# IMA Hosts
# 2006 Blackwell–Tapia Conference

*By Barry A. Cipra*

The program for the 2006 Blackwell–Tapia Conference, in addition to William Massey's talk on queueing theory (see "The Long and Short of It: Queueing Theory Goes Dynamic"), covered a wide range of subjects, from bacterial flagellation to a retrospective on the 1918/19 Spanish flu pandemic. Complementing the technical talks were panel discussions on career opportunities in the mathematical sciences and on strategies for math departments looking to attract—and keep—minority students. The complete program and many pictures can be found at www.ima.umn.edu/2006-2007/SW11.3-4.06/. Here are glimpses of a few of the sessions.

## Faculty Commitment: Key to Recruitment of Minorities

"There are amazing students at our universities that we are ignoring," says William Vélez of the University of Arizona. Vélez described some of his own efforts to encourage minority students—actually, *all* students—to take more math. One of his strategies is to seek out students who, in their application essays, express an interest in engineering because they say they like math. He also refuses to give up on average or even below-average students. He recalls telling a student discouraged by a C in calculus, "I started my academic life with nine units of D, so compared to me you're brilliant."

Vélez sends personal e-mail messages to thousands of students each semester encouraging them to take the next math course and to consider adding math as another major. He disputes the notion that the recruitment of minorities is hampered by weaknesses in the students' preparation: "It's the professors," he says, who are not actively recruiting more students, including minorities, to the study of mathematics. The university is teeming with students who should be enrolled in math classes, Vélez says. "They're all around us, but we don't bother to talk to them."

David Manderscheid related some of the tactics he and colleagues at the University of Iowa have used to boost the number of minority students in their graduate program. Nationwide, he pointed out, the numbers are abysmal: Of the 496 PhDs awarded to U.S. citizens in the mathematical sciences during the 2004/05 academic year, only 27 went to Blacks and Hispanics. The annual survey, conducted by the American Mathematical Society, reports a total of 1222 PhDs for 2004/05, meaning that fewer than 3% went to minority students. The Iowans' numbers border on the respectable: Nearly a quarter of their graduate students, and two-thirds of those who are U.S. citizens, are minorities, and of the aforementioned 27 PhDs, three went to students in the Iowa program.

Faculty commitment is the determining factor in the success of any recruitment/retention program, Manderscheid stresses. At the same time, a couple of simple steps taken by the Iowa department have proved enormously helpful. An example: New furniture for the math lounge turned it from a place to stop for coffee into a place for students to hang out and interact in that peculiar, pen-to-napkin way in which mathematicians socialize. Another was a program assigning teaching assistants to first-year graduate courses to run discussion sections and help form study groups. "The point of this is that all students benefit," Manderscheid says.

## Biological Motion

Ricardo Cortez, a professor of mathematics at Tulane University, presented work on the analysis and computation of biological flows, in particular the interaction of micro-organisms with their typically highly viscous fluid environs. Cortez offered the example of the spirochete *Leptonema illini*, a causative agent of leptospirosis (more descriptively known as hemorrhagic jaundice), spiraling its way through a mucous membrane (see Figure 1). High viscosity in these cases translates into low Reynolds number, which knocks the Navier out of Navier–Stokes, leaving the nicely linear Stokes equation. Problem solved, right?

Not exactly.

"Linear doesn't mean uninteresting," Cortez observes. One challenge is to avoid the singularities that can arise in the summing of infinitely many fundamental solutions known as Stokeslets, which correspond to contributions to
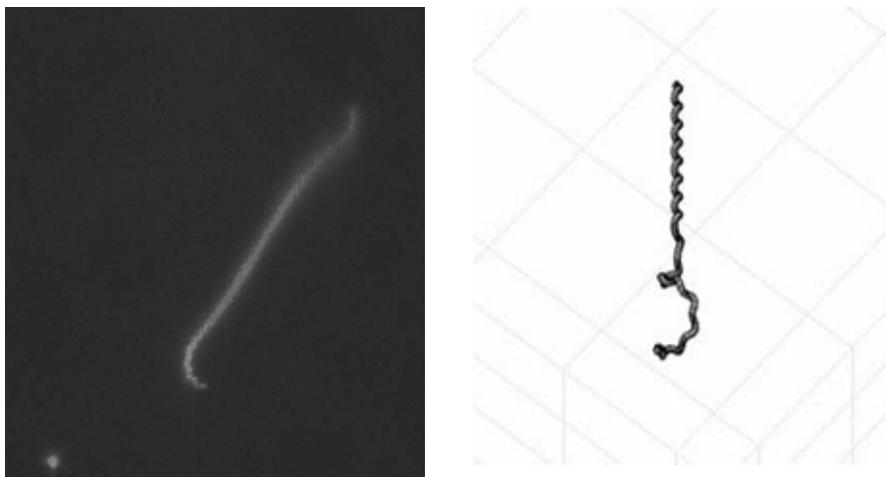


**Figure 1.** Leptonema illini *in a micrograph (left; courtesy of Stuart Goldstein, University of Minnesota, Department of Genetics, Cell Biology and Development) and in microcode (right; courtesy of Ricardo Cortez, Tulane University).*

the velocity field from external forces concentrated at individual points. Cortez has introduced a method of "regularized" Stokeslets, in which the force at a point is spread out over a small ball around the point. Approximating points by balls of radius epsilon makes the numerical computations tractable, but is also a source of error to be analyzed. Cortez and colleagues, including Lisa Fauci, also at Tulane, have looked into both aspects, along with some microbial applications.

In one study of spirochete mobility, the researchers compared their computational results for self-propelling helices of different pitches moving through a viscous fluid with experimental data for *L. illini*. Their model indicated that swimming efficiency is greatest when the helix has between 10 and 18 turns, which includes *L. illini*'s value, 17. According to the



**Figure 2.** *The number of rotations required for a computational spirochete to advance one body length varies with the number of turns (pitches) in its helix. The experimentally observed values—140 rotations and 17 turns— are close to the computed values.*

model, moreover, an organism with 17 turns would rotate roughly 128 times to move forward one body length—in rough agreement with an experimentally determined value of 140 for the real deal (see Figure 2).
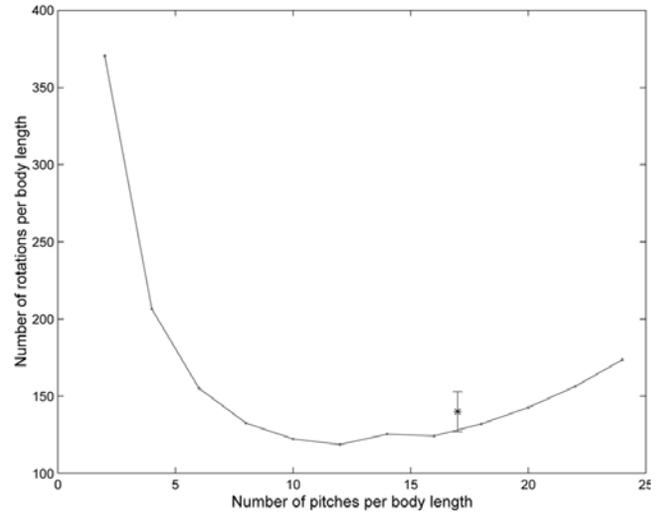
Edward Castillo, a graduate student in computational and applied mathematics at Rice University, reported on a different problem involving biological motion: image registration in "four-dimensional" CT scans of cancer patients' breathing lungs. The goal is to assist in planning for radiotherapy, in which the aim is to maximize the destruction of cancer cells while minimizing damage to healthy tissue.

A 4D scan, a sequence of images taken while a patient breathes normally, holds two items of interest. One, of course, is the location of the tumor. The other is how well the rest of the tissue ventilates—roughly speaking, the ratio of lung volume on inhalation to its volume on exhalation. It's not safe to assume a constant ratio throughout the lung, and pulmonary efficiency varies from patient to patient. But evaluating these variations requires tracking specific blobs of tissue from one image to the next. That, in a nutshell, is the image registration problem.

Tracking deformations that preserve volume is hard enough. (Even registering rigid-body motions is tricky.) When it comes to ventilation, tissue that occupies a single voxel in the exhalation image sometimes expands into many voxels on inhalation. Two other difficulties beset the use of 4D CT scans: The images are inherently noisy, and the data sets are humongous.

Nevertheless, Castillo and his adviser, Yin Zhang, together with colleagues in radiation oncology and diagnostic imaging at the University of Texas M.D. Anderson Cancer Center, have developed a method for dynamic ventilation imaging from 4D CT. The method, which does not require tracer to enhance the contrast, uses images that are already standard in radiotherapy planning. Applying the method in a retrospective study of three patients at the Anderson Center, the researchers found the mass-specific ventilation to be greater in the upper half of the lung in one patient, and greater in the lower half in the other two patients. Such knowledge, Castillo notes, could help in the planning stage to minimize loss of pulmonary function.

## Learning from the 1918 Flu Pandemic

In another medical retrospective, Gerardo Chowell of Los Alamos National Labor-atory described a mathematical model of the Spanish flu pandemic of 1918/19, which killed tens of millions worldwide, including upward of 600,000 in the U.S. (A "normal" flu season in the U.S. these days claims about 36,000 lives, according to the Centers for Disease Control.) Even with the advent of aggressive vaccination programs and anti-viral drugs, another devastating pandemic is widely considered just about inevitable. How can society brace for it?

In collaboration with Catherine Ammon of the Institute of Social and Preventive Medicine in Geneva, Switzerland, Chowell and Los Alamos colleagues Nick Hengartner and Mac Hyman analyzed hospital numbers for the Canton of Geneva for the period from July 1 to November 14, 1918, spanning two waves of the epidemic (see Figure 3). There were 914 deaths in 21,754 hospitalizations for flu during the pandemic, in a total population of about 175,000. (More than half the population of Geneva is estimated to have wound up with the flu.) The researchers used a compartmental model, including categories for susceptible, infected, hospitalized, and dead. They calculated a reproductive number—that is, the mean number of secondary cases generated by a primary case—of about 1.5 for the first wave and 3.8 for the second, during which symptoms were more severe and the fatality rate higher.
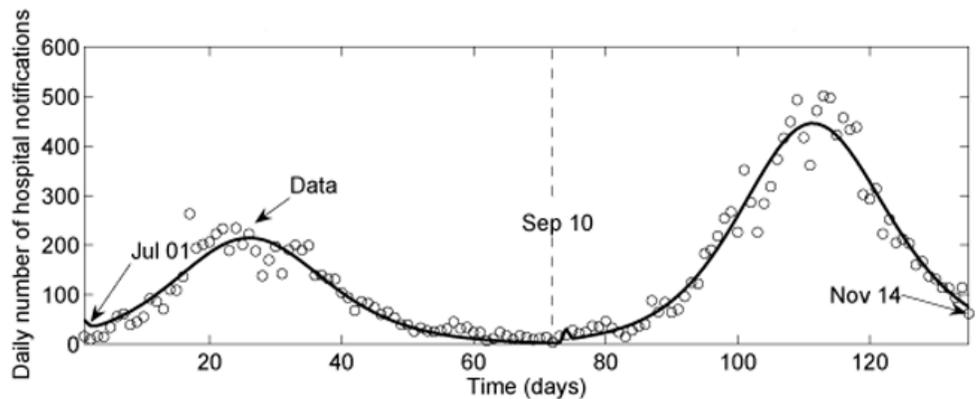


**Figure 3.** *Nothing to sneeze at. A mathematical model (solid curve) fits the daily hospitalization numbers from Geneva, Switzerland, for the 1918 Spanish flu pandemic. The second wave, peaking in mid-October, was the more severe. A third, much smaller wave (not shown) crested in early 1919.*

In terms of averting the next pandemic, the results of the Geneva study suggest that it's not enough to isolate the people who get sick enough to land in the hospital. Protective measures aimed at reducing susceptibility in the general population are far more effective. A combination, of course, works best. Chowell and colleagues found, for example, that the reproductive number for the second wave could have been driven below the epidemic threshold number of 1 had the general susceptibility been reduced by 77%, or by 50% in conjunction with a 65% reduction in transmission rate from hospital wards. In short: Get your shots, wash your hands, and steer clear of those who don't.

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