MASSACHUSETTS
INSTITUTE
OF TECHNOLOGY

Chemical Engineering Alumni News

Spring 2008
Course X

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FROM THE HEAD OF THE DEPARTMENT...

Professor Klavs F. Jensen
Head, MIT
Chemical Engineering

Welcome to the Spring 2008 edition of the Alumni Newsletter. The department continues to maintain its leadership role in the profession, with high productivity and visibility in education and research. As a measure of the vitality of our sponsored research programs, expenditures were over $27 million for the fiscal year ending June 30, 2007. Moreover, several new research initiatives are starting, including several in energy conversion and pharmaceutical manufacturing.

Faculty are actively participating in the MIT Energy Initiative (MITEI) with Bob Armstrong as the Initiative's Deputy Director and Jeff Tester co-chairing the Education task force. Jeff also coauthored the study, "The Future of Geothermal Energy," sponsored by the U.S. Department of Energy. Greg McRae and János Beér were members of the interdisciplinary MIT study, "The Future of Coal - Options for a Carbon Constrained World." Greg Stephanopoulos and Kristala Prather play key roles in the biofuels research. Bill Green co-chairs the newly funded BP Advanced Conversion Research Project, which also involves Paul Barton and Michael Strano, among others. Along with Paula Hammond, Michael is also active in MITEI's research on nanomaterials for solar power. The students are also engaging challenges of energy conversions. For example, senior chemical engineering students contributed to the coal study through their capstone design project in integrated chemical engineering (ICE). Furthermore, junior Joe Roy-Mayhew was part of the team "Biodiesel@MIT" that won the GE/MTVU's Ecomagination Challenge. More details about these research activities appear in the newsletter.

On September 28, 2007, Dr. Daniel Vasella, Chairman and CEO of Novartis, and MIT President Susan Hockfield inaugurated the Novartis-MIT Center for Continuous Manufacturing. The Center combines the industrial expertise of Novartis with MIT scientific and technological innovation with the aim of transforming conventional batch-based systems in the pharmaceuticals industry to continuous manufacturing processes. Novartis will invest $65 million in research activities at MIT over the next 10 years. Bernhardt Trout, who skillfully led the formation of the center, is the center's director; the initial research projects involve additional faculty from chemical engineering (Charlie Cooney, Alan Hatton, Greg McRae, myself) and chemistry. Bernhardt also co-chairs the Department of Chemical Engineering's Singapore–MIT Alliance-II program, Chemical and Pharmaceutical Engineering, which focuses on metabolic engineering, chemical catalysis, and downstream processing relevant to pharmaceutical research and manufacturing.

Arup Chakraborty has established a new consortium (funded by the NIH) called the Immune Response Consortium, which involves nine principal investigators from seven institutions. This consortium brings together theory and computation (based on statistical physics and engineering analysis of chemical kinetics) with genetic, biochemical, and imaging experiments to understand the mechanisms underlying T cell activation. Arup also won the NIH Director's Pioneer Award to initiate a major new research direction aimed toward understanding the principles underlying T cell mediated autoimmunity.

The department faculty continues to show leadership and participation in established programs. Bob Cohen and Karen Gleason are associate directors in the DuPont MIT Alliance and Institute for Soldier Nanotechnology, respectively. Both successful programs are now in their second five-year funding cycles. Charlie Cooney is the faculty director of the Deshpande Center for Technological Innovation, which supports projects in a wide range of emerging technologies, including several sponsored projects in chemical engineering. George Stephanopoulos is the co-director of the newly formed BP Operations Academy, which parallels the BP Projects Academy in which Charlie Cooney and Greg McRae have been active participants.

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ChemE graduate students Joel Moxley and Andy Peterson walk sand dunes in Saudi Arabia (Page 20).

ALSO IN THIS ISSUE:

Practice School News

By Professor T. Alan Hatton

The David H. Koch School of Chemical Engineering Practice has provided a unique opportunity for generations of chemical engineers (over nine decades worth!) to hone their technical leadership skills through augmentation of on-campus academic coursework with immersion in high-profile industrial projects at host company sites. And we continue to do so, attracting top students from around the country and the world to participate in the program. During the summer of 2006, sixteen students attended stations in Minneapolis, MN; Billerica, MA; and Basel, Switzerland. For the 2006-2007 academic year, 15 students worked on projects in Minneapolis, MN; Harlow, UK; and Basel, Switzerland. Thank you to our host companies who have helped provide the kind of education that only these hands-on, real-world challenges can offer!

The Stations

The number of companies with whom we have worked over the past year have provided our students with exposure to a variety of different industrial practices and a range of different technical challenges as described briefly.

The Cabot Station, Billerica, MA (Summer 2006), Directed by William Dalzell

Cabot Corporation hosted the Practice School for the months of June and August 2006. Cabot is the world's leading producer of carbon black, which is used in tires, other rubber products, and elastomers. They also make fumed metal oxides, inkjet pigments, and specialty metals and fluids. In June, the projects involved a study of the kinetics of rubber vulcanization using HPLC, the mechanism of how dispersants and low polarity liquids interact with small particles, and the kinetics of the reactions involved in modifying the surface chemistry of pigments. The working environment at Cabot is highly technical, enthusiastic, and interactive. Billerica is home to some great restaurants including an excellent Indian restaurant and one of the best Chinese restaurants in the Boston area.

The Cargill Station, Wayzata, MN (Summer 2006), Directed by Robert J. Fisher

Cargill is an international provider of food, agricultural, and risk management products and services with 124,000 employees in 59 countries. The Cargill brand may not be readily recognized by consumers in the United States since the corporation may best be described as a commodities supplier in this market. Their products are well known to farmers, livestock producers, food manufacturers, food service distributors and retailers, pharmaceutical and dietary supplement companies, and investors.

This latest station involved working on a total of six projects with the **Process Solutions Technology Development Center**. The projects selected by Cargill afforded us opportunities to learn a great deal and provided useful input to their corporate mission. In the first session the projects covered the range of Cargill's Project Delivery Process, which advances through feasibility, development, and product/process launch phases. Our assignments involved a conceptual design/feasibility study for the utilization of reactive distillation coupled with unique processing steps to improve a bio-based production system, proof-of-concept experiments for implementing a new strategy in a pilot plant aimed at improving product quality for a better market edge, and development of dynamic models used to evaluate process intensification systems. The second session involved three projects, each requiring significant reaction engineering skills. Catalyst deactivation, reactor design and performance evaluations were the focal points. Pilot plant and laboratory scale studies were performed. The former was a continuation project and focused on energy savings while the two lab scale efforts were directed to optimize performance of vendor-suggested alternatives for (1) a catalytic process and (2) a resin based separation scheme.

The Novartis Station, Basel, Switzerland (Summer 2006, Spring 2007), Directed by Claude Lupis

Eight students attended the station over the summer of '06, which was our fifth session at Novartis and the third in Basel, Switzerland. The first session was devoted to two projects and the group was divided into two teams of four. The first project focused on potential opportunities offered by nanotechnologies for the pharmaceutical industry, while the second project investigated recent advances in production technologies that could benefit production processes at Novartis. In the second session, four projects were undertaken by four teams of two. The projects ranged from the development of online sensors for chemical analyses and particle size distributions to the stability testing of an active pharmaceutical ingredient and the development of an economic model to assess the improvements made to a process through the several stages of its development.

The excellent support from the Novartis staff, despite the fact that many were away due to the summer holidays, greatly assisted the work of the students. Their hospitality was also much appreciated. The Swiss countryside is well

renowned for its beauty and the MIT group went on several excursions throughout the country, including one to the top of the Jungfrau, the "Summit of Europe". The company provided bicycles to the students and the daily commuting by bike for several of the students became one of the highlights of their stay. The experience of living and working in a European country also proved to be a most valuable experience in broadening their perspectives.

During the Spring '07 session, the station and our offices were located at the Novartis campus of St. Johann in Basel, but the projects were conducted at three different sites: Stein, Schweizerhalle and Huningue (France). Six students attended the station and conducted four projects that were as varied as their locations. They ranged from measures of production efficiency and optimization of product yield to investigation of high pressure water cleaning systems and application of new software to production scheduling. Interesting results were obtained, which should prove fruitful to the company.

Basel is famous in Europe for its ancient masked carnival, "Fasnacht", a three-day affair starting on the Monday after Mardi Gras, at 4a.m., with a magical parade of drum-and-pipe bands carrying huge illuminated lanterns through the city. Some 12,000 people take part under the auspices of several hundred musical bands. That was certainly one of the highlights of our stay. Another was the visit to Colmar, a wonderfully picturesque little city in nearby in Alsace, France.

The Novartis Practice School team takes a well-earned break in Geneva, Switzerland.

The General Mills Station, Plymouth, MN (Fall 2006 and Spring 2007), Directed by Robert J. Fisher

General Mills has provided numerous Practice School projects over the years focused on improvements in its recognized cereal brands.

During the Fall '06 session, two projects were related to automated filling operations that required development of flow characteristics, residence time distributions, and ANOVA studies for a multi-phase flow system. High particle to fluid ratios and large size and shape distributions contributed to the need for complicated analyses. Operational maps and scale-up criteria were major deliverables. Transport mechanisms and concentration profiles within the multiple components of a food matrix comprised two other projects. The puffing characteristics of one major component were a dominant feature of these studies. Also, product appearance and fracture stability were constraints imposed, and appropriate system metrics needed to be developed. Process identification and control strategies for a continuous process developed for a new product line were another project. Process intensification was the major motivation. Technology assessment and determining mechanisms involved comprised our major emphases. Optimum control strategies were developed for the pilot plant and scale-up criteria suggested. Incorporation of reaction kinetics, thermodynamics, and transport phenomena concepts helped establish performance evaluation criteria for a new baked goods product line being developed. Product preparation by the consumer in a ready-to-cook package, along with shelf life stability, became major assessment criteria. Experimental protocols and performance metrics were established to meet project objectives and useful deliverables.

In Spring '07, we worked on four projects since only six students were assigned to the station. Two projects involved a coating operation with subsequent drying. The objectives were to obtain operational conditions that establish desired ranges of product appearance. This required understanding material property characteristics such as development of nucleation sites and crystal growth kinetics versus amorphous phase generation. The Design of Experiments technique was employed to determine process control variables along with the development of mechanistic models based on the fundamentals associated with energy input schemes and transport processes. The other two projects involved technology assessment of a novel fluid bed system. The operational principles are confidential; however some general comments can be made. Start-up procedures were critical, as was establishing operational maps for various shapes and sizes of products. Scale-up criteria were also significant deliverables. Residence time distribution studies played a key role in understanding performance and subsequent system reconfigurations. Particle to particle moisture distribution determines the product stability to a much greater extent than expected from prior product studies. This is due to the unique characteristics resulting from the nutraceutical nature of key components present.

Practice School News

The GlaxoSmithKline Station, Harlow, United Kingdom (Fall 2006), Directed by Claude Lupis

This was our second station at GSK, and as for the first, was located in Harlow, England, halfway between London and Cambridge. Eight students participated. In the first session, three projects were conducted: the first analyzed current techniques for the extraction of drugs from tablets (in the context of quantitative assays), the second was on the use and control of ultrasonic energy, while the third investigated factors that govern throat deposition for dry powder inhalers. The second session also included three projects: on surface area measurements, on an analysis of agglomeration and deagglomeration mechanisms, and on an investigation of the effects of a coating on the dissolution characteristics of a tablet.

The location of the station provided endless opportunities for sightseeing. In addition to London, a tour of Cambridge proved particularly interesting when guided by an American scientist, retired from GSK, who knew intimately the history of the city and of its luminaries (e.g., Isaac Newton). A "pub quiz" proved also to be an entertaining interlude. Two teams were formed: the "junior team", formed by the students, was named "Born in America", while the "senior team", comprised of the GSK coordinator, David Rudd, and family, the Station Director and his wife, was named "The Brits Are Coming". The senior team won first prize (thanks to the inexhaustible knowledge of David Rudd) while the junior team won the "booby prize"!

Practice School Awards Banquet

Once again, we held an Awards Banquet for the Practice School, attended by about 150 diners, including industrial sponsors, MIT administration officials, and students, faculty and staff from our Department. Following a very interesting and informative slide show by our after-dinner speaker, David H. Koch, who regaled us with stories of his family and the development of Koch Industries (one of the most successful privately-owned companies ever), we presented a number of awards to students for outstanding performance in the Practice School projects. The recipient of the **Vivian Award** were Nicholas Stephanopoulos and Saurabh Tejwani. Ravikanth Annavarapu was rewarded for his enthusiasm for the program by receiving the **Tester Award**. Arman Haidari was recognized for his personal generosity, integrity and commitment to the program through the **Wojtowicz Award**. Finally, Anusha Kothandaraman received the **Rousseau Award** for Leadership and Ethics in Chemical Engineering Practice.

A Final Note

At a recent Practice School Station in East Hanover, NJ (details to be provided next year!), students summarized their experience at the Novartis site with the following slide:

Practice School Experience @ Novartis

9 students…
24 presentations…
147 new friends…
536 pages of report…
5,763 work-hours…
and infinite fun !!!

and that about sums it up for what the Practice School is all about. □

Professor Klavs Jensen from page 1

These research initiatives represent a small sample of the many activities that keep the faculty very busy and contribute to the challenges of focusing on chemical engineering locally at MIT. A department-centered approach is critically important to maintain MIT chemical engineering leadership in a vibrant discipline for the future. This balance between opportunities and responsibilities to the department requires attention and commitment from everyone.

Faculty renewal is a related challenge. We have to find ways to enable intellectual growth for faculty and attract top talent. This year we are fortunate to welcome two new faculty members to the department, John Christopher Love and Michael S. Strano. Chris Love received his PhD in chemistry with George Whitesides at Harvard University and was a post-doctoral associate at Harvard Medical School and the CBR Institute for Biomedical Research, Boston Children's Hospital, with Hidde Ploegh. Chris uses tools from materials science and surface chemistry to develop micro- and nanotechnologies that broadly enable quantitative analysis of the behaviors of both single cells and complex, multicellular systems. Michael Strano received his PhD in chemical engineering with Henry C. Foley at the University of Delaware and was a post-doctoral associate at Rice University with Richard Smalley. In four years as an assistant professor at the University of Illinois, Michael has developed a large research program in the broad area of nanotechnology. He has specifically focused his attention on synthesis, characterization and separation of carbon nanotubes and their assembly into sensors and electronic devices. More information about Chris and Michael are given on page 8. The department's ability to attract such top candidates depends critically on the space and start-up packages we are able to provide. Your alumni contributions are a major factor in our ability to fund new faculty - thank you.

Facilities continue to be a major challenge for the department. As Executive Officer, Greg Rutledge masterly handles the difficult task of managing our limited space resources. The building infrastructure is beginning to show its age. The heat and ventilation systems have never been great, but now they have major problems. You probably remember the many unintended opportunities for conversation or exercise created by an unreliable elevator system. We are working with the department's Visiting Committee and MIT central administration to formulate plans for upgrading the department facilities or even getting new space. This will be a long term effort for which we would appreciate your support.

The new Dean for the School of Engineering, Subra Suresh, former Head of Materials Science, has started a planning process to set directions and priorities for the School. As part of this effort, chemical engineering is updating its long range plan from 2005. The challenges of leading the discipline, keeping focused on delivering top quality education, performing pioneering research, faculty renewal, and space improvements will all be part of this process. We welcome your input on how the department can continue to improve its leadership in education and research.

The ability to attract the very best graduate students is critically important. Thanks to the efforts of Paula Hammond and the graduate committee, we had the best year ever in terms of acceptance of our offers. Paula Hammond is stepping down after three successful years of recruiting to chair the Institute's Initiative on Faculty Race and Diversity, in addition to the myriad of challenges associated with running her large research group. This MIT-wide initiative explores how race affects the recruitment, retention, professional opportunities, and collegial experiences of underrepresented minority faculty members. Its findings will help the department in its efforts to increase the representation of underrepresented minority on the faculty and among the graduate students. The department is grateful to Paula Hammond for her hard work on graduate recruiting and to Arup Chakraborty for accepting the challenge to continue the effort.

The generous external support to the Practice School and our doctoral program by you, our alumni, through graduate fellowships is an essential asset in our effort to attract the very best students. We are truly indebted to you for your ongoing commitment and support. Beyond its value as a recruiting tool, funding for graduate fellowships is an essential element of our graduate educational philosophy. By providing fellowship support for Practice School students and first year doctoral students, we enable them to focus on the core subjects of chemical engineering and explore the breadth of research opportunities before choosing a thesis topic.

The faculty members continue to distinguish themselves, and the months since the previous Newsletter has produced an extensive list of faculty achievements and awards. Bill Green was promoted to full professor (see page 8). To name just a few of the many awards, Bob Langer received the National Medal of Science from President Bush. The American Chemical Society also honored Bob with two 2007 awards: the ACS Award in the Chemistry of Materials and the Herman F. Mark Award from the ACS Division of Polymer Chemistry. Greg Stephanopoulos earned the 2007 Society for Industrial Microbiology's Charles Thorn Award, Paula Hammond was elected as a Fellow of the American Physical Society and Doug Lauffenburger received the 2007 Pierre Galletti Award from the American Institute for Medical and Biological Engineering. Arup Chakraborty was elected a Fellow of the American Academy of Arts and also won the Secretary of Energy's E.O. Lawrence Award for Life Sciences. He received this award from illustrious graduate of the department and former Practice School director, Samuel Bodman (ScD '65), U.S. Secretary of Energy.

We hope you enjoy this issue of the newsletter. Please do write to us to let us know how you are doing and how we can continue to improve. Thank you for your support and best wishes for the coming year. ▫

2006 Chemical Engineering Fellowships

Alkermes Fellows
Arvind Prabhakar
IIT Madras
Jingjing Xu
Beijing Univ. of Chem. Tec.

Bayer Professorship
Ying Diao
Tsinghua Univ.

Frederic A. L. Holloway '39 Fellow
Ashleigh Hildebrand
Oklahoma State Univ.

ChE Practice School Fellows
Nicholas Cordella
MIT
Timothy Gandler
Arizona State Univ.
Graham Good
Tufts Univ.
Steven Sha
Stanford Univ.
James Turco
Tufts Univ.
Gregoire Villeroy de Galhau
Ecole Polytechnique

Edwin R Gilliland '33 Fellow
Miles Barr
Vanderbilt Univ.

John Henry Grover (1948) Fellow
Kenneth Hu
Carnegie-Mellon Univ.

Haas Family Fellows
Abhinav Akhoury
IIT Bombay
Mahriah Alf
Univ. of Wisconsin - Madison
Diana Bower
Pennsylvania State Univ.
Ashleigh Hildebrand
Oklahoma State Univ.
Kenneth Hu
Carnegie-Mellon Univ.
Michael Johnson
Univ. of Illinois-Urbana-Champaign
Chien Pang Lin
Univ. of Rochester
Fernando Gutman Pogoriles
Univ. of Puerto Rico

Robert T Haslam (1911) ChemEng Fellows
Tek Hyung Lee
Seoul National Univ.
Nicholas Musolino
Cooper Union
Hsien-chung Tseng
National Taiwan Univ.

George M Keller (1948) Fellows
Fei Liang
Dalian Univ. of Tech.
Jordi Mata-Fink
Stanford Univ.

George M. Keller (1948) Chevron Fellow
Fernando Gutman Pogoriles
Univ. of Puerto Rico

David H. Koch (1962) Fellows
Tanguy Chau
UC Berkeley
David Couling
Univ. of Notre Dame
Jonathan DeRocher
Univ. of Minnesota - Minneapolis
Jaroslav Keybl
Univ. of Pennsylvania
Gregory Magoon
Univ. of Connecticut
Lam Markely
Univ. of Wisconsin - Madison
Kevin Nagy
Georgia Inst. of Tech.
Geoffrey Oxberry
Univ. of Delaware
Katherine Schadel
North Carolina State Univ.
Kevin Solomon
McMaster Univ.
Nathan Trujillo
UC San Diego
Christopher Zopf
Columbia Univ.

Jerry (1940) & Geraldine Mcafee Fellows
Priyadarshi Panda
IITKanpur
Anita Shukla
Carnegie-Mellon Univ.

MITSCEP 1936 Course Xa Fellow
Mitchell Tai
Carnegie-Mellon Univ.

R. C. Reid (1954) & G. Williams Fellow
Mahriah Alf
Univ. of Wisconsin - Madison

Charles And Hilda Roddey Fellow
Stephanie Freeman
Univ. of Arizona

William & Margaret Rousseau Fellows
Eric Pridgen
Univ. of Delaware
Joseph Scott
Wayne State Univ.

Keith And Helen Rumbel Fellows
Diwakar Shukla
IIT Bombay
Ming Yang
National Univ. of Singapore

Adel F. Sarofim (1962) Fellow
Diana Bower
Pennsylvania State Univ.

Arch Chilton Scurlock (1943) Fellow
Chien Pang Lin
Univ. of Rochester

John C Sluder (1941) Fellow
Su Kyung Suh
Pohang Institute fo Sci. and Tech.

H. (1953) & L. Stern Practice School Fellow
Abhinav Akhoury
IIT Bombay

Frank Hall Thorp Fellow
Andres Abin-Fuentes
Univ. of Minnesota - Minneapolis

Rosemary Wojtowicz Fellow
Michael Johnson
Univ. of Illinois-Urbana-Champaign

DuPont Fellows
Kevin Nagy
Georgia Inst. of Tech.*
Katherine Schadel
North Carolina State Univ.

DuPont Presidential Fellow
Jason Rich
Cornell Univ.

Robert T Haslam (1911) Presidential Fellows
Jaroslav Keybl
Univ. of Pennsylvania
Geoffrey Oxberry
Univ. of Delaware
Christopher Zopf
Columbia Univ.

Lemelson Minority Engineering
Andres Abin-Fuentes
Univ. of Minnesota - Minneapolis

Lemelson Presidential Fellow
Kevin Solomon
McMaster Univ.

Walsh (1937) Memorial Presidential Fellows
Jonathan DeRocher
Univ. of Minnesota - Minneapolis
Tanguy Chau
UC Berkeley
David Couling
Univ. of Notre Dame
Gregory Magoon
Univ. of Connecticut
Lam Markely
Univ. of Wisconsin - Madison

GEM Fellow
Nathan Trujillo
UC San Diego

NGSEG Fellow
Jason Rich
Cornell Univ.

NSF Fellows
Miles Barr
Vanderbilt Univ.
Jonathan DeRocher
Univ. of Minnesota - Minneapolis
Jordi Mata-Fink
Stanford Univ.
Anita Shukla
Carnegie-Mellon Univ.

Practice School Awards for Outstanding Performance

Rosemary J. Wojtowicz Award
Arman Haidari

J. Edward Vivian Award
Nicholas Stephanopoulos
Saurabh Tejwani

Jefferson W. Tester Prize
Ravikanth Annavarapu

William C. Rousseau Award for Leadership and Ethics
Anusha Kothandaraman

Awards Day

By Mary Wesolowski, Graduate Student Coordinator

The annual Awards Ceremony for the Department of Chemical Engineering was held on Monday, May 14, 2007, in the Gilliland Auditorium. Professor and Department Head, Klavs Jensen, presided over the event.

Professor Jensen began the ceremony by recognizing Chemical Engineering members that have been awarded outside the department.

In collaboration with the Student Financial Aid Office, the **Merck Fellow** was awarded to senior ***Alex Bagley*** from Needham, MA. The **Henry Ford Scholar Award**, given to a senior engineering student who has maintained a cumulative average of 5.0 at the end of their seventh term and who has exceptional potential for leadership in engineering and society, was awarded to ***Adam Madlinger*** from Martinsville, NJ. The **Cunningham Scholar Award**, given to a female engineering student in her junior year to celebrate and promote women in engineering, was awarded to ***Sravanti Kusuma*** from Tucker, GA.

The Infinite Mile Award Program for the Offices of the Provost and the Vice President for Research and Associate Provost is designed to recognize those individuals or teams who have made extraordinary contributions within their own organizations to help the Institute carry out its mission. ***Leia Amarra, Sara Darcy, Edith Jaehne,*** and ***Richard Lay*** from the Administrative Services Office received the **Infinite Mile Team Award** and ***Alina Haverty***, administrative assistant for Professor Jensen, received the **Infinite Mile Award** this year from the School of Engineering.

The **Robert Haslam Cup** was awarded to ***Shyam Raghavan***. He is a senior from Tucson, AZ, and was recognized for outstanding professional promise in Chemical Engineering.

The **Roger de Friez Hunneman Prize** is the oldest in the department and is given to an undergraduate for outstanding scholarship and research. This year the award went to senior ***Michael Zhang*** from Fairfax, VA.

The **Edward W. Merrill Outstanding Teaching Assistant Award** was presented to ***Saurabh Tejwani*** for his work with 10.213 in the Spring. Saurabh is a graduate student from Lucknow, India.

The **Outstanding Graduate Teaching Assistant Award** recognizes excellence in teaching in graduate subjects. This year the award was awarded to two students, ***Kurt Frey*** from Bowling Green, OH, for his work with 10.551 in the Spring and ***Brian Skinn*** from Fairborn, OH, for his work with 10.50 in the Fall.

Saurabh Tejwani receives the Merrill Outstanding Teaching Assistant Award from Professor Jensen.

Each Monday, two graduate students present the progress of their research to be evaluated by their peers. Two graduate students were recognized for giving **outstanding seminars**. This year recognition went to ***Kristen Mattern*** from Schnecksville, PA, for her seminar during the Fall term; ***Salmaan Baxanusa*** from Concord, CA received the award for his seminar during the Spring term.

The **Chemical Engineering Special Service Awards** were given to GSC members ***Wayne Blaylock*** from Crossville, TN, ***Kelly Davis*** from Selinsgrove, PA, ***Gary Chia*** from Sabah, Malaysia, ***Amanda Engler*** from Woodbury, MN, ***Kevin Fowler*** from Richland Center, WI, ***Bo Gong*** from Taiyuan, China, ***Michael Harper*** from Yucaipa, CA, ***Daniel Klein*** from Mexico City, Mexico, ***Chris Marton*** from Ontario, Canada, ***Jonathon McMullen*** from Aliquippa, PA, ***Neidi Negron Rodriguez*** from Ponce, Puerto Rico, and ***Huan Zheng*** from Wayne, NJ. The current AICHE president ***Maxine Yang*** from Cambridge, MA, also received a **Special Service Award**.

The **Chemical Engineering "Rock" Award** for outstanding athletics, as voted by the graduate students of the department went to ***Jordi Mata-Fink***, from Ann Arbor, MI for his active participation in a variety of Intramural sports.

The **Outstanding Employee Award** was presented to ***Mary Wesolowski*** and ***Iris Chang***, administrative assistants for Suzanne Easterly, for their exceptional dedication and contributions to the department.

The **Outstanding Faculty Award** from the graduate students went to Professor ***William Deen***, and was presented by Chris Marton. The undergraduate students presented the **C. Michael Mohr Outstanding Faculty Award**, presented by Maxine Yang, went to Lecturer ***Jean Francois Hamel***.

New Faculty Appointments

In the Department of Chemical Engineering

Assistant Professor J. Christopher Love Welcomed to Faculty

The Chemical Engineering Department is pleased to welcome newly appointed Assistant Professor J. Christopher Love, who joined the department in the Fall of 2007. Professor Love received his BS in chemistry with highest distinction from the University of Virginia in 1999, and was awarded a National Defense Science and Engineering Graduate Fellowship for his graduate work in chemistry prior to arriving at Harvard University. Before joining the MIT faculty, Professor Love did postdoctoral research with Professor George M. Whitesides at Harvard, as well as work at the CBR Institute for Biomedical Research. Professor Love's research uses tools from materials science and surface chemistry to develop micro- and nanotechnologies that broadly enable quantitative analysis of the behaviors of both single cells and complex murlitcellular systems. Two areas that his research aims to impact are the identification of potential therapeutic biologics for use as drugs, and the development of diagnostic assays for monitoring immunological responses to infectious diseases.

Welcome to Associate Professor Michael Strano from the University of Illinois at Champaign-Urbana

Before arriving at MIT in the Fall of 2007, Professor Michael Strano was assistant professor of chemical engineering at the University of Illinois at Champaign-Urbana. He received a BS in Chemical Engineering at Polytechnic University in 1997, and the PhD in Chemical Engineering from the University of Delaware in 2001. Following the completion of his PhD, he spent four years as a visiting scientist at DuPont, and two years as a postdoctoral research fellow with Richard Smalley at Rice University. He then joined the Department of Chemical and Biomolecular Engineering at the University of Illinois as an assistant professor in 2003.

Professor Strano's research program in nanotechnology focuses on how to synthesize, characterize, and separate carbon nanotubes and ultimately assemble them into useful systems and devices for specific applications. He received the Coblentz Award in Molecular Spectroscopy and the Presidential Early Career Award for Scientists and Engineers in 2006, and was recently recognized with the 2007 Dreyfus Teacher Scholar Award.

Professor William H. Green Promoted to Full Professor

Congratulations to Professor Bill Green, who was promoted to full professor in July of 2007. Professor Green's research is in chemical kinetics; he is a leader in the accurate computer simulation of combustion, pyrolysis, and other complicated, technologically important, reactive chemical processes.

Professor Green brings detailed chemistry, quantum mechanical calculations, and advanced numerical methods to bear on technologically important engineering questions. These simulation techniques make it possible to predict chemical kinetics even when no experimental data are available, and thus to design rationally new engines, fuels, and chemical manufacturing processes for improved efficiency and reduced environmental impact. He is also well known for several key experiments with major impacts in the field of kinetics. Among his many original accomplishments to date are describing correctly the pressure dependence of kinetic rate constants, developing group additivity methods to generalize the results for small molecules to those for large molecules of technological importance, adaptively selecting the most important species for inclusion in the model, and developing a novel adaptive chemistry method for reacting flows with complex chemistry.

Professor Green has made many significant contributions to revitalization of the chemical engineering curricula for both undergraduates and graduate students, including development of several new subjects, most notably the new Introduction to Chemical Engineering. He is an enthusiastic and effective teacher in large classroom subjects and in individual mentoring as well. We applaud Professor Green for this well-deserved promotion.

Professor Bernhardt Trout Named Co-Director of SMA-2

On July 1, 2006, Professor Bernhardt Trout became Co-Chair, together with Professor Raj Rajagopalan of the National University of Singapore (NUS), of the Singapore-MIT Alliance's Chemical and Pharmaceutical Engineering Program, or the SMA-2 program.

SMA-2 allows students to obtain a dual (not joint) degree: a master's degree from MIT, as well as a master's or PhD degree from either NUS or Nanyang Technological University (NTU). SMA-2 is characterized by greater collaboration in both research and teaching with increased and significant participation by the Singaporean partner universities.

The Singapore-MIT Alliance (SMA) is an innovative engineering education and research collaboration among NUS, NTU, and MIT. Founded in November 1998 to promote global engineering education and research, SMA brings together the resources of the three academic institutions while providing students with access to faculty expertise and superior research facilities. SMA combines a focus on creativity and entrepreneurship with an intense, hands-on approach to research. Graduates comprise some of the industry's best-educated professionals, both in the growing economy of Singapore and in industrial centers across the globe.

Blast from the Past

Below are photos from the MIT Chemical Engineering archives. Are you or anyone you know in them? Email ***melmils@mit.edu*** if something is familiar!

Students mingle at the 1976 dedication of the Ralph Landau Building (Building 66).

Professor George Stephaopoulos works with graduate students.

A typical Practice School group in the 1950s.

Faculty Awards Highlights

In the Department of Chemical Engineering

Langer Receives Two Awards from the American Chemical Society

In January 2007, ***Professor Bob Langer*** was awarded the ACS Award in the Chemistry of Materials for his work in health-related applications. A nominee must have made outstanding contributions to the chemistry of materials with emphasis on research relating to materials of actual or potential technological importance, where a fundamental understanding of the chemistry associated with materials preparation, processing, or use is critical. Because much of the impact of research depends upon the extension of the work of others, consideration is given to the nominee's success as a mentor and colleague. The award is granted without regard to age or nationality.

Professor Langer also won the 2007 Herman F. Mark Division of Polymer Chemistry Award, which recognizes outstanding research and leadership in polymer science through teaching, research, technical leadership, and scientific writings, granted without regard to race, color, national origin, sex, religion, age, disability, or sexual orientation.

For more about the ACS Award in the Chemistry of Materials:
http://pubs.acs.org/isubscribe/journals/cen/85/i01/html/8501awards.html#8

For more about the Herman F. Mark Division of Polymer Chemistry Award:
http://www.polyacs.org/main/awards.shtml#mark

Chakraborty Garners Three National Honors

Professor Arup Chakraborty, who joined the MIT Chemical Engineering faculty in 2006, earned three honors in the past year. To begin with, he was the first engineer ever to receive the National Institutes of Health (NIH) Pioneer Award, designed to support individual scientists of exceptional creativity who propose pioneering approaches to major challenges in biomedical research.

NIH honored Professor Chakraborty because his research "lies at a crossroad of the engineering, physical, and life sciences. In the past few years, his research group has demonstrated that bringing together statistical mechanical approaches with engineering analyses of chemical kinetics and genetic, biochemical, and imaging experiments (carried out by collaborators in medical schools) can shed light on mechanistic principles underlying the adaptive immune response to pathogens… He plans to use the Pioneer Award to launch new research that aims to use the paradigm of bringing together approaches from different disciplines to develop the principles that govern the emergence of T Lymphocyte-mediated autoimmune diseases (e.g., multiple sclerosis)."

In February 2007, he was honored with the Secretary of Energy's Ernest Orlando Lawrence Award. The Lawrence Award honors scientists and engineers at mid-career for exceptional contributions in research and development that support the Department of Energy and its mission to advance the national, economic and energy security of the United States.

"These brilliant scientists and their varied and important research inspire us," Secretary Bodman said. "Their work reminds us of the importance of continued investment in science and the need for increased emphasis on basic research and math and science education programs."

Lastly, Professor Chakraborty was deemed a 2007 Fellow of the American Academy of Arts and Sciences. His fellowship class included Michael Bloomberg, Mayor of New York City, former vice president Al Gore, and retired Supreme Court judge Sandra Day O'Connor.

For more information about the NIH Pioneer Award, go to: **http://nihroadmap.nih.gov/pioneer/**

For more information about the E.O. Lawrence Award, go to: **http://www.doe.gov/news/4769.htm**

For more information about the American Academy of Arts and Sciences, go to:
http://www.amacad.org/news/alpha2007.aspx

Lauffenburger Wins 2007 AIMBE Galletti Award

Professor Douglas Lauffenburger won the 2007 Pierre Galletti Award from the American Institute for Medical and Biological Engineering (AIMBE). He was cited "for training a generation of bioengineering faculty, establishing an innovative biological engineering program at MIT, writing a seminal text on receptors and exemplary service to bioengineering societies."

The Galletti award, AIMBE's highest honor, recognizes an individual's "contributions to public awareness of medical and biological engineering, and to the promotion of the national interest in science, engineering and education." The last member of the MIT faculty to receive the award was Professor Bob Langer, the initial recipient in 1999.

Hammond Named APS Fellow

Professor Paula Hammond was named a Fellow by the American Physical Society and cited for "her contributions on thin-film patterning of polymers through selective deposition and her studies on side-chain liquid-crystalline block copolymers."

The APS Fellowship Program was created to recognize members who have made advances in knowledge through original research and publication or made significant and innovative contributions in the application of physics to science and technology. Election to this Fellowship is limited to no more than one half of one percent of the membership.

For more on the APS Fellowship Program:
http://www.aps.org/programs/honors/fellowships/

Greg Stephanopoulos Wins 2007 SIM Thorn Award

Professor Greg Stephanopoulos won the Society for Industrial Microbiology's Charles Thorn Award.

This award is given to recognize individuals who have made one or more outstanding research contributions in industrial microbiology and/or biotechnology. These contributions are of exceptional merit, reflecting an independence of thought and originality that adds appreciably to scientific knowledge. Activities such as journal editing, organizing and chairing conferences, and serving scientific societies in official capacities also may be considered when judging research contributions. However, the most important factor in selecting nominees for this Award is research accomplishments.

For more on the SIM Thorn Award:
http://www.simhq.org/meetings/society_awards.aspx

Faculty Distinctions

In the Department of Chemical Engineering

Robert Armstrong stepped down as department head in February, after nearly eleven years of service. He became deputy director of the newly formed MIT Energy Initiative in the Fall of 2007, and is working with the director, Ernest Moniz, in launching the research, educational, campus, and outreach components of the initiative. He received the 2006 Bingham Medal of the Society of Rheology, the Society's highest honor, and presented the Bingham Lecture at the Society of Rheology's Annual Meeting in October. In November of 2006 he received the AIChE Warren K. Lewis Award for contributions to chemical engineering education. During this past academic year, he gave the Bernard Andes Hess Lecture at the University of Virginia, the ConocoPhillips Lecture at Oklahoma State University, the Distinguished Lecture in Engineering at the University of Tennessee, and the Stanley Katz Lecture at the City College of New York. He serves on the advisory boards of chemical engineering departments at Georgia Tech, Northwestern University, Virginia Tech, the University of Washington, the University of Tennessee, and the University of Wisconsin.

János Beér (emeritus) participated in the MIT Coal Study: The Future of Coal. He continued his membership on the National Coal Council, Advisory Council to the US Secretary of Energy, and served on its Study Work Group that produced the Council's Report to the Secretary entitled *Coal: America's Energy Future*. He also served on the National Academies NRC Panel on Integrated Gasification Combined Cycle Technology R&D, as part of the Prospective Evaluation of Applied Energy Research and Development at the DOE.

Daniel Blankschtein's research group conducts fundamental theoretical and experimental research in the area of Colloid and Interface Science, with emphasis on industrially and biomedically relevant applications. Professor Blankschtein's teaching responsibility included the interdisciplinary course 10.55, Colloid and Surfactant Science, which draws students from across the Institute. Professor Blankschtein and his students delivered talks and presented posters at the 2006 AIChE Annual Meeting, and at the 2006 20th European Colloid and Interface Society Conference held in Budapest, Hungary. As a member of the DuPont/MIT Alliance, Professor Blankschtein delivered a tutorial on "Modeling the Bulk Solution Behavior of Surfactants in Aqueous Media" at the DuPont Experimental Station, which was very well attended by DuPont scientists and engineers. He continues to serve on the Editorial Board of Marcel Dekker's Surfactant Science Series.

Robert E. Cohen was named an AIChE Fellow in 2005, and he received his citation in a ceremony at the November 2005 Annual Meeting in Cincinnati. At MIT, he continues to direct the operation of the DuPont MIT Alliance, a broadly based $5 million/year research and education collaboration, now in its seventh year of operation. He also served the Institute for a second year as Chair of the Committee on Nominations, which is charged with the responsibility of staffing the various standing committees of the faculty. His numerous invited and contributed research presentations included a plenary presentation at the Asilomar Conference on Polymers in Pacific Grove, CA. His collaborative research with Professor Michael Rubner of the Materials Department at MIT led to patent applications on novel antifogging coatings, a topic that received widespread attention in the popular press, and in radio and TV coverage. He competed successfully in 2005 for a post in the MIT-Balliol College Exchange Program, and in January of 2006 he took up his position of Visiting Fellow at Balliol. The visiting position also affords access to Oxford University's Department of Engineering Science, the site of Professor Cohen's year of postdoctoral study in 1973.

Charles L. Cooney continued as the Faculty Director of the Deshpande Center for Technological Innovation and chaired the Center's annual IdeaStream Symposium in April 2007. He continued to serve as the co-lead, representing the School of Engineering, in developing the MIT BP Projects Academy in partnership with the Sloan School of Management. Professor Cooney completed a role as Chair of the FDA Advisory Committee for Pharmaceutical Sciences. He is a member of the MIT Community Service Fund Board, the Lemelson MIT Screening Committee, the MIT Committee on Intellectual Property, the Faculty Committee on Staff and Administration and the Search Committee for the Dean of Sloan School. Professor Cooney is also an Overseer of the Boston Symphony Orchestra and a Trustee of the Boston Ballet.

Arup Chakraborty continued his research on T cell activation, and established a new consortium (funded by the NIH) called the Immune Response Consortium (IRC), which involves 9 PIs from 7 institutions. The purpose of the IRC is to bring together theory and computation (rooted in statistical physics and engineering analysis of chemical kinetics) with genetic, biochemical, and imaging experiments to understand the mechanisms underlying T cell activation. Professor Chakraborty also initiated a major new research direction aimed toward understanding the principles underlying T cell – mediated autoimmunity. He gave numerous plenary and invited lectures on his research. Professor Chakraborty's research was recognized by three major awards in the past few months: a] The NIH Director's Pioneer Award, b] The E.O. Lawrence Memorial Award in the Life Sciences, c] Election as Fellow of the American Academy of Arts & Sciences. He also taught a new

interdisciplinary subject (with John Deutch), called Statistical Mechanics with Applications to Chemical and Biological Systems, that was cross-listed by 3 departments. He also (with Klavs Jensen) taught a mandatory subject on chemical reaction engineering for chemical engineering graduate students. Chakraborty is chairing a National Academies panel that is preparing a report on "Biomolecular Materials and Processes" at the request of various government agencies. He has also served on the Visiting Committees of the Chemical Engineering department at Lehigh University and the Chemical, Materials, and Petroleum Engineering department at the University of Southern California.

William Deen continued to serve as Graduate Officer and chair of the Graduate Committee, with oversight responsibility for graduate program policy and for the academic progress and well-being of the Department's graduate students. He was the recipient of the Outstanding Faculty Award for graduate-level teaching, as voted by the students. He gave several invited talks at universities and scientific meetings, including a presentation at a well-attended symposium at the annual meeting of the American Society of Nephrology. His work involves the fundamentals of molecular movement through spaces of molecular dimensions, and the analysis of pathophysiological processes involved in kidney disease and in carcinogenesis.

Patrick S. Doyle was promoted to associate professor without tenure this year. He was invited to give the Thiele Lecture at the University of Notre Dame. In addition, he delivered invited talks at several conferences and institutions including Proctor and Gamble and the University of California at Santa Barbara. He serves as the meeting program chair for the fluid dynamics section of AIChE. His research entails fundamental studies of complex fluids in microfluidic flows and fields.

Karen K. Gleason became the first holder of the Alexander and I. Michael Kasser Chair in the department, continued on in her second year as the associate director of MIT's Institute for Soldier Nanotechnologies (ISN), and also continued on as Chief Scientific Advisor to GVD Corporation, a start-up company she co-founded six years ago. In the past year, she presented the Debye Lecture in the Physics Department at the University of Utrecht, Netherlands, and also gave invited presentations on her group's research on chemical vapor deposition (CVD) technology at the American Chemical Society's Fluoropolymer 2006 Conference (Charleston, SC), at the Materials Research Society Conference (San Francisco, CA), and at the Fourth International Conference on Hot-Wire CVD (Takayama, Japan). Additionally, she was elected to chair the Fifth International Conference on Hot-Wire CVD to be held in 2008.

William H. Green presented new methodology for predicting chemical kinetics as a chapter in Advances in Chemical Engineering, and in invited lectures at Princeton, Rice, University of New Hampshire, University of Pittsburgh, and at the national meeting of the American Chemical Society. His students set up the first experiment in the new Harrison Spectroscopy Laboratory space in Building 6, measuring reactions of unsaturated free radicals with an advanced laser apparatus. He reported detailed kinetics of several organic and inorganic chemical systems in several articles in the Journal of Physical Chemistry and other archival journals, and he continues to serve as Associate Editor of the International Journal of Chemical Kinetics. With Professor Paul Barton, he developed a rigorous method for controlling the error introduced by neglecting less-important chemical reactions in steady-state reacting flow simulations. Professor Green participated in the Department of Energy's workshop assessing the nation's basic research needs in combustion and catalysis. He is currently serving on the Institute committee reviewing MIT's research and teaching programs about the environment.

Paula T. Hammond celebrated her promotion to full professor this year, as she continues her service as the Chair of Graduate Admissions for the department. New developments in the formation of sequential drug delivery thin films led to a second year of funding from the Deshpande Center for Innovation and a landmark paper on the method in the Proceedings of the National Academy of Science. Other new research thrusts include a collaborative effort with Professor Angela Belcher of Materials Science and Biological Engineering in the incorporation and self-assembly of viruses in polyelectrolyte multilayer systems, which led to papers in *Nature Materials and Science* (with Professor Yet-Ming Chiang) in 2006. Exploratory research efforts continued in the development of linear-dendritic block copolymers for drug delivery and nanostructured materials, with new sponsorship provided by the NIH. Professor Hammond delivered lectures at numerous universities, corporations and conferences, including the Japan-American Conference on Hybrid Materials and Nanostructures in Asilomar, CA, the Gordon Conference on Biopolymers at Salve Regina, RI, and the Gordon Conference on Supramolecular Chemistry in Ventura, CA. She also participated in a symposium series on Commercializing Academic Innovation at the Chemical Heritage Foundation and was the keynote speaker for the Robert M. Langer Symposium held at Yale University. She continues to serve as a Team Leader and active researcher in the Institute for Soldier Nanotechnologies.

Faculty Distinctions

Klavs F. Jensen was appointed as Department Head February 1, 2007. He continues his research on functional micro- and nano-structured materials and devices for chemical, optical, and electronic applications. With collaborations in chemistry and biology, he has explored a wide range of microfabricated systems for chemical and biological applications with particular emphasis on systems for which microfabrication provides unique process advantages. Physically based simulations of reactive systems, specifically simulation across multiple lengths and time scales, complement the experimental studies and provide new insight into the underlying physical and chemical rate processes. During the past academic year, he gave invited/plenary lectures at, among others, The 20th International Symposium on Micro-Scale Bioseparations (Amsterdam, The Netherlands), NanoBioSymposium (Tokyo, Japan), PITTCON (Orlando, FL), ACHEMA (Frankfurt, Germany), International Symposium on Microchemistry and Microsystem (Hakone, Japan), 17th International Congress of Chemical and Process Engineering,(Prague, Czech Republic), Workshop on New Avenues to Efficient Chemical Synthesis - Emerging Technologie - Schering Foundation (Berlin, Germany), Workshop on Microfluidics as a New Opportunity for Chemistry, l'Ecole Supérieure de Physique et de Chimie Industrielles (Paris, France), Engineering Foundation Endowed Lectureship at University of Texas, Danish Technical University (Lyngby) and Leermakers Symposium, Wesleyan University (CN). He continued to serve on the scientific advisory board for the Singapore A*STAR Institute for Nano and Biotechnology and on the steering committee for the International Conference on Miniaturized Chemical and Biological Systems. He was awarded an Honorary Technical Doctorate from the Technical University of Denmark.

Robert Langer was elected in 2006 to the National Inventors Hall of Fame and received honorary doctorates from Northwestern University and Albany Medical College. He also received AIChE's Bailey Award, was named the University of Pennsylvania's School of Medicine's Distinguished Lecturer and the Weiss Lecturer at Northeastern University. In 2007, he received an Honorary Doctorate from Yale University, was named the Alexander Rich Lecturer at MIT, the Shucart Lecturer at Tufts University and the Ford Lecturer at Case Western University. He also received both the Herman Mark Award and the Chemistry of Materials Award from the American Chemical Society.

Kristala Jones Prather continued work in the area of synthetic biology, with a specific focus on the design of biosynthetic pathways for microbial production of organic chemicals. She became a principal investigator in the newly established interdisciplinary, multi-university "SynBERC: Synthetic Biology Engineering Research Center." SynBERC was initiated in the Summer of 2006 and is supported by a five-year, $17 million grant from the National Science Foundation. Investigators in the Center are drawn from the University of California, Berkeley (lead); University of California, San Francisco; Harvard University, and Prairie View A&M University, in addition to MIT.

Gregory C. Rutledge continued his role as the Executive Officer of the Department of Chemical Engineering, and served on MIT's Computer Space Task Force and the School of Engineering Gender Equity Committee. He is a member of the editorial board of *Polymer* and is a founding editor of the *Journal of Engineered Fabrics and Fibers*. He serves on the Research Award Selection Committee of the Society of Plastics Engineers and co-organized the Materials Research Society Symposium on Structure, Processing and Properties of Polymer Nanofibers for Emerging Technologies. He delivered keynote lectures at the DECHEMA Conference on Chemical Nanotechnologies in Frankfurt, Germany, Electrostatics 2007 in Oxford, England, and the International Nanofiber Symposium 2007 in Tokyo, Japan. He also presented invited lectures at the University of Marburg, ITW Aachen, University of Washington, University of Oklahoma, University of Leeds, Rensselaer Polytechnic Institute, and the Semenov Institute of the Russian Academy of Sciences. His research involves the molecular engineering of soft matter through the development of molecular simulations, materials characterization, and electrospinning of polymer nanofibers.

Gregory Stephanopoulos was named Visiting Professor of the Institute of Chemical and Bioengineering of ETH Zurich where he spent his sabbatical leave. He also continued his service on the Advisory Boards of 6 academic institutions and the Managing Board of the Society for Biological Engineering (SBE) that promotes the engineering applications of biology to industry and medicine. Professor Stephanopoulos also gave the Amundson Lectures at University of Guadalajara, the McCabe Lectureship at North Carolina State University and the 2007 Lowrie Lectures at Ohio State University. He continued to serve as editor-in-chief of the journal *Metabolic Engineering*, published by Elsevier and on the Editorial Boards of 7 other scientific journals. Among numerous research presentations

at professional societies' meetings (AIChE, ACS, ASM) he also delivered plenary and invited lectures at the Genomes to Systems Conference (Manchester, UK), the 1st Maga Circe Conference on Metabolic Systems Analysis (Monte Circeo, Italy), the 10th International Symposium on Genetics of Industrial Microorganisms (Prague), the Annual Conference of the Society for Industrial Microbiology (SIM, Baltimore, MD), the 6th Metabolic Engineering Conference (The Netherlands), the 1st International Conference on Biomolecular Engineering (San Diego, CA), and the 2nd ASM conference on Integrating Metabolism and Genomics (IMAGE2, Montreal). He continued his educational and research activity in Bioinformatics and Metabolic Engineering that led to the publication of two seminal papers and 4 patents that received widespread coverage by the media and scientific press. These ideas provided the basis for a biotech start up that won the first prize at the MIT 100K competition and three other international contests.

Jefferson W. Tester's research program focuses on clean chemical processing and renewable energy technologies with new research thrusts in biomass conversion in hydrothermal media and advanced drilling technology using spallation and fusion methods. This past year, he accepted co-chair responsibilities for the Energy Education Task Force as a part of MIT's newly launched energy initiative (MITEI). Professor Tester continued to serve as chair of the National Advisory Council of the US Department of Energy's National Renewable Energy Laboratory and as chair of the Governor's Advisory Committee of the Massachusetts Renewable Energy Trust. He also served on advisory boards for Los Alamos National Laboratory, Cornell University, American Council on Renewable Energy, and the Paul Scherrer Institute of the Swiss Federal Institute of Technology (ETH). He co-chaired panels dealing with supercritical water oxidation technology and energy research and technology issues for the Army Research Office and the Defense Science Board. He gave invited lectures at Universities of Maryland, Nevada, Alberta, City College of New York, Amherst College, and the MIT Clubs of Boston, Hartford, and Milwaukee. Significant time was spent writing, producing, and releasing a 400+ page MIT-led assessment of the role of geothermal energy in the US. This report led to major international interviews and media coverage and an extensive lecture circuit in the US, Iceland, and Australia, as well as professional geothermal conferences, and congressional briefings and testimony. Professor Tester is also the Institute of Geophysics and Planetary Physics (IGPP) Orson Anderson Fellow at Los Alamos National Laboratory for 2007-2008.

Bernhardt L. Trout set up major new projects with biopharmaceutical companies, including the new Novartis-MIT Center for Continuous Manufacturing. He took over the leadership of the SMA (Chemical and Pharmaceutical Engineering) program CPE. He is a member of the Committee on the Undergraduate Program, as well as multiple other Institute and Departmental Committees. He has been the invited or keynote speaker in various conferences on protein stabilization, in addition to being a Freshman Advisor and Fellow of Next House.

Daniel I.C. Wang delivered the Keynote Address at the Bioprocess Engineering Conference at Hubei University, Wuhan, China in 2006. He completed his third year term in 2006 as a member of the Membership Policy Committee for the National Academy of Engineering. He continued as the Chairman of the Scientific Advisory Board for the Bioprocessing Technology Institute, Singapore in 2007. He delivered a lecture at the L.T. Fan Distinguished Lecture Series in 2007 at Kansas State University. He continued to hold the Temasek Distinguished Visiting Professor for the fourth year at the National University of Singapore. He was also invited to be the Distinguished Visiting Professor at Shanghai Jiao Tong University, China in 2006. He delivered seminars in 2006-2007 at the University of Illinois, Rensselaer Polytechnic Institute and Kansas State University. Lastly, his former students hosted a celebration and symposium in honor of his 70th birthday in 2006. The proceeding from the symposium was published as a special issue in the *Journal of Biotechnology and Bioengineering* in his honor in 2006. ▫

ChemE Connection

Happenings around the Department

Prof. Paul Barton Leads Development of a Math Model for Natural Gas

MIT engineers have developed a mathematical model that could help energy companies produce natural gas more efficiently and ensure a more reliable supply of this valuable fuel. The researchers are now collaborating with experts at Shell to apply the model to a natural gas production system in Malaysia.

Natural gas companies would like to operate their production networks more efficiently and flexibly. But operators can be overwhelmed by the sheer number of choices to be made and obligations to be met under supply contracts with customers and facility- and production-sharing agreements with other companies.

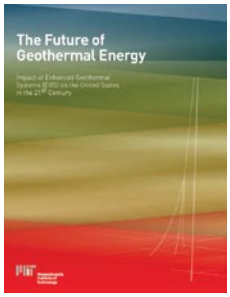
According to Professor Paul Barton, the only way for a company to optimize such a system—that is, to operate it so as to best meet all obligations, objectives, and constraints—is to formulate it as a mathematical problem and solve it.

"If there were just one or two decisions to make, an engineer could do it," he said. "But when you've got 20 valves to set and 50 different constraints to satisfy, it's impossible for a person to see. Computer procedures can take all of that into account."

Professor Barton and chemical engineering graduate student Ajay Selot have spent the past two years developing a mathematical model to help guide operators' decisions one to three months in advance. The model focuses on the "upstream supply chain," that is, the system from the natural gas reservoirs to bulk consumers such as power plants, utility companies, and liquefied natural gas plants.

(excerpted from an article by Nancy Stauffer, MIT ERC. The entire article can be found at : **http://web.mit.edu/erc/spotlights/naturalgas.html**).

Geothermal Report Works to Solve Energy Problems of Today and Tomorrow



Professor Jeff Tester led a comprehensive study of the potential for geothermal energy within the United States. It has found that mining the huge amounts of heat that reside as stored thermal energy in the Earth's hard rock crust could supply a substantial portion of the electricity the United States will need in the future, probably at competitive prices and with minimal environmental impact.

Although geothermal energy is produced commercially today and the United States is the world's biggest producer, existing U.S. plants have focused on the high-grade geothermal systems primarily located in isolated regions of the west. This study takes a more ambitious look at this resource and evaluates its potential for much larger-scale deployment.

"We've determined that heat mining can be economical in the short term, based on a global analysis of existing geothermal systems, an assessment of the total U.S. resource and continuing improvements in deep-drilling and reservoir stimulation technology," said Professor Jeff Tester, who led the panel.

"EGS technology has already been proven to work in the few areas where underground heat has been successfully extracted. And further technological improvements can be expected," he said.

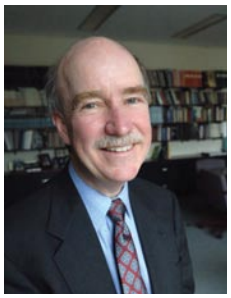
For the full article go to:
http://web.mit.edu/newsoffice/2007/geothermal.html

Professor Prather Goes to Washington

Professor Kristala Prather testified before the Senate Energy and Natural Resources Committee on the research and development of biofuels. She told the committee that "biofuels represents a grand challenge in technology. There is no single silver bullet that will make a robust transportation fuels industry a reality. There are many different components to this process, including: (1) biomass production and harvesting, (2) preparation and treatment, (3) conversion to fuel, and (4) purification of the fuel. Each of these areas requires significant R&D to produce workable biofuels at scale. I believe that Biotechnology, the integration of life sciences and engineering, will play a key role in each of these component stages."

For more information, go to :
http://web.mit.edu/newsoffice/2007/biofuels.html

Armstrong Tapped as MITEI Deputy Director



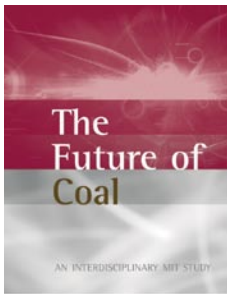
Professor Bob Armstrong was named Associate Director of the newly formed MIT Energy Initiative (MITEI), established in line with the recommendations of an Institute-wide group of faculty convened in June 2005 to help MIT understand how best to tackle the world's energy crisis.

While announcing the formation of MITEI, President Susan Hockfield thanked the members of the Energy Research Council (ERC) for articulating recommendations that will allow MIT, with its unique talents and capabilities, to address what she called "one of the most urgent challenges of our time."

According to Hockfield, in a Sept. 20, 2006, letter to the MIT community, MITEI will address "the science, technology, policy, and systems design required to meet the global energy challenge." As a "virtual center," it will progressively build focused research programs, coordinated educational offerings and the necessary campus infrastructure, leading over several years to the establishment of a new interdepartmental laboratory or center that will involve researchers from all five schools.

For the full article, go to:
http://web.mit.edu/newsoffice/2006/energy-initiative.html

McRae and Beér Examine the Future of Coal



Professor Greg McRae and Professor Emeritus János Beér were among a group of MIT researchers who have examined the role of coal in a world where constraints on carbon dioxide emissions are adopted to mitigate global climate change. This follows "The Future of Nuclear Power" which focused on carbon dioxide emissions-free electricity generation from nuclear energy and was published in 2003. This report, "The Future of Coal in a Carbon-Constrained World", evaluates the technologies and costs associated with the generation of electricity from coal along with those associated with the capture and sequestration of the carbon dioxide produced coal-based power generation. Growing electricity demand in the U.S. and in the world will require increases in all generation options (renewables, coal, and nuclear) in addition to increased efficiency and conservation in its use. Coal will continue to play a significant role in power generation and as such carbon dioxide management from it will become increasingly important. This study, addressed to government, industry and academic leaders, discusses the interrelated technical, economic, environmental and political challenges facing increased coal-based power generation while managing carbon dioxide emissions from this sector.

For the full report, go to **http://web.mit.edu/coal/**

Hydrogel Particles Pave Way for New Bedside Diagnostics

Daniel Pregibon, left, and Professor Pat Doyle, survey microparticles on a monitor in their lab.

MIT researchers, led by Professor Pat Doyle and chemical engineering graduate student Daniel Pregibon, have created an inexpensive method to screen for millions of different biomolecules (DNA, proteins, etc.) in a single sample--a technology that could make possible the development of low-cost clinical bedside diagnostics.

The work, based on tiny customizable particles, could also be used for disease monitoring, drug discovery or genetic profiling. Even though the particles are thinner than the width of a human hair, each is equipped with a barcoded ID and one or more probe regions that turn fluorescent when they detect specific targets in a test sample.

Using a new, extremely versatile technique, the researchers can produce a "virtually unlimited" array of particles to test for DNA, RNA, proteins and other biomolecules, said Pregibon.

Pregibon is the lead author of a paper on the work that appeared in the March 9, 2007, issue of *Science*.

He and co-author Professor Doyle believe their particles could become an effective and inexpensive way to perform medical diagnostic tests at a patient's bedside.

For full article, go to:
http://web.mit.edu/newsoffice/2007/particles.html

ChemE Connection

biodiesel@MIT Wins National Ecomagination Challenge

Chemical engineering junior Joe Roy-Mayhew, left, and mechanical engineering senior Matthew Zedler offer up a vat of used cooking oil for use as biodiesel fuel.

biodiesel@MIT, a student-led initiative to turn used vegetable oil from campus dining facilities into biodiesel fuel for MIT diesel campus vehicles, has won a national contest and $25,000 from GE and mtvU, MTV's 24-hour college network. The grant will go toward a biodiesel processor in a solar-powered filling station on the MIT campus. The winning team included chemical engineering junior Joe Roy-Mayhew.

The group was one of 10 finalists in GE/mtvU's Ecomagination challenge, which encouraged student involvement in campus greening and raising awareness for sustainability. Student groups from across the country submitted proposals for projects that would make their campuses more environmentally friendly.

MIT Dining's Fry-o-lators work almost around the clock to serve up French fries and chicken fingers. And every month, MIT pays $1.10 a gallon to cart away the used vegetable oil.

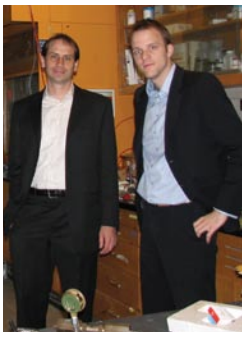
biodiesel@MIT wants to see that dark brown liquid processed and pumped into the tanks of campus vehicles such as the Tech Shuttles, which will soon use up to 30,000 gallons of diesel fuel a year, and others owned by the Department of Facilities.

biodiesel@MIT proposes to install a processor to convert used vegetable oil (UVO) to biodiesel and to later help plan a solar-powered fueling station where this local biodiesel would be available. The 20 percent bio-derived fuel called B20 would be useable by most MIT diesel vehicles, all of which currently have to go off-campus to fuel up.

"We keep looking for new ways to create and store energy, yet we often don't look at how we could use what we already have more efficiently or in unorthodox ways," Roy-Mayhew said.

For full article, go to:
http://web.mit.edu/newsoffice/2007/biodiesel.html

ChemE Grad Students Develop an Efficient Process to Create Propane Biofuel



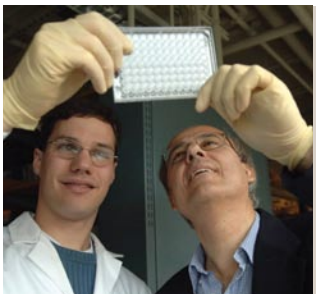
MIT researchers, led by chemical engineering graduate students Andy Peterson and Curt Fischer, say they have developed an efficient chemical process for making propane from corn or sugarcane. They have incorporated a startup to commercialize the biopropane process, which they hope will find a place in the existing $21 billion U.S. market for the fuel.

While much of the attention on biofuels has focused on ethanol, the process developed by Peterson and Fischer produces propane, said Peterson, who demonstrated the reactions. Propane is used in the United States for residential heating and some industrial processes, and to a limited extent as a liquid transportation fuel.

"We're making a demonstrated fuel" for which a market and an infrastructure already exist, says Peterson, who works in the lab of Professor Jeff Tester and has founded the startup C3 BioEnergy, based in Cambridge, MA, to commercialize the technology.

For the full Technology Review article, go to:
http://www.technologyreview.com/Energy/18551/

MIT's Anti-Microbial "Grammar"



Chris Loose, left, and Greg Stephanopoulos look for signs of bacteria.

Professor Greg Stephanopoulos and chemical engineering graduate student Chris Loose have introduced custom peptides that "punch" holes in Anthrax and Staph bacteria.

In most languages, sentences only make sense if the words are placed in the right order. Now, Professor Stephanopoulos, Loose, and an IBM colleague have used grammatical principles to help their search for new antimicrobial medicines.

After identifying "grammatical" patterns in naturally occurring antimicrobial peptides, the researchers custom-designed molecules that proved extremely effective in killing microbes, including anthrax bacteria. The research could lead to new medicines to combat deadly drug-resistant bacteria.

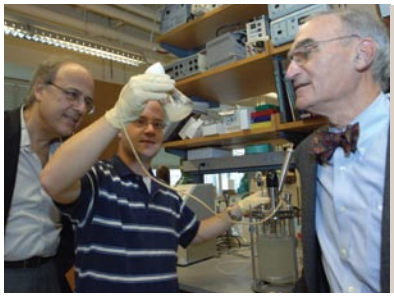
"In the last 40 years, there have been only two new classes of antibiotic drugs discovered and brought to the market," said Loose, lead author of a paper on the work that appears in the Oct. 19, 2006 issue of *Nature*. "There is an incredible need to come up with new medicines."

Loose, research associate Kyle Jensen and Professor Stephanopoulos are focusing their attention on antimicrobial peptides, or short strings of amino acids. Such peptides are naturally found in multicellular organisms, where they play a role in defense against infectious bacteria.

The researchers' newly designed peptides were shown to be effective against dangerous microbes such as Bacillus anthracis (anthrax) and Staphyloccus aureus, a bacteria that spreads in hospitals and is frequently drug-resistant. The peptides may also be less likely to induce drug resistance in these bacteria, according to the researchers.

For the full article, go to:
http://web.mit.edu/newsoffice/2006/peptide-grammar.html

Greg Stephanopoulos and Colleagues Engineer Yeast for Ethanol



Greg Stephanopoulos (left), postdoc Hal Alper and professor of biology Gerald Fink in the lab.

MIT scientists, led by Professor Greg Stephanopoulos and post-doctoral associate Hal Alper, have engineered yeast that can improve the speed and efficiency of ethanol production, a key component to making biofuels a significant part of the U.S. energy supply.

Currently used as a fuel additive to improve gasoline combustibility, ethanol is often touted as a potential solution to the growing oil-driven energy crisis. But there are significant obstacles to producing ethanol: one is that high ethanol levels are toxic to the yeast that ferments corn and other plant material into ethanol.

By manipulating the yeast genome, the researchers have engineered a new strain of yeast that can tolerate elevated levels of both ethanol and glucose, while producing ethanol faster than un-engineered yeast. The work is reported in the Dec. 8, 2006 issue of *Science*.

Fuels such as E85, which is 85 percent ethanol, are becoming common in states where corn is plentiful; however, their use is mainly confined to the Midwest because corn supplies are limited and ethanol production technology is not yet efficient enough. Boosting efficiency has been an elusive goal, but the MIT researchers took a new approach.

The key to the MIT strategy is manipulating the genes encoding proteins responsible for regulating gene transcription and, in turn, controlling the repertoire of genes expressed in a particular cell. These types of transcription factors bind to DNA and turn genes on or off, essentially controlling what traits a cell expresses.

For the full article, go to:
http://web.mit.edu/newsoffice/2006/biofuels.html

The First Mohr UROP Scholar Researches Drug Delivery

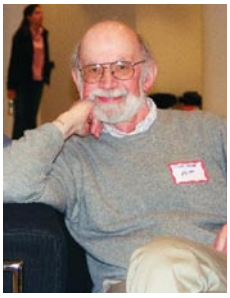
Natalia Rodriguez ('09) was selected as the first Mohr UROP (Undergraduate Research Opportunity Program) Scholar. Her work was in orthopedic medicine, specifically enhancing the way therapeutics are delivered to joint implants to minimize infection and rejection by the body.

Rodriguez's research involved developing a drug delivery device through layer by layer assembly to release therapeutic agents such as antibiotics, anti-inflammatory agents, and growth factors directly from the implant coating. The anti-inflammatory agents and antibiotics help prevent infection and swelling in the area of the implant, while the growth factors promote cell proliferation of the surrounding tissue to facilitate the healing of the wound. Her work during the Independent Activities Period (IAP) focused specifically on a layer-by-layer technique that involved a barrier layer.

Rodriguez was an excellent UROP and went on to be a UROP advisor during IAP 2007. The department thanks all alumni and donors who helped to make this scholarship possible.

ChemE Connection

About the Mohr UROP Fund



In June of 2005, the Chemical Engineering Department lost a dear friend, colleague, mentor and teacher: Dr. C. Michael "Mike" Mohr (SB '55, ScD '61), a beloved MIT lecturer whose undergraduate students presented him with the annual Outstanding Faculty Award more than 10 years in a row.

In recognition of Mike Mohr's extraordinary devotion to undergraduates, the department created a fund to support chemical engineering UROPs. The fund is named the C. Michael Mohr (1955) UROP Fund, and provides for UROP wages during IAP and summer terms, when the UROP is not being performed for credit.

Donations to this fund can be made by sending a check to the Chemical Engineering Department payable to MIT with a notation designating the contribution to this fund. You can reference either the fund name or the account number, which is 3159180.

Faculty and Students visit Saudi Aramco

The MIT group and its Saudi Aramco hosts.

In late January 2007, a delegation of MIT professors and graduate students visited the Saudi Aramco headquarters in Dhahran, Saudi Arabia. The goal of the trip, according to Professor Bob Armstrong, was "to have a look at the oil and gas industry in general and the operations of the biggest oil company in the world… We're also looking at different areas and possibilities for mutual cooperation between Saudi Aramco and the university."

Trip participant and chemical engineering graduate student Joel Moxley commented, "Saudi Aramco is the best oil company in the world, and the MIT chemical engineering department is the best in the world…Saudi Aramco's reserves amount to 260 billion barrels of proven oil – a little less than the 261 billion e-mails that our dean sent us about this visit."

During their week-long trip, the group met with senior executives and toured the Oil Supply, Planning and Scheduling center, refinery and storage facilities and boarded an oil tanker. They also saw the school where high-school-level students are trained and stayed in the expansive central compound, which is like a small city.

There were also many social and sight-seeing opportunities. The group had a sunset dinner with MIT alumni working at Saudi Aramco, shopped, rode camels, and spent the day at an oasis.

Participants from the chemical engineering department included Professors Bob Armstrong, Greg McRae, and Danny Wang, and graduate students Joel Moxley and Andy Peterson.

Stericoat Continues to Garner Awards

Chris Loose, Joel Moxley and UROP Michael Henke of SteriCoat.

In 2006, ChemE graduate students Vipin Gupta, Christopher Loose, Joel Moxley, Shannan O'Shaunnessy, and ChemE undergraduate (as well as Sloan Fellow David Lucchino) came together to create and market a product based on their research, dubbed SteriCoat. SteriCoat targets the billion-dollar medical catheter market with an application designed to prevent the formation of bacterial "biofilms" on medical devices.

In 2006, the team garnered wins in numerous business plan competitions, including the Business Venture Category of the MIT $100K Entrepreneurship Competition, the Harvard Graduate School of Arts and Sciences Biotechnology Competition, the MIT-CMI competition and the International Business Plan competition of Oxford University. In March 2007, they got second place in the Rice University Business Plan Competition, the largest of its kind.

In May 2007, Stericoat moved from its labs at MIT into its new lab space in nearby Kendall Square.

Chris describes his experience and gives tips for other young scientists in the July 2006 issue of *Nature*:

> "I knew that creating a biotech start-up was inherently risky given that the long development times and clinical hurdles make it difficult to attract investors. I've learned that the keys to success are finding a clear problem with an elegant and compelling solution, and pulling together an experienced team.
>
> Indeed, identifying a clear problem is my top recommendation for young researchers interested in breaking into biotech. Our product, SteriCoat, prevents infections from forming on medical devices such as catheters and heart implants.
>
> Prospective entrepreneurs should be willing to take advice and criticism from potential users and business experts. And they should seek advisers and co-workers whom they trust and enjoy working with. This not only increases the chances of success, but makes the long hours and high-pressure environment much more bearable."

SteriCoat Summary

Each year, bloodstream infections associated with medical devices cost hospitals $9 billion and cause 70,000 deaths in the U.S. SteriCoat is commercializing a patented antimicrobial coating to prevent these infections. SteriCoat's exclusive application technology allows us to coat devices of virtually any size, shape, or material. Furthermore, our unique mechanism of action makes the coating more durable and does not affect the performance of the coated device. Our initial market will be central venous catheters, which access the patient's bloodstream directly. Our innovation addresses two critical concerns: For patients, it increases safety by reducing the risk of infections, which prolong hospital stays and are potentially fatal. For providers, it minimizes expenses from treating bloodstream infections, which cost $10K-50K per patient.

Undergraduates place in MIT IDEAS Competition

Aron Walker

Oliver Venn

Undergraduate students Aron Walker & Oliver Venn were members of the teams New DOTS and Cabanga, which placed in the MIT IDEAS competition.

Venn's team Cabanga came up with the uBox, a cheap, rugged pillbox that is left with the patient. The uBox electronically records times of dosages and DOT (Directly Observed Therapy) worker visits. The data enables timely and targeted intervention leading to improved adherence and better patient care, requires no training and does not rely on infrastructure or user literacy. A prototype uBox is being assembled and tested and will cost about $2 per patient per trial. Cabanga received one of two $7,500 Yunus Innovation Challenge Awards for increasing adherence to Tuberculosis drugs in rural developing country contexts. The Yunus awards are sponsored by Mr. Mohammad Abdul Latif Jameel.

New DOTS, which included Walker, was awarded the $5,000 award sponsored by The Lemelson-MIT Program. The team developed a tuberculosis monitoring plan, which involves urinalysis test strips, patient health care worker cell phone reporting, and microfinance incentives.

The MIT IDEAS Competition encourages teams to develop and implement projects that make a positive change in the world. Entries are judged on their innovation, feasibility, and community impact. The Competition is open to everyone, but at least one third of each team must be full-time MIT students. Examples of entries are a novel water filtration device or a unique translation system for immigrants.

Madlinger Wins the Henry Ford II Award

Chemical engineering senior Adam Madlinger beat out 28 other eligible MIT seniors to win the Henry Ford II Award. This award is presented to a senior engineering student who has maintained a cumulative average of 5.0 at the end of their seventh term and displays the qualities of a well-rounded citizen. The award consists of $5,000 and is listed in a June awards issue of *Tech Talk*. as "the senior in the School of Engineering who has attained the highest academic record at the end of the third year and who has exceptional potential for leadership in the profession of engineering and in society." □

Symposium to Honor the Life and Work of Professor Robert C. Reid

On the afternoon of Friday, October 13, 2006, the MIT Chemical Engineering Department held a Symposium to honor ***Robert C. Reid***, who passed away May 18, 2006. The symposium highlighted his educational and research contributions to Chemical Engineering through a series of invited presentations with emphasis on applied thermodynamics and physical property estimation.

From 1:00 -5:30 p.m., a technical symposium was held at MIT in the Gilliland Auditorium (66-110), featuring an overview of "The Early Years" and his "Teaching and Mentoring across Generations", given by his colleagues and former students. The second half of the event, which delved into his research, was entitled "Thermodynamics is Alive and Well in the 21st Century."

Speakers included Professors Bob Armstrong, Jeff Tester ('71), Ken Smith ('58), Ed Merrill, Mike Modell ('64), Pablo Debenedetti ('85), Thanos Panagiotopoulos ('86), and Sanat Kumar ('87), as well as former students Lis Drake ('58) and Lucie (Shane) Wilkens ('77).

The day ended with a reception and dedication of a Japanese red maple tree planted in Professor Reid's honor in the courtyard outside of the Landau Building (Building 66).

Professors Bob Armstrong and Jeff Tester pose with the Reid family in front of the tree planted in Professor Bob Reid's honor (L.-R. Bob Armstrong, Don Reid, Nancy Reid, Christine Reid, Jeff Tester).

For more information and to view the webcast of the Symposium, go to:
http://web.mit.edu/cheme/news/archives/06/reid.html

Professor Robert C. Reid is known throughout the chemical engineering community for his contributions to methods of teaching thermodynamics, estimating physical properties and the understanding of a variety of complex physical-chemical phenomena including the phase behavior of supercritical fluids and boiling heat transfer at the interface between two immiscible liquids. Generations of 10.40 students have known him for the thermodynamics text he co-authored with Mike Modell, "Thermodynamics and Its Applications", through two editions. His basic postulatory approach and conceptual problem formulation methods continue to be used at MIT and elsewhere in teaching graduate chemical engineering thermodynamics.

In addition, Professor Reid co-authored the legendary reference book on the "The Properties of Gases and Liquids" with Tom Sherwood in 1958. This was later revised and published in 4 separate editions over 40 years during which John Prausnitz, Bruce Poling and Jeff Tester were added as co-authors. Professor Reid also served as editor of the *American Institute of Chemical Engineers (AIChE) Journal*; his efforts substantially enhanced the Journal's reputation as the leading scientific publication of the chemical engineering profession. He was a director of AIChE from 1969 to 1971 and was a member of the National Academy of Engineering. He won AIChE's Warren K. Lewis Award in 1976 and its Founders Award in 1986. Professor Reid received the Purdue Distinguished Alumnus Award in 1976. He has over 150 publications, including 6 books.

Professor Reid was an active member of the MIT faculty for 31 years before retiring in 1985. His former students, many of whom went on to careers in teaching and research, remember him as an inspiring mentor. He was known to be humble and thoughtful in his approach to engineering problems, and all who remember him comment on his welcoming and friendly demeanor. He was particularly noted for the personal interest that he took in every student with whom he interacted. Professor Reid also liked to have fun with his classes, occasionally dressing up for a "guest" lecture as the great thermodynamicist, J. Willard Gibbs, complete with 19th-century dress, wig, and accent.

Professor Reid received a B.S. degree in Chemical Engineering in 1949 from Purdue University and a B.S. degree in Mechanical Engineering in 1950 from the U.S. Merchant Marine Academy. He continued his studies at Purdue and graduated with an M.S. degree in Chemical Engineering in 1950. He then earned his Sc. D. degree from MIT in 1954, and became Assistant Professor and Director of the Oak Ridge Station of the Practice School, finally returning to Cambridge in 1956 permanently to teach and mentor hundreds of graduate students in the department over the next three decades.

Reid is survived by his wife of 55 years, Anna M. (Murphy) Reid of Lexington, MA, son Donald M. Reid of Chapel Hill, NC, daughter A. Christine Reid of Arlington, VA, four grandchildren and many nieces and nephews.

The Fall 2006 Hoyt C. Hottel Lecture in Chemical Engineering

"Energy Security… What Does It Take?"
John Hofmeister
President, Shell Oil Company

On November 3, 2006, the MIT community played host to Mr. John Hofmeister, President of Shell Oil. After a spirited luncheon with members of MIT's Energy Club, Mr. Hofmeister spoke about energy security and Shell's expansion of its energy focus.

Shell Oil isn't just about oil anymore. The multinational company has invested $1 billion in wind over the last decade, owns companies working on solar and hydrogen technologies and would soon announce the acquisition of an entity that uses municipal waste to produce biofuel.

"With these, we could go a very long way toward meeting energy security requirements," according to Mr. Hofmeister. But conservation has to take hold "in our hearts, minds and behavior of who we are as a people. We have to teach our young people that energy is a precious commodity. We're doing a disservice to young people, because instead of teaching about energy, we're allowing ignorance to reign."

Hofmeister said he represents "an industry some would say has all but zero credibility." Yet Shell, he said, is exploring new technologies to find untapped and unconventional oil and gas reserves, investing in alternative sources such as wind and solar and not simply "listening to its cash registers go ka-ching."

Consumers accuse Shell and other major oil companies of price gouging, a characterization Hofmeister feels is unfair in the current era of limited supply. Meanwhile, he said, the company goes "tin cup in hand" to beg legislators for more access to untapped domestic oil and gas reserves to make the United States less reliant on foreign oil.

Unlike others in the petroleum industry, Shell believes that global warming is a real issue, he said.

Even though Shell invests around 5 percent of its total budget in alternative energy sources, Hofmeister warned it will take 20-25 years before these fledgling technologies meet even 10-15 percent of the country's energy needs. The alternatives to fossil fuels are still based on "immature technologies" that markets are not quite ready for, he said.

Meanwhile, "I do believe energy security is at a point of national crisis," Hofmeister said, although Shell does not "subscribe to the theory" (based on work by geophysicist Marion King Hubbert) that world oil production will peak in 10-15 years.

More than 112 billion barrels of oil and gas--"more oil and gas than to be had in the entire Middle East"--can be tapped from federal lands on the outer continental shelf, offshore Alaska and from the Gulf of Mexico, he said. And while finding future oil in other places will be more technically difficult, technology will change the game. "Technology will help us not have to face this issue which peak oil suggests," Hofmeister said.

Even so, untapped reservoirs will not be enough to meet America's future needs, so Shell is pursuing unconventional sources in Canada.

The trillions of barrels of untapped oil and gas around the world present a "carbon management issue" that Shell would "at least like the opportunity to try" to address, he said. For instance, electrical utilities are committing to clean, efficient gas-turbine technology, but natural gas supplies are low compared with increasing demand. Meeting this demand for additional liquified gas would mean building regasification terminals that no one wants in their back yard, he pointed out.

Shell is working on creating a biofuels infrastructure in select markets in the Midwest to make ethanol available at the pump to vehicles that can use blends of biofuels. Although the United States plans to produce 7 billion gallons annually of ethanol by 2010, we would need to produce 15 billion gallons to meet even 10 percent of the country's transportation fuel needs, Mr. Hofmeister said.

"We think there needs to be more regulatory push and more market pull" for alternative sources to take hold, he said.

Shell would like to see a national framework of carbon management principles, he said, and wants to be included in the debate "to help think through what different policy alternatives would be like." (Quoted from MIT *Tech Talk* 11/08/06)

For more information and to view the webcast and transcript of Mr. Hofmeister's lecture, go to:
http://web.mit.edu/cheme/news/archives/06/hottel-nov3.html

(Hottel Lecture cont.)

John Hofmeister was named president of Houston-based Shell Oil Company in March 2005.

A business leader who has observed and participated in the inner workings of general industries for more than 30 years, Hofmeister has held key positions in General Electric, Nortel and AlliedSignal (now Honeywell International), in addition to Shell. In his current role, Hofmeister heads the U.S. Country Leadership Team, which includes the leaders of all Shell businesses operating in the United States.

Hofmeister believes that to ensure U.S. energy for the future, the energy industry must address the delicate balance between energy production and consumption with increased supply. He calls for a full array of energy sources: conventional oil and gas—including access to resources presently off limits in offshore waters and on federal lands—as well as unconventional oil and gas from oil shale and oil sand. In addition, he encourages development of clean fossil fuels and alternative and renewable energy sources, while conducting business in socially and environmentally responsible ways.

Hofmeister earned a master's degree in political science from Kansas State University. During his career, he has lived and worked in North America, Europe and Asia. Hofmeister is a member of the Department of Energy's new Hydrogen and Fuel Cell Technical Advisory Committee. He also currently serves on the boards of the American Petroleum Institute, United States Energy Association, National Association of Manufacturers, National Urban League and the Foreign Policy Association, and is a Fellow of the National Academy of Human Resources.

The **Hoyt C. Hottel Lectureship** was established in early 1985 to recognize Professor Hottel's contributions to the intellectual climate of the Chemical Engineering Department, to the encouragement of students over six decades, and to the foundation and direction of the Fuels Research Laboratory. The lectureship is intended to draw eminent scholars to MIT - preferably in the fields of combustion and energy technology - for short periods of residency in order to stimulate future generations of students. The inaugural Hottel Lecture was presented in April 1985 by Professor Hottel himself.

The 2007 Alan S. Michaels Distinguished Lectureship in Medical and Biological Engineering

"Artificial Amino Acids in Protein Engineering, Evolution and Analysis"
Professor David Tirrell
Division of Chemistry and Chemical Engineering
California Institute of Technology

Professor David Tirrell ('74), presented the 2007 Alan S. Michaels Lecture on Friday, April 27, 2007.

Professor Tirrell discussed his work on a protein engineering approach to macromolecular chemistry. Macromolecular chemistry has traditionally been divided into two fields, with biochemists and biochemical engineers working on proteins and nucleic acids while polymer chemists and materials scientists have concerned themselves with synthetic polymers. These two classes of macro-molecules are profoundly different from one another; proteins and nucleic acids are uniform, well-folded, and evolvable, whereas polymers are heterogeneous and for the most part adopt random-coil conformations. The advantage held by synthetic polymers is their compositional diversity; thousands of different monomers are available to the polymer chemist, while proteins and nucleic acids are made from relatively small numbers of amino acids and nucleotides.

This lecture described Professor Tirrell's ongoing attempt to bridge the gap between polymers and proteins by devising methods to build functional proteins that contain non-standard amino acids. Implications for biomaterials science, protein therapeutics, protein evolution and proteomic analysis were explored.

For more information and to view the webcast of Professor Tirrell's lecture, go to:
http://web.mit.edu/cheme/news/michaels.html

David A. Tirrell is the Ross McCollum-William H. Corcoran Professor and Chairman of the Division of Chemistry and Chemical Engineering at the California Institute of Technology. After earning the B.S. in Chemistry at MIT, Tirrell enrolled in the Department of Polymer Science and Engineering at the University of Massachusetts, where he was awarded the Ph.D. in 1978 for work done under the supervision of Otto Vogl. After a brief stay with Takeo Saegusa at Kyoto University, Tirrell accepted an assistant professorship in the Department of Chemistry at Carnegie-Mellon University in the Fall of 1978.

Tirrell returned to Amherst in 1984 and served as Director of the Materials Research Laboratory before moving to Caltech in 1998. He has been a Visiting Professor at the University of Queensland, at the Institut Charles Sadron

in Strasbourg, at the University of Wisconsin, and at the Institut Curie in Paris. He was Editor of the *Journal of Polymer Science* from 1988 until 1999, and has chaired the Gordon Research Conferences on Polymers in Biosystems and on Chemistry of Supramolecules and Assemblies.

Tirrell's contributions to macromolecular chemistry have been recognized in a variety of ways, including his election to the American Academy of Arts and Sciences and the National Academy of Sciences. He has been awarded the Arthur C. Cope Scholar, Carl Marvel, Harrison Howe, S. C. Lind and Madison Marshall Awards of the American Chemical Society, as well as the American Chemical Society Award in Polymer Chemistry. He holds the Chancellor's Medal of the University of Massachusetts, and the degree of Doctor honoris causa from the Technical University of Eindhoven.

The **Alan S. Michaels Distinguished Lectureship in Medical and Biological Engineering** was established in 1995 to stimulate the collaboration of the medical profession, life sciences industries, and chemical engineering researchers.

The most exciting and promising developments in medicine and the life sciences - those leading to improved therapies for the treatment or mitigation of intractable diseases, and strategies for prevention of debilitating or life-threatening genetic deficiencies - are largely emerging from discoveries in molecular biology and biochemistry, in concert with those in the sister-sciences of immunology, pharmacology, and genetics. These developments involve, in a very direct way, the basic tools that are the hallmark of the chemical engineer's profession: molecular thermodynamics, chemical reaction kinetics, homogeneous and the heterogeneous catalysis, fluid mechanics, and mass- and energy-transport processes. Few other engineering disciplines are as well qualified to deal with the microscopic and molecular phenomena affecting living systems.

The 2007 Warren K. Lewis Lecture

"Sustainable Growth through Chemical Innovation"
Stefan Marcinowski
Member of the Board of Executive Directors and Research Executive Director of BASF

On Friday, May 4, 2007, Dr. Stefan Marcinowski gave a lively presentation on chemical innovation. After introducing the different areas and evolution of BASF, he demonstrated through the destruction of a cell phone that the electronics industry is based in chemistry: chemicals and materials are used to create semi-conductors, which in turn are used in electronics.

Dr. Marcinowski focused on innovation, which to be successful, should be at the juncture of 1) what is acceptable, 2) what is possible, and 3) what is needed. BASF is putting this into effect as it focuses on five new and emerging "growth clusters": plant biotechnology, white biotechnology, energy management, raw material change and nanotechnology. Dr. Marcinowski concluded that people are the essence of coming up with new ideas and solutions and encouraged students to look at and explore the chemical industry.

For more information and to view the webcast of Dr. Marcinowski's lecture, go to:
http://web.mit.edu/cheme/news/lewis.html

Stefan Marcinowski was born in Stuttgart, Germany, in 1953. From 1971 to 1976, he studied chemistry at the Universities of Stuttgart and Freiburg. He obtained his doctorate under Professor Grisebach in 1978 and remained as an assistant at his Biochemical Institute in Freiburg until 1979.

In 1979, Dr. Marcinowski joined BASF's Main Laboratory, where he performed research work in the field of biotechnology until 1986. He then worked as personal assistant to the Chairman of the Board of Executive Directors for two years.

From March 1988 to May 1992, Dr. Marcinowski headed the Public Relations Department. From June 1992 until the end of 1994, he was Vice-Presidente Executivo of BASF S.A. in Brazil. From January 1995 to May 1997, he was appointed President of the Plastic Foams and Reactive Resins division in Ludwigshafen.

Dr. Marcinowski was appointed to the Board of Executive Directors of BASF Aktiengesellschaft with effect from May 16, 1997. He was initially responsible for research, later also for the Functional Polymers and Performance Chemicals divisions as well as for the region South America.

Since February 2003, Dr. Marcinowski's responsibilities include the Inorganics, Petrochemicals and Intermediates divisions, as well as the competence centers Chemicals Research & Engineering and Corporate Engineering. In addition, Dr. Marcinowski is Research Executive Director and is responsible for University Relations & Research Planning. Since April 2001, Dr. Marcinowski has been responsible for BASF Future Business GmbH.

Dr. Marcinowski married in 1976 and has three children.

The **Warren K. Lewis Lectureship** was established in 1978 to recognize Professor Lewis's revolutionary impact on chemical engineering education. One of MIT's first students in chemical engineering, he made seminal impact to the discipline. By developing the concept of unit operations, first proposed by A. D. Little and William Walker, he revolutionized the design of chemical engineering processes and equipment. Throughout his career, Professor Lewis was mindful of the needs of industrial practice; accordingly, the Lewis lecture features speakers from industry and academia. ▪

News from Alumni

In the Department of Chemical Engineering

Clyde K. Smith **(SM '35)** shares that, at age 95, he is still alive, but not kicking, just walking.

Mansukhalal D. Parekh **(SM '38, ScD '40)** is doing well and is ninety-five. He still does some consultation in fertilizers and chemical plants.

Chitta Ranjan Mitra **(SM '48)**, 80 years old, was felicitated on February, 2007, at Pune, India by the Engineering Foundation and Sinhgad Technical Education Society as a pioneer of educational innovation, a great institution builder and for his outstanding contribution to higher education spanning over half a century.

Dr. Mitra graduated from Allahabad University and the Indian Institute of Science, Bangalore before going on to earn an SM in chemical engineering from MIT and a PhD from Columbia University.

As director, Dr. Mitra was instrumental in reorganizing the Harcourt Butler Technological Institute (HBTI), Kanpur, into an autonomous institution. As director and president, he transformed the Birla Institute of Technology and Science (BITS), Pilani, into one of India's premier universities. Dr. Mitra also helped establish the NIIT Academy while acting as its president.

Dr. Mitra has authored or co-authored several books in the areas of educational innovation and knowledge enterprise and is the recipient of several awards including the Wattumul Foundation Award and the Mewar Award. Dr. Mitra was on the visiting committee of the MIT Chemical Engineering, Department and was the first Asian to be elected president of the Association of Commonwealth Universities.

Col. Robert S. Day **(SM '48)** has published a book of his memoirs, entitled *Luck and Duty*.

Thomas McCarthy **(SM '52)** shares that in his second career, he is busy as a consultant on sustainable waste management to European governments and industry. He is encouraging the recovery of the huge potential energy and materials from urban waste.

Herbert L. Stone **(ScD '53)** received an international patent on a "Method for Improved Sweep of Oil Reservoirs" on January 5, 2005. Subsequently, this patent was submitted and is pending in individual nations. It was granted by Australia on March 22, 2007.

The patented process has the potential of having a profound effect on future world-wide supplies of producible crude oil. It was developed by computational methods. The next logical step is field testing.

Allan S. Hoffman **(SB '53, SM '55, ScD '57)**, currently a professor of bioengineering at the University of Washington, received the 2007 Founders' Award from the Controlled Release Society, recognizing a lifetime of achievement in controlled release for drug delivery. This award provides international recognition for a body of work that has yielded outstanding contributions.

Hoffman was elected to the National Academy of Engineers in 2005 and received the Founders' Award from the Society for Biomaterials in 2000. He taught as an instructor (1954-1956), assistant professor (1958-1960) and associate professor (1964-1970) in the MIT Chemical Engineering Department.

Carlos Paya Riera **(SM '59)**, reflects on his experience at MIT: "After many years since my graduation (MS Chem. Energ 1958-59), I am sharing my personal reflections and feelings about MIT. I thought that this could be of value to the school as well as to past, present and prospective students.

When I finished my PhD in chemistry at Valencia University in Spain I was awarded a Fullbright scholarship to attend MIT; that was my dream since I started my university studies. My starting date at MIT on September 4, 1958 coincided with the birth of my first child (Carlos) away from Boston as my wife Pepita remained in Valencia for financial reasons. When they finally arrived to Logan six months later she could not believe how thin I was (had lost 30 pounds!), which was in a large part a reflection of the stress and hardship endured during my first semester. The day I first met my son cannot be forgotten. The second semester was an easier one. I did my thesis with Dr. Gilliland, whose English was so fast that in my weekly meeting to review my work

I had to use a tape recorder. I finished in June 1959 with the highest grades and we went to New York to work with M.W. Kellogg. After one year, we went back to Spain. The impact that MIT had on my training allowed me to successfully lead the building of the petrochemical industry in Spain, and ultimately become a successful CEO of several of the petrochemical companies that emerged, and be named President of the European Petrochemical Association. I retired in 1990 as chairman and CEO of Repsol Exploration and Production, after which I started a consulting company and applied my leadership skills to run, as President, the Red Cross organization in Madrid and I am enjoying both.

What really motivated me to send this information, is my gratitude to MIT because it gave me confidence in my capacity. It also influenced my offspring, as exemplified by my eldest son Carlos's career as a full professor of Medicine at Mayo Clinic and now currently vice-president of Lilly Research Laboratories at Indianapolis. It is like closing a circle."

Dick Wuopio **(SM '60)** has been retired from Chevron for almost 13 years, and is now doing part-time consulting, which he's finding very enjoyable. His online sheet music business is also doing quite well, so he's not at a loss for things to do.

John C. O'Quinn **(SM '98)** is currently serving as Deputy Associate Attorney General in the US Department of Justice, where he is involved in overseeing civil litigation and developing policy for the Department. He previously was an attorney with Kirkland & Ellis LLP where his practice focused on intellectual property and complex litigation.

Randy Weinstein **(PhD '98)** has been promoted to full professor and is currently chair of the Chemical Engineering Department at Villanova University.

In Memoriam

George M. Morrow, III **(SM '41)** passed away on July 20, 2006. After graduating from MIT with a master's degree in chemical engineering practice in 1941, Morrow began his business career with Standard Oil in California. From 1941 to 1943, he was Assistant Director of the Chemical Bureau of the War Productions Board in Washington, D. C. In 1944, he was commissioned an officer in the U.S. Navy. Durring the last months of World War II, he was stationed in Europe and investigated a number of known or suspected weaponry advances by the Germans, including a submarine powered by hydrogen peroxide.

After the war, Morrow moved to Larchmont, NY, and began a career of 35 years with Union Carbide, working on entrepreneurial assignments in new ventures and businesses. He moved to Chapel Hill, NC, in 1984, where he became active as a board member in the Chapel Hill Preservation Society and as a participant in the formation of Chapel Hill Executive Services Corps. He was also a great advocate for UNC Hospice, providing a unique vision for the organization and advancing its presence in the Chapel Hill community.

Morrow is survived by his wife, Ruth Wilkinson of Chapel Hill, his two sons, George Morrow of Hastings on Hudson, NY and Robert Morrow of Roswell, GA, and two granddaughters, Ann Morrow and Susannah Morrow. ⊡

Alumni Donors

This honor roll is a special salute to those who have given over $100 to the MIT Chemical Engineering Department for the period July 1, 2006, through June 30, 2007.
Thank you to everyone who has supported us throughout the year!

Every effort has been made to ensure the accuracy of this list.
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Research Highlights

In the Department of Chemical Engineering

Surface Modification by Design via Vapor Deposition

Karen K. Gleason

Surface properties include the ability to be wet more or less easily by water (hydrophilic and hydrophobic, respectively); to be antimicrobial or conducive to cell growth; and to be electrically conductive versus electrically insulating. Surface modification can provide these benefits with negligible weight gain, since the applied coatings can have thicknesses of less than 100 nanometers. Surface modification allows valuable surface properties like lubricity, biocompatibility or chemical resistance to be imparted to inexpensive substrates having complementary bulk properties.

If the coating material has limited solubility or if the object to be coated degrades or swells upon exposure to solvent, the method of choice for surface modification becomes vapor phase processing. Additionally, vapor phase deposition can yield conformal coverage ("shrink-wrapping") of complex nano- and micro-structures, thus avoiding difficulties due to surface tension effects and wettability issues which arise in liquid phase processing (Figure 1).

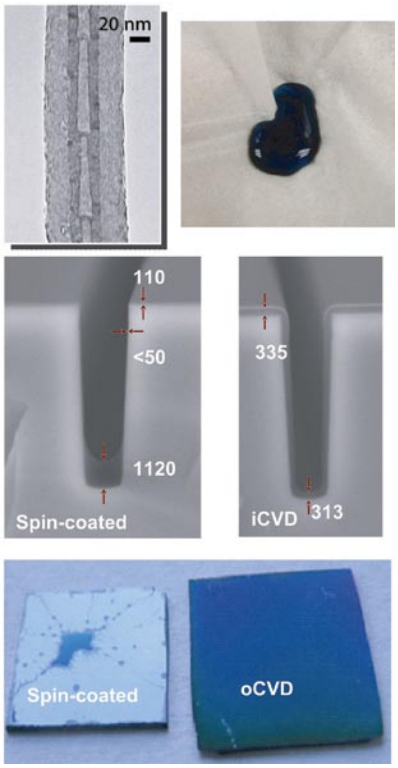

Figure 1

New techniques for vapor deposition recently developed in Professor Karen Gleason's laboratory are low-energy ("gentle") cousins to methods currently employed by the semiconductor industry to produce high purity thin films and interfaces. While these existing high energy processes are excellent for inorganic materials, reduced energy processing is essential to allow delicate organic functionalities to be fully incorporated on the surface. Lower energy processing also reduces undesired cross-linking, hence resulting in flexible films. Flexibility is a key factor in enabling semi-continuous roll-to-roll operation, which provides a substantial cost benefit over batch operation. Low-energy, solvent-free methods are also compatible with delicate substrates, such as paper and plastics.

The first new method is initiated chemical vapor deposition (iCVD) in which vapors of an initiator species are introduced into a vacuum chamber (~0.1 to ~1.0 torr) along with vapors of one or more vinyl monomer species. The initiator decomposes to form free radical species under conditions where the monomer is stable. The free radical fragments and monomers absorb and react onto a cooled (usually room temperature) substrate. This is an efficient process where one free radical fragment can result in the polymerization of hundreds of monomer units. Even though gas phase concentrations are low, the surface concentrations of the absorbed species can approach that of a liquid, enabling rapid reaction. The surface reactions in iCVD polymerization are identical to the radical polymerization steps in a bulk liquid phase, albeit on a surface. Detailed kinetic modeling studies of iCVD have confirmed that the kinetic polymerization rate constants for many vinyl monomers at the surface match those for standard bulk polymerization in solution.

The use of a free-radical initiating species is the key feature which greatly enhances the deposition rate while simultaneously decreasing the energy required to perform the iCVD deposition, typically < 5 watts for a 8" diameter substrate. For comparison, vapor phase deposition of inorganic material over the same area would typically require hundreds or even thousands of watts. The gentle nature of the iCVD process derives both from this low energy utilization rate as well from an ability to work at low substrate temperatures.

The iCVD method is a platform technology which has produced more than 40 different homopolymers. Random copolymers, alternating copolymers, and grafted polymer chains have all been demonstrated using the iCVD method. Surface properties achieved include non-leaching

antimicrobial layers, flexible dielectrics with low leakage current, and coatings with specific ligand binding capability on porous substrates and particles. Both superhydrophobic and superhydrophilic iCVD coatings have been developed. Engineering of iCVD coatings has led to extremely stable and flexible biopassivation coatings for neural implants and enteric coatings of drug particles for pH sensitive release.

A second robust vapor deposition technique has been developed for the family of conducting polymer thin films which are synthesized by step growth rather than free radical polymerization. Using a mechanistic approach, the oxidative chemical vapor deposition (oCVD) method involves gas phase delivery of both an oxidant and monomer to the growth surface. The reaction is spontaneous and the substrate temperature is low, resulting in the formation of high conductivity coatings without damage to the underlying substrate. The solventless oCVD technique yielded poly (3,4-ethylenedioxythiophene) (PEDOT) thin films with 10x to 100x higher conductivity than the PEDOT: poly(styrenesulfonate) films which were cast from a commercially available aqueous suspension. The improved properties for the oCVD films stem from eliminating the need to use nonconductive poly(styrenesulfonate) component to achieve solubility.

Mechanistic understanding of growth mechanism led to the ability to propagate conductive polymer chains directly from the growth surface with the use of any additional linker molecules. The creation of durable covalent linkages between the substrate and the surface functionalization layer affords excellent adhesion and also enables high resolution (60 nm) lithographic pattern formation. The demonstration of patterns in conducting polymer patterns grafted onto common plastic substrates is a potential breakthrough for integrated circuitry for flexible electronics where mechanical robustness is extremely important, requiring excellent interfacial properties and adhesion.

Each organic thin film synthesized by iCVD and oCVD displays a well-defined chemical structure as a result of selectively limiting the reaction pathways available during processing through a judicious choice of reactants and minimizing the energy input that drives the CVD chemistry. The exquisite control over composition and conformality achieved by these new vapor phase methods enables precise organic functionality to be designed and applied to almost any type of substrate.

Predicting the Complex Chemistry of Energy

William H. Green

The world is facing several major energy-related challenges: 1) providing the energy needed at an affordable price, so that all the people of the world can have an acceptable standard of living; 2) ensuring security and reliability of energy supply to all the nations of the world in the face of geopolitical and natural disasters; 3) accomplishing all this without wrecking the world's climate or causing inordinate harm to the public health or the local environment. A quick look at current economic, resource, and greenhouse gas models indicates that accomplishing these goals will require the introduction of new fuels and new energy-use technologies on a vast scale. Reliable predictions of the efficiency, performance, and life-cycle environmental impact of the many options are needed now, to reduce the huge societal, environmental, and economic risks associated with huge investments in new energy sources and technologies.

Chemical engineers attempted to make these sorts of predictions ~30 years ago during the first energy crisis. At that time, it was very difficult to make reliable predictions for any process that involved multiple chemical reactions even if bench-scale data were available (Fig. 2.) So they proceeded by building large pilot and demonstration units. Data from these large-scale units could then be used to make predictions, but these were typically valid only over the relatively small range where data were available. This data-heavy approach made energy R&D slow and very expensive, and the restriction to interpolation biased R&D towards incremental rather than step-out improvements.

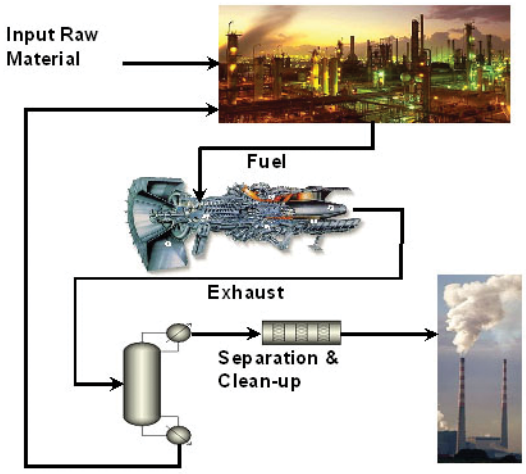

Figure 2

This time around, we have the benefit of computers, algorithms, quantum chemistry, and rate theories that were not available in the 1970's, so a very different approach is possible. We can now model the chemistry in many proposed energy systems at a fundamental level, allowing much more accurate extrapolations. This has the potential to allow reactive chemistry to be treated using rigorous process optimization approaches, as has already been done for most separation and flow processes.

Ideally, Chemical Kinetics should proceed as shown in Fig. 3: present knowledge allows the predictions needed for engineering, innovation, and decision-making. Some of these predictions are tested against experiment, and from that comparison the state of knowledge is improved, allowing more accurate predictions the next time.

All of this assumes that one can use the existing knowledge to make quantitative predictions, in particular to extrapolate from existing fuels and energy conversion devices to predict the behavior of proposed new fuels/devices. However, in practice it is very difficult to make accurate quantitative predictions for energy-related chemistry, since invariably the fuels are complex mixtures of many different molecules, all reacting simultaneously, often in a nontrivial heat and mass transport environment.

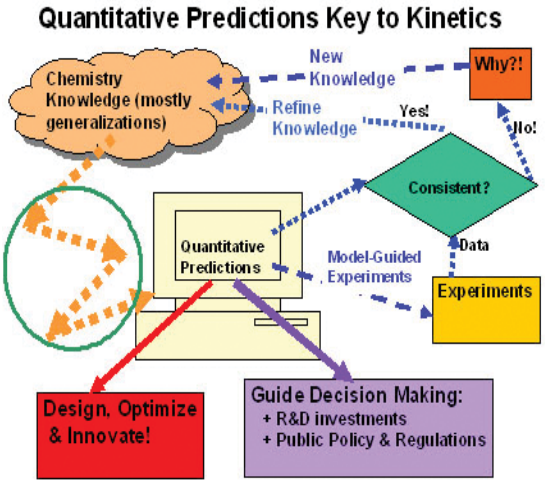

Figure 3: The real purpose of kinetics is to provide the quantitative predictions needed for rational design and for decision-making. Comparison of the predictions with experiment is a key step in improving our understanding of reactive chemistry. Despite their importance, it is still rather difficult to make quantitative predictions; more often in the literature one sees "postdictions" made after the experimental results are known. Prof. Green's research group has been developing methods and software to automate and improve the accuracy of the predictions (circled arrows).

Prof. Green's research group has been working to fill in the gaps in our ability to make quantitative predictions of reaction rates and product slates, i.e. he has been focusing on the steps in the circle in Fig. 3. His group recently developed extensible open-source software that rapidly constructs the large chemistry models (typically about 1000 reactions) needed to describe the thermal chemistry of liquid fuels (Fig. 4.) In the process the software uses results from quantum chemistry to estimate all the needed rate constants and molecular thermochemistry. It is important that this software is extensible and widely distributed, so that the chemistry knowledge that underlies the model predictions can be easily updated by experts on each type of reaction and reactive intermediate.

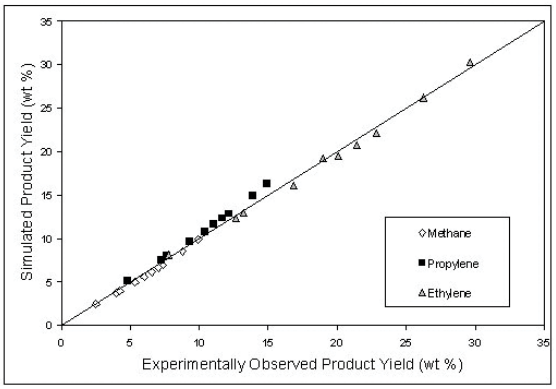

Figure 4: Comparison of the computer-generated model predictions with experimental data on the 1000 K pyrolysis of n-hexane. This is a pure prediction, no parameters were adjusted. For systems like the thermal decomposition of hydrocarbons, where the fundamental chemistry is well known, computer-generated a priori predictions can be as accurate as experimental data. (Adapted from K. van Geem et al., AIChE J.(2006).)

The large chemical kinetic models constructed by the computer can be very difficult to solve. Prof. Green and Prof. Barton have collaborated to address many of the numerical issues arise when solving these large chemical kinetic simulations, and developed a numerical procedure for rigorously determining whether or not these predictions are consistent with experimental data (after considering all the uncertainties involved).

In 2006-2007 Prof. Green has published several journal articles, including a chapter in Advances in Chemical Engineering, demonstrating the quantitative accuracy of the new Predictive Chemical Kinetics procedure for fuel pyrolysis, and exploring how well present chemistry knowledge can predict other types of energy-related chemistry. The model predictions were compared with

experimental data measured by several different research groups including Prof. Tester's group at MIT, Prof. Marin's group at the University of Gent (Fig. 4), Prof. Pfefferle's group at Yale, and direct measurements of reactive intermediates by Dr. Taatjes's group at Sandia National Laboratory. This approach focuses attention on key gaps in the chemistry knowledge base, as well as providing decision-makers and designers with a measure of the reliability of the extrapolative predictions.

In the coming year, Prof. Green's students will work with chemical engineers around the globe to help them to become familiar with the new predictive tools, and to enlist their aid in expanding and improving the chemistry knowledgebase to make quantitative predictions feasible for an ever-expanding range of energy chemistries.

Multifunctional Hybrid Nanomaterials via Electrostatically Driven Polymer Assembly

Paula T. Hammond

New materials developments in the Hammond group have focused both on biomedical applications and on new approaches to the design of electrochemical energy devices. The alternating adsorption of oppositely charged molecular species, known as the electrostatic layer-by-layer (LBL) process, is a simple and elegant method of constructing highly tailored ultrathin polymer and organic-inorganic composite thin films. We have utilized this method to develop a number of functional ultrathin film systems, including materials that can be tailored for biomaterials surfaces, cell templating, display, sensor and delivery applications. A method of generating biodegradable, conformal thin films on a number of different surfaces with nanometer scale control of the composition throughout the film thickness has allowed the design of multiple agent delivery thin films.

Initial work led to Deshpande funding to launch the idea of these multi-drug delivery release films for orthopedic implant coatings; the work has since been funded by an NIH grant, and the concept was entered into the $100K competition by MIT Chemical Engineering graduate students, where it reached the final round of competition.

New explorations in the group have include the use of some of these controlled thin films as unique redox active nanoscale systems that systematically deconstruct to release proteins and biopolymers on application of small electrochemical potentials. Possible applications as electroresponsive remote-release drug delivery systems are currently under study.

These highly controlled thin films can also be designed to act as solid state electrolytes or polymer membranes for the transport of ions in ultrathin electrochemical devices, including fuel cells and batteries. New developments in fuel cells include multilayer membranes that can block fuel gases or liquids at the electrode, but readily allow the passage of protons across the membrane. Such films could be used to modify existing Nafion membranes or as independent components of a composite thin film membrane.

Finally, new developments in collaboration with the Angela Belcher research group and the Yet-Ming Chiang research group in Materials Science and Engineering led to a thin film battery electrode based on the assembly of viruses with the solid state electrolyte polymer systems. The resulting films led to highly packed viruses with large surface areas; the viruses were genetically engineered to support biomineralization of cobalt and/or cobalt oxide and to bind gold nanoparticles. The resulting electrode exhibited 60% improvement in capacitance over standard Li ion based batteries; this work was published in *Science* in 2006 and received a Popular Science Innovation Award this past November.

GSC-X 2006-2007 News

By Michael Harper

Hello Course X Alumni!

The 2006-2007 year has been one of change: we have a new department head, a new building number (Hurricane D.Wayne flipped "Building 66" to read "Building 99"), and a new crop of 1st years that arrived our way in the Fall. However, the one thing that remained untouched was the GSC-X's efforts to ensure the ChemE community's social life was not non-existent.

As some of you may recall, summer 2006 brought the world together in the form of the Men's World Cup. The GSC-X offered daily viewings of all televised soccer matches in 66-110, which were watched by graduate student and faculty alike! While watching the World Cup may sound detrimental to research, we were surprisingly productive, thanks to the newly installed fume hood in 66-110; the chalkboards will be sorely missed.

The summer also brought about the ChemE 2nd Annual (the second time around makes "Annual" official!) Scramble Golf Tournament at Pembroke Country Club and the Annual Summer Picnic (we were not allowed to call it a BBQ because BBQs inherently have open flames according to MIT administration, and everyone knows ChemEs have no business around open flames). At the golf outing, the winning team shot under par, bringing to mind the old adage: "If you shoot over 90, you're spending too much time at work; if under 90, you're spending too much time on the links." The Picnic included sumo wrestling outfits, an ice cream truck, and the traditional dunk booth at which 1st years were given the opportunity to get even with their core course professors and TAs!

The department celebrates the beginning of another school year with its annual summer picnic.

The Fall semester brought about the usual TGs. The Welcome TG encouraged the 1st years to ask the Nth years something other than "Who do you work for?" by forcing them to play Bingo in which the boxes were people in the department. The Mini-TG assisted the 1st years with forgetting the terrible thought that is your first round of midterms. The Halloween TG featured apple bobbing, guess how many candy corns are in the jar, and a costume contest: won by a group of four students dressed as characters from Monty Python and the Holy Grail. The Thanksgiving TG allowed us time to give thanks: For the 1st years, that midterms were finally over; for the Nth years, that we were one semester closer to not graduating.

Professor Bill Green awaits his next antagonizer at the dunking booth.

The Winter TG had its normal festivities: baking contest, Secret Snowflake, and a visit from a certain jolly sole in a bright red suit. This year's skits were exceptionally brilliant. The 1st years tried to determine the new department head by having a debate between their core course professors. The Nth years had a similar idea, interviewing celebrities – Bob Barker, Donald Rumsfeld, and Tom Cruise in tighty-whities (a la Risky Business) – for the vacated department head position. The faculty skit, showing students what really goes on in their mind during Oral Qualifying Exams, managed to stay under the 50 minute time limit this year.

2007 gave all the 1st years a resolution to stick to: pass the Quals! To remind them that Quals are not the end of the world, the GSC-X provided them with goody bags, including one with a 4-piece Styrofoam puzzle, an "I Love my Grandpa" bib, a squeaky T-bone dog toy, and, to wash all that down with, power steering fluid. The spring semester's TGs included the Valentines TG, the Recruitment TGs, and the Cinco de Mayo TG.

The ChemE IM teams had another great year, including: reaching the semi-finals in Dodgeball, Flag Football, Fall Soccer, and Volleyball; reaching the finals in Tennis (we'll beat those BioEs one of these days); being crowned champions in the newly-formed Spring Soccer league; and defending our titles in A League Octathon and A League Unihoc! These great showings resulted in the ChemE team placing 3rd among Large Divisions (affiliations with >100 people) in the Affiliation of the Year Award!

On behalf of the former GSC-X, have a great year!

Best Regards,
Your GSC-X

ChemE – Red Sox Connection

This year, the Chemical Engineering Department got closer to the World Champion Boston Red Sox than most fans can dream about.

First, on July 28, 2006, Bob Langer threw out the first pitch in the game between the Sox and the Anaheim Angels. This was part of the celebration of his 30 years of contributions to innovation.

Professor Langer prepares for his first major league pitch at Fenway Park.

For more on the Langer event, go to:
http://web.mit.edu/newsoffice/2006/langer.html

On St. Patrick's Day 2007, the Department made another visit to Fenway Park, this time to celebrate Bob Armstrong's eleven years as department head. After dinner in the EMC Club overlooking the baseball field, incoming department head Klavs Jensen presented Armstrong with a Louisville Slugger signed by faculty and staff and official Red Sox jerseys for him and wife Debbie (well deserved recognition for her dedication as "first lady" of the department).

Melanie Miller, Editor
Department of Chemical Engineering

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