ChE department

Chemical Engineering at the University of California, Santa Barbara

This Young Department Has Built a National Reputation Through Timely Recruiting and a Stress on Interdisciplinary Activities

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It wasn't so long ago that mention of UC Santa Barbara in the engineering world might get a response like "UC what?" Until 1961, this University of California campus located on the scenic coast sometimes called California's Riviera did not even *have* an engineering school. It took some time after that for the school and its chemical engineering program (established in 1966) to get noticed. But by the usual academic standards, their rise to national prominence was lightning-fast.

Brad Chmelka, now a professor in the ChE department at UCSB, was scouting for his first faculty position in 1992 after earning his doctorate at UC Berkeley and spending two

years in post-doctoral work at the Max Planck Institute for Polymer Research in Germany. He recalls visiting UCSB almost as an afterthought. He already had decided that he would go to either Caltech or the University of Minnesota. When he was choosing Ph.D. programs a few years earlier, he had judged UCSB's engineering programs to be promising but still obscure.

But what he saw at Santa Barbara changed his plans. "I was shocked," he says. "I had no idea what had happened since I had looked at it last." A once-obscure school was now an academic powerhouse attracting national notice.

So what did happen to put UCSB's young ChE program on the map so quickly? Probably the best answer is that several factors converged in the right place at the right time. One was a strategic decision in the mid-1980s by the University of California Regents to make the Santa Barbara campus into a major research center. Another was a pool of talented scientists and engineers made available by the downscaling of corporate research labs. Yet another was the talent already in place or just arriving. One of UCSB's most distinguished ChE faculty members is **Jacob Israelachvili**, a fellow of the National Academies of Science and Engineering, who came to the department in 1986.

Leadership from forward-looking deans and departmental chairs played a role, as did the near-perfect climate and the beauty of the university's ocean setting. So did the culture of collaboration and interdisciplinary research that was emerging at UCSB. The university's emphasis on cross-disciplinary teamwork has attracted corporate and academic researchers eager to move beyond the restrictions of traditional academic boundaries.

CONCENTRATED TALENT

The progress that so struck Chmelka 15 years ago has continued to this day. The ChE department at UCSB is not the largest ChE program in the nation, but it may have the highest concentration of top-flight talent. Its strong standing is signified by the ninth-place ranking among ChE graduate programs in the latest survey by *U.S. News and World Report*. A 1999 study by the Korean Advanced Institute of Science and Technology ranked it first based on "research impact factor per ChE faculty member." In 2003, *Chemical Engineering News* ranked the department first based on citations per publication; it also noted that the department's percentage of National Academy of Engineering (NAE) members was the highest of any ChE department in the country. Currently, seven of the department's 17 senior faculty members share this honor.

Additionally, seven of its professors are fellows of AIChE or the American Physical Society (APS), and one, Israelachvili, is a fellow of the Royal Society (U.K.) as well as a member of the National Academies of Science and Engineering.

A number of ChE faculty at UCSB also have won prestigious awards in recent years. **Glenn Fredrickson**, a member of the NAE and an APS fellow, won the APS Polymer Prize in 2006. **Bud Homsy**, who is also an NAE member and an APS fellow, won the APS Fluid Dynamics Prize in 2005. Israelachvili won the 2004 Materials Research Society Medal. The department chair, **Gary Leal**, won the APS Fluid Dynamics Prize in 2002. **Mike Doherty** won the both the Clarence G. Gerhold and the Alpha Chi Sigma awards in 2004 from the AIChE. **Joe Zasadzinski** won the 2004 American Chemical Society Award in Colloid Science. **Samir Mitragotri** received the Allan P. Colburn Award in 2005 from the AIChE. **Sanjoy Banerjee** won the AIChE's Donald Q. Kern Award in 2006.

BUILDING A NATIONAL REPUTATION

The ChE program started in 1965-66 with the arrival of the first faculty member, **Bob Rinker** and the first department chair, **Jack Meyers**, who had been a faculty member at Purdue for 16 years. (Bob now has emeritus status and Jack died in 1994) Three other faculty members who are now emeriti (**Orville Sandall**, **Duncan Mellichamp**, and **Owen Hanna**) were hired in quick succession.

The subsequent recruitment of the current ChE faculty is summarized in the sidebar, at end. In 1969 the department's nuclear engineering degree program was initiated. The nuclear engineering program was subsequently discontinued in 1995, yet its impact remains: Four of the department's current faculty were originally hired as nuclear engineers.

By necessity, the early years of the ChE department were concerned with building the department by developing instructional programs, constructing laboratories, and initiating research programs. Several faculty members also provided leadership of the campus and the University of California (UC) System during critical periods. In particular, Duncan Mellichamp was elected head of both the campus Academic Senate and the UC Academic Council, unusual honors for an engineering professor. The pioneering efforts of the initial complement of faculty provided the basis for the department's subsequent growth and enhanced reputation. By 1981, the ChE program had nine faculty positions, 195 undergrads, and 33 graduate students. Hired during those years were current ChE faculty members **Dale Seborg** (1977), **Gene Lucas** (1978), and Banerjee (1980).

Meanwhile, the university as a whole had established strong programs in biology, chemistry, and especially physics, as well as distinguished institutes in marine sciences and theoretical physics.

The elements were in place for UCSB's next big leap, to the status of a full-fledged research university, with the College of Engineering and the ChE department playing key roles in the university's rise to national prominence.

Under Dean of Engineering **Robert Mehrabian**, the focus at the College of Engineering initially was on materials. Fredrickson, who came to UCSB in 1990, says Mehrabian

was hired in 1983 "with orders to create a world-class materials department." He proceeded to do so, with an impact that went well beyond one discipline. As Fredrickson (who has a joint appointment in ChE and Materials) explains, Mehrabian filled the Materials Department with people who had worked in corporate settings such as Bell Labs and who had gained high visibility in academia by publishing extensively. A number of them were given joint appointments in chemical or mechanical engineering, and their experience in industry had accustomed them to working in cross-disciplinary project teams. These factors "had the effect of breaking down barriers between different parts of the College of Engineering," Fredrickson says. "It created a research and education experience different from almost any university I know of." Three current ChE faculty members came to UCSB during this era: **Theo Theofanous** (1985); and Israelachvili and Zasadzinski (both hired in 1986).

The ChE program's rise in reputation and visibility within the chemical engineering community continued with the recruiting, in 1989, of Gary Leal and **Henry Weinberg** from Caltech. Leal became the department chair and remains in that post today. Weinberg was on the ChE faculty until 1996, when he left to become chief technology officer with the Silicon Valley firm Symyx Technologies. Fredrickson, recruited from Bell Labs, was Leal's first hire. He was followed by current faculty members **Eric McFarland** (1991), Chmelka (1992), and **Ed Kramer** (1997).

The strategy behind these and later hires, says Leal, was simply to find the best people. "We always seek to hire the best candidate regardless of his or her particular research interests, the type of person who comes along every few years at one of the other top departments," he says. "We do not seek to hire people in a specific research area." But it also helped reinforce the department where it already was strong, in areas such as process control and chemical kinetics, while building strength in emerging areas such as materials. Frederickson, whose focus was on polymer theory when he came to UCSB, says there also "was a drive to strengthen the theoretical and computational side of the department. I was hired in part to help meet that objective." In the characteristic UCSB way, the new recruits opened up new avenues for collaboration.

To take just one example, the polymer theorist Frederickson found his experimental counterpart in Kramer. They have done a number of projects together, to the benefit of their shared students. Recently, they have been working with UCSB Chemistry Professor **Craig Hawker** to develop a new generation of nanoscale computer chips based on self-assembling polymers.

The rapid growth of the department and research programs since 1981 has also benefited the educational programs by allowing a broader range of elective courses. Also, many influential textbooks were written by department faculty during this period.

INTERDISCIPLINARY RESEARCH

Collaboration across academic disciplines and departments is a UCSB trademark. It is impossible to give an accurate picture of the ChE department without including the departments and research groups, both in and out of Engineering, with which its faculty is affiliated. Most of its professors have joint appointments, including eight with the Materials Department of the College of Engineering. The ChE faculty also includes the dean of the College of Engineering, **Matt Tirrell**, who is also a professor of Materials. (Tirrell, who came to UCSB from the University of Minnesota in 1999, has received the Allan P. Colburn, Charles Stine, and Professional Progress awards from AIChE, as well as delivering its Institute Lecture in 2001.)

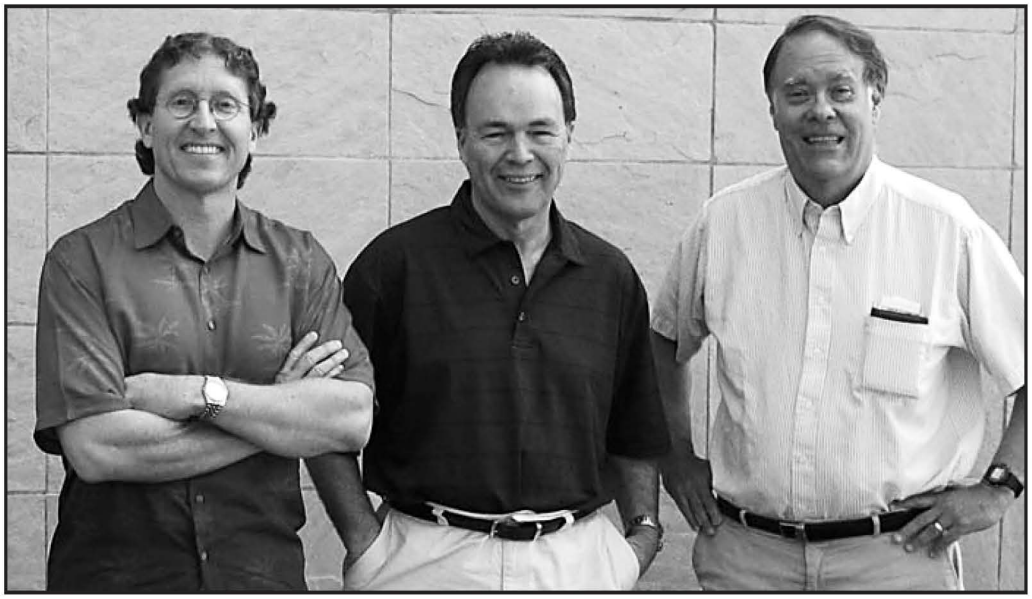
Another department colleague is UCSB Executive Vice Chancellor **Gene Lucas**. Chancellor **Henry Yang** also has engineering ties—he is a professor of mechanical engineering. These connections suggest the importance of engineering, including ChE, at UCSB. As Seborg notes, it is "very rare for a nonengineering university" to have the engineering disciplines so well represented in its top leadership.

The opportunities for collaborative research and education in ChE extend beyond academic departments and well beyond UCSB. ChE faculty play key roles in government- and industry-financed research groups. Fredrickson is associate director of the Materials Research Laboratory, an NSF-funded institute that brings researchers together from physics, chemistry, biology, materials, and biochemistry as well as chemical engineering. The MRL also includes ChE faculty members Tirrell, Homsy, Israelachvili, Kramer, and Leal. Fredrickson is director of the Mitsubishi Chemical Center for Advanced Materials (MC-CAM) and the MRL's Complex Fluids Design Consortium (CFDC), which also includes Banerjee.

Frank Doyle is the associate director of the Institute for Collaborative Biotechnologies (ICB), an Army-funded research organization led by UCSB in collaboration with MIT and Caltech. Its mission is to develop revolutionary innovations in bio-inspired materials and energy, biomolecular sensors, bio-inspired network science, and biotechnological tools. Most of its more than 60 researchers are from UCSB science and engineering departments. In addition to Doyle, the ChE faculty members associated with ICB include Chmelka, **Patrick Daugherty**, Fredrickson, Israelachvili, Mitragotri, Tirrell, and Zasadzinski.

NEW RESEARCH CHALLENGES

The department's research interests have evolved over the years along with the larger trends in science and the economy. Zasadzinski says he was working on enhanced oil recovery when he arrived at UCSB in 1986, and he has seen his own interest shift toward "biologically relevant materials." He is



UCSB Department of Chemical Engineering leadership, pictured left to right: Brad Chmelka, Gary Leal, and Dale Seborg.

now involved in research aimed at developing tiny nanodevices to deliver drugs or diagnostic agents to specified targets in the human body. Doyle and Seborg are applying their expertise in process modeling and control to develop control strategies for diabetes patients, in collaboration with medical researchers. But energy-related research has become increasingly important in recent years. Chmelka, the department's vice chair for graduate affairs, says new Ph.D. students are as eager to explore challenging problems related to energy as they are to study bio-engineering topics. Chmelka is involved in energy-related research along with ChE colleagues **Eric McFarland** and **Susannah Scott**. In one project, funded by the U.S. Department of Energy, Scott and Chmelka are designing materials for catalysts that can be used to produce fuels such as biodiesel from plant oils.

The department research activities also include traditional areas of chemical engineering, such as reaction engineering, thermodynamics, and transport phenomena, in their modern forms; Leal says it is particularly strong in the thermo and transport areas. It also is strong in materials, especially complex fluids and "soft materials," as well as in research that links materials and colloid science with biological applications. Israelachvili's lab does important work in the surface force measurements of biological binding strengths and biological lubrication phenomena. Leal lists other strengths —process design and control (including systems biology) as well as surface chemistry, catalysis, and surface physics—and states that the department has "one of the strongest theory and simulation activities in the country."

One theme runs through all this research—an emphasis on basic engineering science rather than applied engineering. "We are a very fundamentally oriented department," Leal says. It is also an inner-directed program, driven more by the intellectual curiosity of first-rate faculty than by an urge to hop on bandwagons. Trends come and go, Leal explains, but the best minds will always be out in front: "The basic philosophy is that the hot new topic is always changing. We want to be in a position to be a leader in whatever the future brings as well as a leader in the topics of the present." ❐

ChE at UCSB: At a Glance	
Web site	http://www.chemengr.ucsb.edu
History	University of California founded: 1868 Santa Barbara campus joined the UC System: 1944 College of Engineering founded: 1961 ChE Department established: 1966
U.S. News & World Report rankings	ChE Department: 9th College of Engineering: 19th
Faculty statistics and honors	Current faculty: 20 (17 full professors, one associate, two assistants) Emeritus and adjunct faculty: 5 NAE members: 7 NAS member: 1 Fellow of the Royal Society (U.K.): 1 Fellows of AIChE or APS: 7
Student enrollment statistics	Undergraduate: 190 students (30% female, 30% minority) Graduate: 79 students (33% female, 67% have B.S. degrees from U.S. schools)
Campus environment	UCSB coastline: Approx. 2.5 miles Distance to Los Angeles: 105 miles Distance to San Francisco: 333 miles Average January temperature: 52 °F Average July temperature: 66 °F Average yearly rainfall: 16.1 inches Average days of rain each year: 35

WHO'S WHO IN CHE AT UCSB

The Chemical Engineering Department at the UC Santa Barbara currently has 20 faculty—17 full professors, one associate professor, and two assistant professors. In the order in which they joined UCSB (and year of arrival), they are:

- Dale Seborg (1977), professor and department vice chair. Ph.D.: Princeton. Research interests: process control, system identification, and process monitoring. Current applications include monitoring and control strategies for type 1 diabetes patients and monitoring strategies for industrial bioreactors. Honors and awards: AIChE Fellow, 2004; Statistics in Chemistry Award (shared), American Statistical Association, 1994; Education Award, American Automatic Control Council, 1993; Meriam-Wiley Distinguished Author Award (shared), American Society of Engineering Education, 1990.

- Gene E. Lucas (1978), professor, executive vice chancellor. Joint appointment in: Materials. Ph.D.: MIT. Research interests: composite materials for aerospace applications, fusion reactor materials, and radiation embrittlement of light-water reactor steels. Honors and awards: R.E. Peterson Award for Best Paper on the Application of Experimental Mechanics, Society for Experimental Mechanics, 1997; Young Member Engineering Achievement Award, American Nuclear Society (ANS), 1991.

- Sanjoy Banerjee (1980), professor. Joint appointment in: Mechanical Engineering. Ph.D.: University of Waterloo. Research interests: multiphase, complex-fluid, turbulent/chaotic, and environmental systems. Current projects range from nanoscale problems to macroscale phenomena such as turbulent transport processes at the air-sea interface, of importance in global warming. Honors and awards: Donald Q. Kern Award, American Institute of Chemical Engineers (AIChE), 2006; Heat Transfer Memorial Award, American Society of Mechanical Engineers, 1999; Danckwerts Memorial Lecture, Chemical Engineering Science/Institution of Chemical Engineers, London, U.K., 1991; Melville Medal, American Society of Mechanical Engineers, 1983.

- Theo G. Theofanous (1985), professor; director, Center for Risk Studies and Safety. Joint appointment in: Mechanical Engineering. Ph.D.: University of Minnesota. Research interests: risk assessment and management of complex technological and environmental systems. Areas of investigation include multiphase flow physics, issues of uncertainty in risk assessment, interfacial instabilities in high-speed flows, aero-breakup, explosive dissemination of liquids, defense against chem-bio weapons, and burnout physics and nuclear reactor safety. Honors and awards: Elected to National Academy of Engineering, 1998; elected to Russian Academy of Science, Ufa Branch, 1998; E.O. Lawrence Medal, U.S. Department of Energy, 1997.

- Jacob N. Israelachvili (1986), professor. Joint appointment in: Materials. Ph.D.: Cambridge University. Research interests: Intermolecular and intersurface forces in complex fluid systems; friction and stickiness; using the Surface Forces Apparatus (SFA) to study interactions between surfaces separated by various liquids, surfactants and polymers, as well as interactions of biomembranes and biological macromolecules. Honors and awards: elected to National Academy of Science, 2004; MRS Medal, Materials Research Society, 2004; elected to NAE, 1996; Alpha Chi Sigma Award, AIChE, 1991; elected fellow of Royal Society of London, 1988; elected fellow of Australian Academy of Science, 1982.

- Joseph A. Zasadzinski (1986), professor. Joint appointment in: Materials. Ph.D.: Univ. of Minnesota. Research interests: visualization of molecular and supramolecular ordering in complex fluids and biomaterials; development of new techniques to make complex fluids and biomaterials compatible with high-resolution microscopy; creating biologically inspired materials with potential uses in drug delivery and diagnosis. Honors and awards: American Chemical Society Award in Colloid Science, 2004; fellow of the American Association for the Advancement of Science, 2000; Burton Award of the Microscopy Society of America, 1993; Presidential Young Investigator, NSF, 1986.

- L. Gary Leal (1989), professor, department chair. Joint appointment in: Materials and Mechanical Engineering. Ph.D.: Stanford University. Research interests: fluid dynamics and rheology of complex fluids (*e.g.*, polymeric liquids, liquid crystalline polymers, immiscible blends and emulsions, and colloidal and nanoparticle suspensions); nonlinear and surfactant-induced phenomena in interfacial flows. Honors and awards: Fluid Dynamics Prize, American Physical Society (APS), 2002; Bingham Medal, American Institute of Physics, 2000; William H. Walker Award, AIChE, 1993; elected to the National Academy of Engineering, 1987; fellow of APS, 1984; Allan P. Colburn Award, AIChE, 1978; Camille and Henry Dreyfus Foundation Teacher-Scholar Award, 1975.

- Glenn H. Fredrickson (1990), professor; director of Mitsubishi Chemical Center for Advanced Materials. Joint appointment in: Materials. Ph.D.: Stanford University. Research interests: analysis of complex fluid and multiphase polymer systems; study of equilibrium and dynamical properties of suspensions, polymer solutions and melts. Honors and awards: Polymer Physics Prize, APS, 2007; elected to National Academy of Engineering, 2003; Alpha Sigma Chi Award, AIChE, 1999; elected fellow of APS, 1998; John H. Dillon Medal, APS, 1992; Camille and Henry Dreyfus Teacher-Scholar Award, 1991; Presidential Young Investigator, NSF, 1990.

- Eric McFarland (1991), professor. Joint appointment in: Electrical and Computer Engineering. Ph.D.: MIT (also M.D., Harvard). Research interests: study of condensed matter systems with emphasis on developing high-throughput screening technologies for combinatorial ma-

terials research; investigating new photocatalytic systems for energy production. Honors and awards: Special Award for Outstanding Advances in Nuclear Technology, ANS, 1992; Presidential Young Investigator, NSF, 1990-1995.

- Bradley F. Chmelka (1992), professor. Ph.D.: UC Berkeley. Research interests: study at the molecular level of the fabrication and functions of new catalysts, adsorbents, optoelectronic materials, porous ceramics, heterogeneous polymers and biominerals; development and application of nuclear magnetic resonance imaging techniques to observe heterogeneous solids. Honors and awards: Alfred P. Sloan Foundation Research Award, 1996; David and Lucile Packard Foundation Award, 1993; Camille and Henry Dreyfus Foundation Teacher-Scholar Award, 1993; New Young Investigator Award, NSF Division of Materials Research, 1992.
- Ed Kramer (1997), professor. Joint appointment in: Materials. Ph.D.: Carnegie-Mellon. Research interests: microscopic fundamentals of fracture of polymer glasses, diffusion in polymers, polymer surfaces, and interfaces. Honors and awards: Maurice Higgins Award, Polymers-West Gordon Conference, 2001; Swinburne Award, Institute of Materials (U.K.), 1996; elected fellow of American Association for the Advancement of Science (AAAS), 1994; elected to National Academy of Engineering; Polymer Physics Prize, APS, 1985; elected fellow of APS, 1983.
- Matthew V. Tirrell (1999), professor, dean of Engineering. Joint appointment in: Materials. Ph.D.: Univ. of Massachusetts, Amherst. Research interests: interfacial properties of materials used in applications ranging from coatings and adhesion to lubrication and bioengineering. Honors and awards: Le Prix Dédale de la Société Française d'Adhesion, 2005; Institute Lecturer, AIChE, 2001; elected to National Academy of Engineering, 1997; Charles M.A. Stine Award, AIChE, 1996; Professional Progress Award, AIChE, 1994; Fellow of the APS, 1987; John H. Dillon Medal, APS, 1987; Allan P. Colburn Award, AIChE, 1985; Presidential Young Investigator, NSF, 1984; Camille and Henry Dreyfus Teacher-Scholar Award, 1980.
- Michael F. Doherty (2000), professor. Ph.D.: Cambridge University. Research interests: process synthesis and conceptual design of chemical process systems. Topics of current interest include combining reactions and separations, crystallization of organic materials, and systems with complex chemistry. Honors and awards: Clarence G. Gerhold Award, Separations Division, AIChE, 2004; Excellence in Process Development Research Award, Process Development Division, AIChE, 2004; Alpha Chi Sigma Award, AIChE, 2004.
- Samir Mitragotri (2000), professor. Ph.D.: MIT. Research interests: developing novel methods of drug delivery based on controlling the transport of biomolecules to desired targets. Strategies include use of external forces (*e.g.*, ultrasound, chemicals, and high-velocity jets) as well as new biomaterials with advanced structure-function characteristics. Honors and awards: Allan P. Colburn Award, AIChE, 2005; Outstanding Pharmaceutical Research Award, Controlled Release Society (CRS), 2004; CRS-Capsugel Innovative Aspects of Oral Delivery Award, 2004; 3M Young Faculty Award, 2001.
- Patrick S. Daugherty (2001), associate professor. Ph.D.: U. Texas, Austin. Research interests: elucidating protein interaction principles in biological systems; developing biotechnologies that apply molecular and cellular engineering to diagnosis and treatment of disease. Honors and awards: Camille and Henry Dreyfus Foundation Teacher-Scholar Award, 2006; NSF Career Award, 2005.
- G.M. (Bud) Homsy (2001), professor. Joint appointment in: Mechanical Engineering. Ph.D.: U. Illinois. Research interests: fluid mechanics and transport, with particular focus on interfacial flows, polymer and viscoelastic fluid mechanics, porous media flows and microgravity fluid mechanics. Honors and awards: Elected to National Academy of Engineering, 2006; Fluid Dynamics Prize, APS, 2004.
- Frank J. Doyle III (2002), professor and associate director of the Institute for Collaborative Biotechnologies (ICB). Ph.D.: California Institute of Technology. Research interests: nonlinear model-based control of complex nonlinear and distributed processes; application of systems engineering tools to problems in biology. Honors and awards: Alexander von Humboldt Research Fellow, 2001; Ray Fahien Award, American Society for Engineering Education (ASEE), 2000; Office of Naval Research Young Investigator Award, 1996; National Young Investigator Award, NSF, 1992.
- Susannah L. Scott (2003), professor. Ph.D.: Iowa State University. Research interests: chemistry and physics governing interactions and reactions of molecules at solid surfaces; applications in heterogeneous catalysis, electronic materials and advanced materials. Honors and awards: Union Carbide Innovation Recognition Award, 1998-1999; John Charles Polanyi Prize in Chemistry, 1994.
- Todd M. Squires (2005), assistant professor. Ph.D.: Harvard. Research interests: physical effects in micron-scale systems. Current topics of focus include "pore-scale engineering" techniques for analytical separations, microfluidic manipulation for potential use in portable or implantable devices, active microrheology to characterize a material's response, and the fluid mechanics of the inner ear. Honors and awards: NSF Career Award, 2007; named one of four "Rising Stars" by Chronicle of Higher Education, 2005.
- M. Scott Shell (2007), assistant professor. Ph.D.: Princeton. Research interests: protein structure prediction and sequence design; protein stability, dynamics, and intermolecular association; the glass transition and dynamics in rough energy landscapes; anomalous behavior in complex liquids and mixtures; robust simulation algorithms for free energy calculations. ❐