Department of Chemistry

In the 2006–2007 academic year, the Chemistry Department continued its strong programs in undergraduate and graduate education. There were 244 graduate students, 107 postdoctoral researchers, and 119 undergraduate chemistry majors. As of July 1, 2007, the Chemistry Department faculty will comprise 38 full-time faculty members, including four assistant, four associate, and 30 full professors, two of whom are Institute Professors. Professor Alice Ting was promoted to associate professor without tenure. Professor Andrei Tokmakoff was promoted to full professor. Additionally, Professor Jonas Peters joined the Department as the W.M. Keck professor of energy. Professor Peters obtained his PhD in inorganic chemistry at MIT in 1998 under the direction of Professor Christopher C. Cummins. He joins the department from the Division of Chemistry and Chemical Engineering at Caltech, where he served from 1999 to 2006.

Highlights

Swager Wins Prestigious Lemelson-MIT Prize

Professor Timothy M. Swager, John D. MacArthur professor of chemistry and department head, was named the recipient of the 2007 Lemelson-MIT Prize, which recognizes individuals who turn their ideas into inventions and innovations that change the world we live in and improve life for all of us. The $500,000 Lemelson-MIT Prize is bestowed upon outstanding midcareer inventors who have developed a patented product or process of significant value to society, which could be or has been adopted for practical use. Professor Swager won the prize for his invention of amplified chemical sensors to detect vapors of common bomb-making chemicals, such as TNT. In 2001, MIT licensed his patented polymer technology to Nomadics, now a unit of ICx Technologies, for use in the company's Fido® Explosives Detector, so named for its ability to simulate a bomb-sniffing dog.

Currently, American soldiers in Iraq are using Fido devices in two ways—either attached to a robotic platform for development to hard-to-reach and dangerous areas, or as a portable, handheld monitor to analyze people, clothing, and automobiles.

In 2005, Fido earned the US Army Greatest Invention Award. General (Retired) Paul J. Kern, the former US Army senior military advisor in Research, Development, and Acquisition, wrote in a nomination letter for Swager, "It is not realistic to put a number on how many attacks have been prevented by early detection of bomb makers and IEDs, but one could easily estimate that hundreds of individuals have avoided serious injury or death as a result of Swager's chemical invention."

Bawendi Elected to NAS

Professor Moungi G. Bawendi was elected to the National Academy of Sciences. The election was held Tuesday, May 1, 2007. The National Academy of Sciences is a private organization of scientists and engineers dedicated to the furtherance of science and its use for the general welfare.

Chakraborty and Fu Elected to American Academy of Arts and Sciences

Professors Arup K. Chakraborty and Gregory C. Fu were elected to the American Academy of Arts and Sciences. Awards were announced April 30, 2007, in Cambridge, MA. The Academy will admit 203 new fellows and 24 new foreign honorary members.

Other Major Faculty Awards and Honors for AY2007

Professor Robert A. Alberty	Association of American Publishers—Best Text Book, 2006, *Biochemical Thermodynamics: Applications of Mathematica*
Professor Moungi G. Bawendi	2007, Elected, National Academy of Sciences E.O. Lawrence Award of Material Research Lester Wolfe Chair, effective July 1, 2007
Professor Klaus Biemann	2007 Benjamin Franklin Medal in Chemistry
Professor Stephen L. Buchwald	2006 Siegfried Medal
Professor Sylvia T. Ceyer	2007 Gibbs Medal
Professor Arup K. Chakraborty	Elected, American Academy of Arts and Sciences E.O. Lawrence Award in Life Sciences NIH Director's Pioneer Award (2006)
Professor Christopher C. Cummins	2007 F. Albert Cotton Award in Synthetic Inorganic Chemistry Raymond and Beverly Sackler Prize in Physical Chemistry
Professor John M. Deutch	Elected, American Philosophical Society
Professor Robert G. Griffin	Günther Laukien Prize for 2007 EAS Award for Outstanding Achievements in Magnetic Resonance
Professor Robert W. Field	Coblentz Society's Bomem-Michelson Award, 2006
Professor Gregory C. Fu	Elected, American Academy of Arts and Sciences Elected, American Association for the Advancement of Science
Professor Mohammad Movassaghi	2007 AstraZeneca Excellence in Chemistry Award 2007 Amgen Young Investigator Award 2007 GlaxoSmithKline Chemistry Scholar Award 2007 US National Committee/IUPAC Young Observer Fellowship Award 2006 Merck Academic Development Program Award 2006 Beckham Young Investigator Award 2006 National Science Foundation Career Award

Professor Daniel G. Nocera	Henry Dreyfus Chair, effective July 1, 2007 Burghausen Chemistry Award
Professor Jonas Peters	W.M. Keck Chair, effective July 1, 2007
Professor Sarah E. O'Connor	Alfred P. Sloan Research Fellowship
Professor Joseph P. Sadighi	Everett Moore Baker Memorial Award for Excellence in Undergraduate Teaching
Professor Richard R. Schrock	Elected, Harvard Board of Overseers
Professor Dietmar Seyferth	Awarded a doctorate honoris causa by the Technical University of Chemnitz in Saxony, Germany
Professor Robert J. Silbey	Joseph O. Hirschfelder Prize in Theoretical Chemistry from the University of Wisconsin for 2007–2008 Gordon Y Billard Award
Professor Steven R. Tannenbaum	Elected, American Association for the Advancement of Science
Professor Alice Y. Ting	Named one of *Technology Review's* Young Innovators Under 35 for 2006
Professor Troy Van Voorhis	Alfred P. Sloan Research Fellowship 2006 Packard Foundation Fellowship for Science

Named Lectures

The Department welcomed many speakers who gave named lectures:

A.D. Little Lectures in Inorganic Chemistry—Jean-Michel Saveant, University of Paris, France

Merck-Banyu Lecturer in Organic Chemistry—Motomo Kanai, University of Tokyo

The Wyeth Lecture in Organic Chemistry—Eric N. Jacobsen, Harvard University

George Buchi Lectures in Organic Chemistry—Huw Davies, University at Buffalo, The State University of New York

T.Y. Shen Lectures—Rolf Thauer, Max Planck Institute for Terrestrial Microbiology, Philipps University, Marburg

Bristol-Myers Squibb Lectures in Organic Synthesis—Rodney Parsons, Bristol-Myers Squibb, and David A. Evans, Harvard University

Novartis Lecture in Organic Chemistry—Philip A. Cole, Johns Hopkins University School of Medicine

The Dow Lectures in Physical Chemistry—Richard Mathies (University of California, Berkeley)

The Alan S. Michaels Distinguished Lectureship in Medical and Biological Engineering—David Tirrell, California Institute of Technology

The Dow Lecture in Organic Chemistry—Karen Wooley, Washington University in St. Louis

Merck-Karl Pfister Lectures in Organic Chemistry—Roeland J. M. Nolte, University of Nijmegen

Undergraduate Education

In the area of undergraduate education, 27 students graduated in June with BS degrees in chemistry. The 2006 Undergraduate Spring Awards Banquet was held on Thursday, May 17, 2007, in the MIT Museum. The following awards were presented:

Alpha Chi Sigma Award, for distinguished scholastic achievement, originality, and breadth of interest in chemistry—Erin McNeil, Lars Plate, Mandeep Virdi

Research Award for outstanding contributions in the area of research—Kapil Amarnath, Karen Condon, Amy Weeks

Frederick D. Greene Teaching Award—Lars Plate

Merck Index Award for outstanding scholarship—Sergio Bacallado

Hypercube Scholar Award in recognition of outstanding contribution to the advancement of computational chemistry—Joel Yuen

Outstanding Thesis Award—Mandeep Virdi

Strem Award, in recognition of the best undergraduate research presentation at the UROP Symposium on May 12, 2007—Brian Sparling

ACS Analytical Chemistry Award for an outstanding analytical chemist (junior year)—Paresh Agarwal, Emily Tsui

Sophomore Achievement Award for outstanding performance in academics, research, and service to the department—Annelise Beck, Stephen Fried

CRC Freshman Chemistry Achievement Award for outstanding academic achievement in chemistry—ChungYang "Dennis" Huang

New Initiatives for 2007–2008

Recent revolutionary developments in chemistry required a new paradigm for teaching laboratory skills and technique. This year, we retired the old lab sequence of 5.311, 5.32, and 5.33, and launched Undergraduate Research Inspired Experimental Chemistry Alternatives, or URIECA. URIECA will introduce students to cutting-edge research topics in a new modular format. Based on or linked to the current research of chemistry faculty, URIECA modules will teach core chemistry concepts within the modern contexts of synthesis, catalysis, nanoscience, materials science, biological imaging, and spectroscopy. Leading this effort is the new URIECA lab director, Dr. Mariusz

Twardowski. Dr. Twardowski, who comes to us from both academia and industry, is looking forward to the challenge of launching URIECA.

Next fall, our sophomore majors will engage in four new modules: Fundamentals of Spectroscopy (based on the research of Professor Keith Nelson), Synthesis of Coordination Compounds and Kinetics (based on the research of Professor Richard Schrock), Fabrication of a Polymeric Light-Emitting Device (based on the research of Professor Timothy Swager), and Organic Structure Determination (based on the research of Professors Steve Buchwald and Greg Fu and developed by Professor Rick Danheiser). With a total of 12 modules, the remainder will be rolled out over the next two years. For more information about URIECA (and there is much more than can be included here), go to http://web.mit.edu/chemistry/www/academic/urieca.html/.

Another new initiative being launched next fall comes through a Howard Hughes training grant. Catherine Drennan and Keith Nelson will be expanding the 5.111 Principles of Chemical Science curriculum to include illustrative examples of how chemistry affects and relates to the fields of biology and medicine. Helping them in this initiative are Dr. Elizabeth Vogel and Dr. Danny Yun, postdocs in the department.

ClubChem

ClubChem remains an important social group for our majors. Thanks to the generous support of James K. Littwitz (1942), ClubChem has been able to offer many events to promote community among our majors. During the past year, they held weekly study breaks and dinners with professors, and they are beginning to breathe new life into the chemistry magic show. ClubChem officers also established a blog, photo gallery, and academic calendar. All can be found at the ClubChem homepage (http://mit.edu/clubchem/www/).

UROP

The Undergraduate Research Opportunities Program (UROP) remains the quintessential chemistry experience among our majors. Many of our exiting seniors tell us that their UROP was the single most important aspect of their degree program. This past year, approximately 90 percent of our majors worked on a UROP project. Listed below is a small sample of their publications this past year.

Graduate Education

Last year marked the 100th anniversary of the first PhDs being conferred at MIT. Commencement 2007 honored 37 PhDs from September 2006 through June 2007. In fall 2007, 43 students will enter the graduate program of the Chemistry Department.

Graduate Students Awards and Honors

Ryan Altman, Buchwald Group—Ruth L. Kirschstein National Research Service Award (NIH Predoctoral Fellowship)

Trisha Andrew, Swager Group—Corning Fellowship, Morse Travel Grant

Maskym Artomov, Chakraborty Group—David A. Johnson Award

Forrest Arp, Fu Group—Merck Summer Fellowship

Wesley Austin, Danheiser Group—Kenneth M. Gordon Scholarship

Vik Bajaj, Griffin Group—Morse Travel Grant

Marvin Bayro, Griffin Group—Morse Travel Grant

Kyle Bittinger, Field Group—David A. Johnson Award

Jiejin Chen, King Group—Morse Travel Grant

Kee-Hyun Choi, Licht Group—Morse Travel Grant

Brandi Cossairt, Cummins Group—Strem Summer Graduate Fellowship

Eric Dane, Swager Group—C.P. Chu and Y. Lai Summer Fellowship

Jeremy Evans, Van Voorhis Group—David A. Johnson Award

Alexander R. Fox, Cummins Group—Alan Davison Graduate Fellowship for 2007–2008

Victor Gehling, Jamison Group—Morse Travel Grant

Michael Goldberg, Langer Group—Morse Travel Grant, AstraZeneca Graduate Fellowship

Francis H. González, Essigmann Group—Ford Foundation Diversity Scholarship

Evan Guggenheim, Lippard Group—Koch Graduate Fellowship

Matthew Hill, Movassaghi Group—MIT Wyeth Scholar Award, Amgen Summer Fellowship, Morse Travel Grant

Hao Huang, Bawendi Group—Morse Travel Grant, David A. Johnson Award

Alan Hyde, Buchwald Group—2007 Sigma Aldrich Graduate Student

Heather Lanman, Buchwald Group—NSF Predoctoral Fellowship

Józef Lewandowski, Griffin Group—Morse Travel Grant

Katie Lovejoy, Lippard Group—Student Award from the International Precious Metals Institute

Zhe Lu, Fu Group—Selected to be a member of the Martin Family Society of Fellows for Sustainability for the 2007–2008 academic year

Langdon J. Martin, Imperiali Group—Wyeth Scholarship

Scott Meek, Swager Group—Morse Travel Grant

Chris Morten, Jamison Group—George Buchi Summer Graduate Fellowship

SzeSze Ng, Jamison Group—Bristol-Myers Squibb Graduate Fellowship 2006–2007, Eli Lilly Graduate Fellowship 2007–2008, MIT Wyeth Scholar Travel Grant 2007

Alison Ondrus, Movassaghi Group—Roche Excellence in Chemistry Award, Morse Travel Grant

Vladimir Petrovic, Field Group—Morse Travel Grant

Julia Robinson, Danheiser Group—NSF Graduate Fellowship

Michael A. Schmidt, Movassaghi Group—Bristol-Myers Squibb Graduate Fellowship, Morse Travel Grant, Wyeth Travel Grant

Christian Schubert, Kemp Group—Daniel S. Kemp Summer Graduate Fellowship

Changsik Song, Swager Group—Morse Travel Grant

Adam Steeves, Field Group—2007 Coblentz Society Student Award

Meiliana Tjandra, Movassaghi Group—2006 Novartis Graduate Fellowship in Organic Chemistry for Minorities and Women

Brett Van Veller, Swager Group—David A. Johnson Award

Jessica Vey, Drennan Group—Morse Travel Grant

Brian Walker, Bawendi Group—NSF Graduate Fellowship

Jun Wang, Stubbe Group—David Koch Graduate Fellowship from MIT Center for Cancer Research

Research Highlights

Rick Danheiser

Research in the Danheiser laboratory in the past year has resulted in the development of an exceptionally environmentally friendly method for synthesizing amides, the key functional group found in peptides and many organic compounds of biological and medicinal interest. New benzannulation strategies have been developed, leading to highly substituted aromatic and heteroaromatic compounds such as indoles.

Cathy Drennan

In the September 12, 2006, issue of *PNAS*, the Drennan group describes the structures of the *E. coli* nickel regulatory protein NikR in all three states: apo, nickel-bound, and in complex with DNA. Interestingly, these structural comparisons suggest that nickel exerts its effect through short-range communication within the regulatory domains, rather than through long-range communication to the DNA binding domains, challenging the current dogma in the field of ligand-mediated transcription factors.

Barbara Imperiali

Research in the group focuses on developing innovative chemical tools for the study of complex biological systems with spatial and temporal resolution. In particular, methods for sensing kinase activities using environment-sensitive and chelation-enhanced fluorescence and the generation of caged phosphopeptides and proteins are being developed for studies of cell migration, cell cycle control, and the regulation of synaptic plasticity. Major progress has also been made in the application of lanthanide-binding tags in structural and functional proteomics. Research on the comparative analysis of eukaryotic and prokaryotic protein glycosylation is ongoing.

Timothy F. Jamison

The theme of the Jamison group's research is the discovery of new chemical reactions of broad utility. In the past year, they developed several that significantly simplify the synthesis of several classes of important complex organic molecules. With an eye toward energy and environmental issues, they are currently developing catalytic reactions that convert (rather than generate) carbon dioxide into molecules useful for many applications, including polymers. They also discovered that water is the optimum promoter of a chemical reaction long sought by the chemistry community, and this work will soon appear as a research article in *Science*.

Stephen J. Lippard

DNA cross-links formed by the anticancer drug cisplatin phases nucleosomes, overriding natural positioning sequences in the DNA. Attachment of a cisplatin pro-drug to single-walled carbon nanotubes facilitates entry of platinum into testicular cancer cells. The resulting "longboat" construct is more effective at killing cancer cells than an equivalent amount of cisplatin. The crystal structure of the enzyme phenol hydroxylase bound to its regulatory protein was determined. A dual MRI/fluorescent agent for imaging intracellular mobile zinc was prepared.

Mohammad Movassaghi

Professor Movassaghi's research program continues to focus on the development of new strategies and technologies relying on a cascade bond-forming reaction for synthesis of complex molecules. They have completed the total synthesis of three optically active calycanthaceous alkaloids, in addition to three dimeric and complex diketopiperazine alkaloids, using a new cobalt-promoted dimerization strategy for complex alkaloid synthesis. These syntheses provide the most concise solutions to these complex alkaloids. In the context of our synthetic studies, they have developed several new chemical transformations, including the development of a practical reagent for reductive deoxygenation of alcohols. They have continued to develop new and practical methodologies for the rapid synthesis of important azaheterocycles that are ubiquitous in natural products, pharmaceuticals, and functional materials. These include new highly practical methods to access pyridines, pyrimidines, quinolines, and quinazolenes.

Sarah E. O'Connor

Professor O'Connor's research focuses on elucidating and reengineering the biosynthetic pathway of terpene indole alkaloids, a complex metabolic pathway responsible for the production of hundreds of pharmaceutically important alkaloid natural products. They have shown that this pathway can support the production of "unnatural" natural products. Current efforts are focused on assessing the biological activity of the unnatural products, further reengineering the pathway in the plant Madagascar periwinkle, and identifying additional genes involved in the pathway.

Richard R. Schrock

Professor Schrock's research is in the area of high oxidation state early metal organometallic chemistry and is sponsored by the National Science Foundation and the National Institutes of Health (NIH). He is also sponsored by the Army and the Department of Energy in the area of controlled polymer synthesis. Finally, the NIH also supports a project concerned with reducing molecular nitrogen at room temperature and pressure.

Timothy M. Swager

The Swager group continues to innovate in the area of chemical sensors for security applications and last year developed novel optical methods to detect the high explosives RDX and PETN. In the coming year, they will be placing increasing emphasis on electrical sensors based on carbon nanotubes. These senors are inexpensive to produce and can be easily assembled into wireless, low-power, distributed networks that have the potential to preemptively locate threats in urban environments.

Alice Ting

The Ting lab designs and synthesizes molecular reporters for imaging specific biomolecules and biochemical events in living cells. Recently, in collaboration with Moungi Bawendi's group, they have created small and monovalent quantum dots suitable for single-molecule fluorescence imaging of any receptor on the surface of living cells. They are using these quantum dots to study trafficking of the AMPA-type glutamate receptor during synaptic remodeling in the brain. Other ongoing work includes the development of new site-specific protein labeling methods and techniques to deliver nanoparticles into living cells.

Andrei Tokmakoff

The Tokmakoff group studies time-dependent changes of molecular structure in chemical reactions and biophysical processes. Ultrafast two-dimensional infrared spectroscopy was used to characterize changes in the hydrogen-bonded structure of liquid water and describe the mechanism of protein folding. Ongoing studies seek to characterize the mechanism of proton transfer through water and understand the interactions of proteins and peptides with water.

Timothy M. Swager
Department Head
John D. McArthur Professor

More information about the Department of Chemistry can be found at http://web.mit.edu/chemistry/www/.