropsychology Ph.D. subprogram. And for mathematics he turns to talented undergraduates.

"Biology is the new discipline driving innovations in mathematics. It used to be physics," said Michael Schwemmer (Macaulay Honors College at Queens College 2005), who expects to earn his doctorate in applied mathematics from the University of California-Davis in 2010). Examining brain activity to discover how cognition works "is really cool stuff." His doctoral research probes the relationship

1985

Jerome Karle and Herbert Hauptman (both CCNY 1937, with Hauptmann a math major) receive Nobel Prize in chemistry for developing mathematical techniques through which X-ray crystallography can disclose 3-D structure.



Jerome Karle



Herbert Hauptman

1999

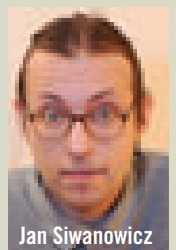
Statistician Matthew Goldstein (CCNY 1963) becomes CUNY chancellor.



Matthew Goldstein

2001

CCNY student Jan Siwanowicz (CCNY 2008) is among five to win Putnam Competition, the most prestigious U.S. undergraduate math prize.



Jan Siwanowicz

between neurons' synchronized electrical activity and sensory information processing, motor skills and associative learning. "What are the fundamental biophysical mechanisms that make them synchronize their activity?"

Schwemmer, a guitarist, was first attracted to Queens College's Aaron Copeland School of Music, which he attended in high school. But math won out,

thanks to a graduate-level class in number theory with assistant math chair Steven J. Kahan. "That made me appreciate how mathematics can be an art form."

With Brumberg, Schwemmer examined action potentials, or electrical discharges, in neurons, looking at how cell geometry affects firing. "It was amazing to use math to understand biology," he said. Upon graduation, he received the Claire and Samuel Jacobs Award for excellence in mathematics.


Brumberg is now working with Harold Gomes (Queens 2009), an honors student majoring in math and physics. He started at Queensborough Community College and his studies are supported by the National Institutes of Health Minority Access to Research Careers program. He wondered whether the shape and size of a neuron affect physiology and signal processing. "We showed that the geometry of the cell matters," said Gomes.

Or as Brumberg put it, "Neurons involved in one pathway have different properties than neurons in another pathway. That's what Harold's data is showing you." The next step will be to see whether those mathematical findings bear out in the laboratory.


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What if Romeo had fallen for Juliet at first sight and then discovered that she smelled bad?

"The play would have gone in a complete opposite direction, into extreme hatred or apathy to one another," said Shari



**THE SOLUTION:** There's a 44 percent (more precisely, 7/16) chance that the professors will meet. Here's how to solve the problem:



Associate each arrival time between 1 p.m. and 2 p.m. with a real number  $r$  such that  $0 < r < 1$ . The number  $r$  represents the part of the hour that has elapsed before the arrival. In this way the arrival times of the two professors determine a coordinate pair  $(x, y)$  that corresponds to a point in the unit square with  $0 < x < 1$ ,  $0 < y < 1$ .

The pair  $(x, y)$  corresponds to a situation where the professors fail to meet if either  $y > x + \frac{1}{4}$  or  $x > y + \frac{1}{4}$  (see below).

In the first of these cases the point  $(x, y)$  lies in the triangle that lies above the line  $y = x + \frac{1}{4}$ . The area of this triangle is  $\frac{1}{2} \times \frac{3}{4} \times \frac{3}{4} = \frac{9}{32}$ . Similarly, in the second case, the point  $(x, y)$  lies in the triangle with area  $\frac{9}{32}$  that lies below the line  $x = y + \frac{1}{4}$ . We deduce that the probability that the professors do not meet is  $\frac{9}{32} + \frac{9}{32} = \frac{9}{16}$ .

Bearing in mind that a 100 percent guaranteed meeting would be  $\frac{16}{16}$ , you subtract the probability you've derived of their not meeting ( $\frac{9}{16}$ ) from that to get the probability that they will meet,  $\frac{7}{16}$ .

Levine (Hunter 2008), who is studying for a math Ph.D. at Oxford. "The only way the story could explode into intense romance is if both were attracted from the start."

How does she know that? Differential equations tell her so.

Cornell mathematician Steven Strogatz first seized upon "Romeo and Juliet" in 1988 to inject drama into his teaching of differential equations. Levine gave "Romeo" her own spin in undergraduate research supported by the National Science Foundation and then wrote equations to explain "Hamlet," "Henry V" and "Midsummer Night's Dream." Graphing the equations shows how the play will end, but change the conditions and the graphs and endings will differ wildly.

"It surprised me how surprised people are that you could do this," she said. She presented her work at the 2007 Einsteins in the City International Student Research Conference, which alternates between CCNY and The Technical University of Vienna.

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As the financial world imploded this year, critics vilified financial engineers — the once-vaunted quantitative analysts, or "quants," who use mathematics to study and manage the market. Weren't they responsible for creating those toxic mortgage derivatives?

Partly, but there's plenty of blame to go around, and more should be heaped upon salespeople and rating agencies. Had the raters fairly valued those derivatives from the beginning, things might have turned

out differently, most commentators agree.

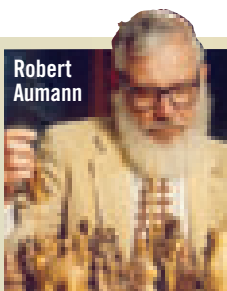
"The field is bound to continue growing," said Dan Stefanica, director of Baruch College's Master's of Financial Engineering (MFE) Program since it started in 2002. "With the advent of electronic trading, all transactions are recorded electronically. There are terabytes of information. You need models to sift through and process that information, which you can use to hedge your positions and invest more efficiently. You can't go back to pencil and paper."

Since the advent of financial engineers in the last decade, quants primarily determined exposure to risk and analyzed structured products. But today their algorithms also drive trading decisions, particularly at hedge funds.

The three pillars of financial engineering get equal emphasis in Baruch's highly competitive program — mathematics, which creates a model; finance, which employs the model; and computer programming, which runs the model.

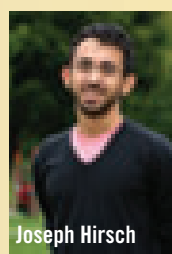
Baruch's strategy of admitting only the most qualified candidates, not a predetermined number, appears to be paying off. Most students earn their degrees and quickly find work, if they aren't in the financial industry already. Consider the 22 graduates of December 2008: Five worked in the sector; by February 2009, 11 others had landed jobs guaranteed to pay an average of \$94,000 in the first year — an impressive record, especially in these nail-biting times.

**2005**  
**Robert Aumann**  
(CCNY 1950, math major) receives Nobel Prize in economics.



**2005**  
Goldstein announces **CUNY's Decade of Science** (2005-2015), resulting in hiring of many mathematicians and emphasizing math-heavy STEM fields—science, technology, engineering and math.

**2008**  
**Joseph Hirsch** (Macaulay Honors College at Queens College 2008) wins National Science Foundation graduate research fellowship; now pursuing Ph.D. in math at CUNY Graduate Center.



**2009**  
More than 2,700 undergraduates register for first **CUNY Math Challenge**.

**2009**  
Six students in Baruch's Master's of Financial Engineering Program place in **2009 Interactive Brokers Trading Olympiad**, 10% of winners in this international graduate student competition.