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Chemical Engineering Alumni/ae News

Spring 2005
Course X

Room 66-350 · Fax: 617.258.8992

Generations mix at alumni/ae and faculty reception, pg. 24

Landau Memorial, pg. 25

New Bioengineering Program, pg. 27

ALSO IN THIS ISSUE:

FROM THE HEAD OF THE DEPARTMENT...

Professor Robert C. Armstrong
Head, MIT
Chemical Engineering

Welcome to the 2004 edition of the department's newsletter. It is good to have the opportunity to bring you up to date on the department. The past two years have been particularly introspective as we have looked hard at the changes in the world that impact chemical engineering, and have been actively translating our vision of the future into new educational and research programs. It has been, and continues to be, an exciting journey, which I will say more about later.

Tempering the excitement of research and education in the department is the loss of several of our distinguished alumni/ae *(See page 25)*. Particularly difficult is the passing of Dr. ***Ralph Landau*** in April 2004. The department and MIT are truly grateful for the life of service and devotion Ralph gave to the Department of Chemical Engineering. Ralph gave so much to us—intellectually, emotionally, and financially—over the years. It is virtually impossible to capture the enormous impact he had on the field of chemical engineering and the department at MIT in particular. He was an extraordinary visionary and a most gracious individual. It is certainly fitting that our building bears his name as a lasting legacy to his contributions. Dr. Landau's contributions to the department and MIT are summarized in the article on *page 25*. We will all greatly miss him.

First, a few highlights: The department's graduate and undergraduate programs were both ranked number one among chemical engineering departments in the most recent *U.S. News & World Report* academic survey; our faculty achieved a record $22 million research volume; we revamped our existing Course X degree, and developed an entirely new degree program, XB. It is indeed a wonderful and an exciting time in Chemical Engineering at MIT! *(See page 27)*

As I have discussed in previous newsletters, the discipline of chemical engineering is undergoing significant and exciting change. Although historically focused on the petrochemical sector, the chemical engineering profession has evolved to a point where it is now critical to such other sectors as microelectronics, medicine, biotechnology, and new materials. While demands for well-educated engineers have continued to grow, our educational programs have not kept pace—it is time for change if the profession is to remain vibrant and attractive to young students and meet the needs in the emerging technologies that depend on molecular transformations.

HEAD see page 21

Practice School News

By Professor T. Alan Hatton, Director

The **David H. Koch School of Chemical Engineering Practice** continues to be recognized as a unique educational opportunity within the department, attracting top students from around the country and the world. A total of 32 students attended stations during the Fall '02 through Summer '03 sessions, and 30 students participated in the program over the past year ('03–'04). With the strong support of our hosting companies, we are able to continue to provide the diversity of experiences for our students that has traditionally characterized our program.

Over the past year and a half since our last report, we have operated stations at a number of different host companies, providing a range of corporate and geographical environments for our students. In Spring '03, ***Mike Modell*** directed a station at **Masterfoods, Inc.,** in Reno, Nev., while ***John Friedly*** once again ran the **Cargill** station just outside Minneapolis, Minn. For the summer of 2003, we ran two stations in parallel in Minneapolis, Minn., at **Cargill** ***(John Friedly)*** for one month, and at **General Mills** for two months; the **General Mills** station was directed by newcomer ***Claude Lupis*** *(See below)*. One set of students then traveled overseas to Japan for two months to work at the **Mitsubishi Chemical Group** station in Mizushima, under the direction of ***Mike Modell***, while the second group of students went from **General Mills** directly to the Schenectady, N.Y., area to work on fuel cell development projects at **PlugPower**, under the supervision of ***Bill Dalzell***. In Fall '03, we were hosted again by **General Mills**, this time for one month in Buffalo, N.Y., then a second month just outside Chicago, Ill., with ***Claude Lupis*** in charge. The students then crossed the Atlantic to go to the **BP Chemicals** Saltend site near Hull in the UK for two months; ***Mike Modell*** ran the show this time. Because of a larger number of students than expected (some signed up late for the program), it was necessary to run two parallel groups through the program during the Spring '04 session. For the first two months, one student group went to Basel, Switzerland, with ***Mike Modell***, to tackle problems at **Novartis**, while the second group worked on glass-processing problems at **Johns–Manville** facilities in Toledo, Ohio, under the supervision of ***Claude Lupis***. Both groups ended up in the Minneapolis, Minn., area, one at **Cargill** ***(John Friedly)*** and the other at **General Mills** (with ***Mike Modell***). Over this past summer, students were again hosted by **Novartis**, but this time closer to home, in East Hanover, N.J., where ***Claude Lupis*** has taken the helm. The final month of the summer session was spent back in Cambridge, Mass., with **Alkermes, Inc.,** directed by ***Bill Dalzell***.

Cargill, Spring 2004 back row from L to R: Cargill Host Mike Tupy, Theis Clarke, Jacob Albrecht, Dhananjay Dendukuri, and Station Director, John Friedly. Front row from L to R: Sharon Soong, Amy Lewis, Mohit Rawat and Saswata Ghosh.

We continued our joint program with Cambridge University under the **Cambridge–MIT Institute (CMI)**, in which Cambridge students participate in our core courses here at MIT, return to Cambridge, UK, for additional coursework and research, and then attend two months of a Practice School session alongside MIT students. Last Fall, three Cambridge students attended the **General Mills** station, and two students were hosted by **BP Chemicals**. The intake for the 2004–05 academic year has increased to 14 students, who will be resident at MIT this Fall, and will be attending stations next year. By all accounts, this has been a very successful collaboration, one that is looked upon by the upper CMI management as being the best in the CMI portfolio of Practice School Programs, and we look forward to continuing it in the years to come.

BP Chemicals, UK Fall 2002 from L to R: Edward Murphy and Kerrill Titiyevskiy, U. Cambridge exchange students Stuart Scott and Bart Hallmark, with Anna Pisania, Chad Augustine, Asst. Director Andrew Kim, U. Cambridge exchange student Daniel Holland, and Station Director Barry Johnston.

The breadth of technical problems and environments provided by this large number of diverse companies afforded an excellent educational opportunity for our students. We are certainly grateful to these companies for their hosting of our Practice School Stations.

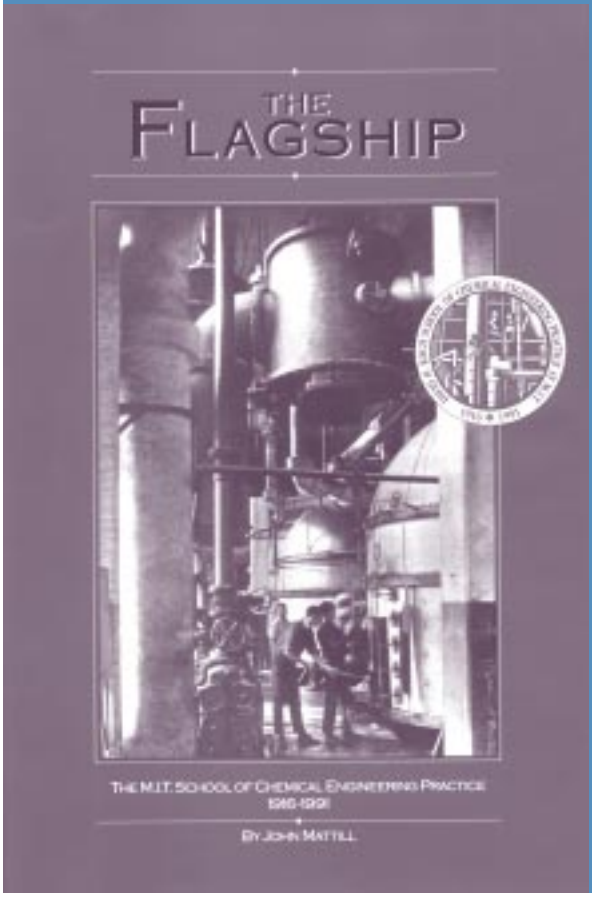
PS see facing page

The Flagship

The School of Chemical Engineering Practice, 1916–1991

By John I. Mattill, Editor Emeritus,
Technology Review

190 pages, 120 photographs, scores of anecdotes, and three reminiscences by alumni/ae capture the special passion of this audacious—and still unique—concept that has become a world standard for engineering education.



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MIT, Room 66-309
Cambridge, MA 02139 US

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David H. Koch School of Chemical Engineering Practice

PS from facing page

John Friedly retired from the program at the end of last year, having been a Station Director for more than six years, although he will fill in from time to time on an *ad-hoc* basis when we have the need for additional station directors. We wish him and his wife, ***Lorue Friedly***, every happiness in their retirement, and are very thankful for all their contributions to the Practice School during a long and successful second career with our program.

It is a pleasure to welcome ***Mike Modell*** and ***Claude Lupis*** to the Practice School community. Mike and Claude have both had distinguished careers spanning academia and industry, and have served as independent consultants over the years. Both have written influential thermodynamics textbooks, and both have recently been involved in on-campus teaching here at MIT. Mike was a faculty member at MIT before branching out to start his own companies exploiting supercritical water oxidation technologies; while at MIT, he co-wrote the classic text, *Thermodynamics and Its Applications*, with ***Bob Reid*** (the 3rd edition is the revision of this book by ***Jeff Tester***). Claude's early academic career was at what is now called Carnegie Mellon University; after many years in industry and consulting, primarily in the metallurgical fields, he taught in the Materials Science and Engineering Department for a number of years before joining the Practice School; his book is titled, *Chemical Thermodynamics of Materials*.

This continues to be a stimulating environment for the Practice School, and we look forward to continuing our development and testing of innovative approaches to station operations over the next year to ensure that our students get the best education possible!

2003 Chemical Engineering Fellowships

Class of 1936 Fellow
Chuang-Chung Lee

Haas Family & Adel F. Sarofim Fellow
Andrew A. Peterson

Robert T. Haslam Fellows
Mai-Lan Ho
Kangyi Mao
Bin Pan
Anna K. Schampel
Janet Tse

George M. Keller Chevron Fellow
Curt R. Fischer

Ralph Landau Fellows
Adam F. Miller
Michele C. Verticchio

Jerry & Geraldine McAfee Fellow
Earl Osman Pauco Solis

Reid & Williams Fellow
Felipe Osorno

Charles & Hilda Roddey Fellow
Sandeep Sharma

William & Margaret Hutchinson Rousseau Fellow
Mahmooda Sultana

Keith & Helen Rumbel Fellow
Vernella Velonie Verlin Vickerman

Arch Scurlock Fellow
Hemantkumar Ramesh Sahoo

John C. Sluder Fellow
Linlin Ye

Howard Stern Fellows
Panayiotis P. Lemonidis
Lakshman Pernenkil

Frank Hall Thorp Fellow
Gaurav Bhalla

Rosemary Wojtowicz Fellow
Ingrid M. Berkelmans

Robert T. Billings Fellow
Matthew L. Cohen

John H. Grover/Haas Family Fellow
Ling Chao

Tae Sup Lee Fellow
Ju Jin An

Peter Spitz Fellow
Sarah Virginia Petway

Alkermes Fellow
Minglin Ma

GEM/ATOFINA Fellow
Aqueelah C. McKinley

Bayer Fellow
James Thomas Wertman

ExxonMobil Fellows
Rocco P. Ciccolini
Barry M. Grace

Procter & Gamble Fellow
Julie Cha

Dumbros Fellow
Daniel C. Pregibon

Dupont Fellows
Anthony G. Balducci
Michelle T. Hardiman
Ryan S. Waletzko

Haslam/Presidential Fellows
Kristin J. Mattern
Brian E. Mickus
Andrew C. Miller

Hertz/Walsh Presidential Fellow
Christopher R. Loose

NDSEG/Haslam Presidential Fellows
Helen F. Chuang
Scott M. Paap

NSF/Frederick Holloway Fellow
Lily V. Tong

NSF/Edwin R. Gilliland Fellow
Robert Wilson Ashcraft

NSF/George M. Keller Fellow
Aviva Presser

NSF/Walsh Presidential Fellow
Karen Danielle Daniel

Walsh Presidential Fellow
Greg M. Thurber

Practice School Awards for Outstanding Performance

William C. Rousseau Award for Leadership and Ethics
2002:
Manish Bajaj
2003:
Chad Augustine

J. Edward Vivian Award
2002:
Brian Anderson
2003:
Bernat Olle

Jefferson W. Tester Award
2002:
Joseph Moritz
and
Ramin Haghgooie
2003:
Jin Zhou

Rosemary J. Wojtowicz Award
2002:
Joanna Yu
and
Soon Siong Darren Ong
2003:
Keith Tyo

Awards Day

The 2004 Chemical Engineering Awards Ceremony was held on May 10, 2004, in Gilliland Auditorium. Professor and Department Head ***Robert C. Armstrong*** presided over the event.

Armstrong began the ceremony by recognizing ChemE undergraduates who have been awarded outside scholarships. These include:

- ***Wei Chan***, a junior from Pleasantville, N.Y., and ***Hana Oh***, a junior from San Diego, Calif., were the recipients of **Merck Fellowships** for scholastic excellence.

- ***Peter Miller***, a junior from Atlanta, Ga., was the recipient of the **National Goldwater Scholarship** for his academic excellence.

- ***Nnennia Ejebe***, a senior from Plymouth, Minn., was chosen for the **Ronald E. McNair Scholarship Award**. The scholarship, established in Dr. McNair's honor by the Black Alumni/ae of MIT, recognizes a Black undergraduate who has demonstrated strong academic performance and made a considerable contribution to the minority community. Physicist and Astronaut Ronald E. McNair (PhD '77), who died in the 1986 Space Shuttle *Challenger* explosion, was well known for his involvement in the greater MIT community. Ejebe was acknowledged at the MIT Awards Convocation held on May 4th, 2004.

Armstrong then presented the following Departmental Awards:

Dow Chemical annually recognizes one junior in the Department of Chemical Engineering for a balanced record of achievements in academics, participation in professional and social organizations on campus, as well as work experience. This year's recipient of the **Dow Outstanding Junior Award** was ***Henry Bergquist*** from Ellington, Conn.

The **Robert T. Haslam Cup** was given to senior ***Sudha Amarnath*** from Lansing, Mich., for displaying exceptional professional promise in the field of chemical engineering.

The **Roger de Friez Hunneman Prize** is the oldest award in the department, and is given to an undergraduate for outstanding scholarship and research. This year's recipient was senior ***Sonali Rudra*** from Sugar Land, Tex.

The **Edward W. Merrill Outstanding Teaching Award** was presented to graduate student ***Saeeda Jaffar*** from Dubai, UAE, for her work with 10.302 during the Fall 2003 semester.

Every Monday, two third-year graduate students present the progress of their research for peer evaluation as part of the 10.991/2 seminar series. Two graduate students were recognized for their seminars. This year's recipients of the **Outstanding Seminar Awards** were ***Brian Baynes***, from Sewell, N.J., for the Fall 2003 semester; and ***Andre Ditsch***, from Alliance, Nebr., for the Spring 2004 semester.

The **Chemical Engineering Special Service Awards** were given to members of the GSC, for their hard work organizing various graduate student events. The recipients were ***Hal Alper***, from Owings Mills, Md.; ***Ryan Bennett***, from Longwood, Fla.; ***Theis Clarke***, from Valparaiso, Ind.; ***Malancha Gupta***, from Flushing, N.Y.; ***Joel Moxley***, from Richmond, Va.; ***Jane Rempel***, from Milwaukee, Wisc.; ***Mark Styczynski***, from Freehold, N.J.; and ***Benjamin Wang***, from Santa Monica, Calif.

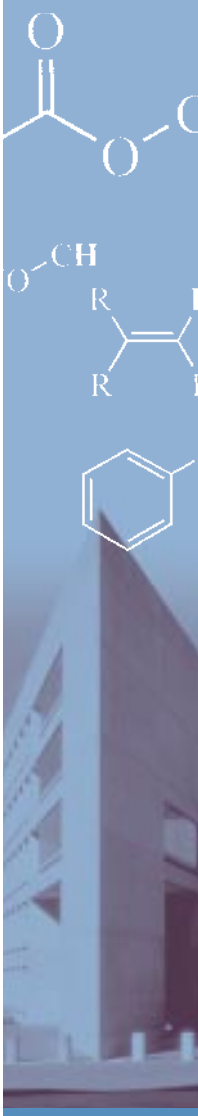
Senior ***Cindy Chung*** from Parsippany, N.J., was given a **Special Service Award** for her dedication and hard work as AIChE President for the past year.

The **Outstanding Employee Award** was given to ***Gwen Wilcox***, an Administrative Assistant for Professors *Jefferson W. Tester* and *Bernhardt L. Trout*. A first-time winner, Wilcox was praised for her commitment, attention to detail, and excellence in organizing the faculty seminars.

The **Outstanding Faculty Award** from the graduate students was a tie this year, and was given to Professors ***William M. Deen*** and ***Jefferson W. Tester***. This award was presented by graduate student *Joel Moxley*. Lecturer ***Jean-François Hamel*** received the undergraduate **Outstanding Faculty Award**, which was presented by *Cindy Chung*.

Finally, the **Chemical Engineering Rock Award** for outstanding athletic ability and participation, as voted on by the ChemE graduate students, was given to ***Mark Styczynski***.

Visit us on the web at: **http://web.mit.edu/cheme**



Faculty Appointments & Promotions

In the Department of Chemical Engineering

New Faculty Appointment

Prather Welcomed to Faculty

We are very pleased to welcome newly appointed Assistant Professor ***Kristala Jones Prather***, who joined the department this Fall. Professor Prather received an SB degree in chemical engineering from MIT and was the winner of the Karl Taylor Compton Prize. She received a PhD in chemical engineering from the University of California, Berkeley, before joining Merck, where she worked in bioprocessing research. Professor Prather was recently named as one of only nine recipients nationwide of the Camille and Henry Dreyfus New Faculty Award. This extremely competitive award goes to both chemists and chemical engineers starting academic careers, and recognizes her outstanding research accom plishments and bright promise. Professor Prather's proposed research is concerned with methods for optimizing recombinant gene dosages to maximize productivity in the metabolic engineering of *E. coli.* Her addition enhances an already-outstanding group of faculty in the important area of bioprocessing technology.

Faculty Promotions

Rutledge Promoted to Full Professor, Executive Officer

Gregory C. Rutledge, promoted to Full Professor and, effective July 2004, to Executive Officer for Chemical Engineering, received a BS degree from the University of Virginia (1983) and a PhD from MIT (1990). Professor Rutledge, recent past Director of MIT's Interdepartmental Program in Polymer Science and Technology (PPST), aims to develop quantitative relationships between chemical architecture and materials properties on polymers and other complex molecular systems. His breakthroughs include a definitive theoretical resolution of a 30-year-old problem concerning the nature of folding at the crystal/amorphous interface in polyethylene.

Green Promoted in 2004 to Associate Professor with Tenure

William H. Green, Jr., specializes in reactive chemical engineering: quantitatively predicting the time evolution of chemical mixtures. Chemical kinetic models are increasingly used as input for major business and public policy decisions, ranging from the design of chemical process units to energy tax proposals. Rapid advances in computer hardware and software now make it feasible to construct truly predictive kinetic models based on a detailed understanding of the molecular processes occurring in complicated systems, rather than the very empirical interpolative models typically used today. Professor Green's efforts are focused on the development, demonstration, and validation of new methods for predicting the course of chemical reactions, and on the application of these methods to important technological and policy problems.

Trout Promoted to Associate Professor

Bernhardt L. Trout is developing and applying molecular computational methods to gain insights that will lead to the design of chemical materials and processes. At the heart of his research group's methodology lies quantum mechanical methods, such as density functional theory and molecular orbital theories that include high-level correlation. These are used to compute energies of interaction of atoms and molecules with the highest possible accuracy.

Applications include heterogeneous catalysis on zeolites for the synthesis of cleaner-burning fuels and olefins; high-conversion, next-generation automotive catalysts; heterogeneous stratospheric chemistry to understand the consequences of releasing chemicals into the atmosphere; natural gas hydrates as an abundant, clean, future fuel source; CO_2 hydrates involved in the sequestration and storage of CO_2; nucleation and crystallization of chemical pharmaceuticals and semiconductor materials; and stabilization of therapeutic proteins. Overall, there is an emphasis on environmental research and development of more environmentally benign technologies and on human therapeutics.

Ying Takes Charge of New Singapore Bioengineering/Nanotech Institute

Professor ***Jackie Y. Ying*** is currently on a professional leave from MIT to assume the Executive Director position at Singapore's new **Institute of Bioengineering and Nanotechnology (IBN)**. IBN is a new national research institute under the Agency of Science, Technology, and Research–Singapore. Professor Ying is in charge of establishing the Institute to a staff size of 250 in research areas that include: drug delivery, genes and proteins, tissue engineering, artificial organs and implants, medical devices, biological and biomedical imaging, and nanobiotechnology.

For more about IBN, visit their website:
http://www.ibn.a-star.edu.sg

Faculty Awards Highlights

Merrill Merits Biomaterials Founders' Award

We're proud to recognize Emeritus Professor ***Edward W. Merrill***, who was selected as the 2003 recipient of the **Founders' Award** of the **Society for Biomaterials (SFB)**. The SFB Founders' Award is based on long-term, landmark contributions to the discipline of biomaterials. Professor Merrill presented a special address at the 29th Annual Meeting of the Society for Biomaterials in Reno, Nev., in April 2003.

Congratulations to Professor Merrill on being selected for this important award!

For more about the SFB Founders' Award...
http://www.biomaterials.org/award_founders.htm

For more about Professor Edward W. Merrill...
http://web.mit.edu/cheme/people/faculty/merrill.html

Langer Wins 2003 John Fritz Medal (AASE) and Charles F. Kettering Prize (GM Cancer Research Foundation)

Professor Robert S. Langer, well known for his contributions in the field of controlled drug delivery systems and tissue engineering, and his dominance in the field of bioengineering, was honored by the **American Association of Engineering Studies (AAES)** with the **2003 John Fritz Medal**.

The **John Fritz Medal** is awarded for scientific or industrial achievement in any field of pure or applied science. It was established in 1902 as a memorial to the great engineer whose name it bears.

Another recent major award for Professor Langer was the General Motors Cancer Research Foundation's **Charles F. Kettering Prize**, one of three awards given annually by the General Motors Cancer Research Foundation. The $250,000 prize recognizes the most outstanding recent contribution to the diagnosis or treatment of cancer. Professor Langer was cited for his major contributions to the development of sustained-release drug delivery systems for the treatment of cancer.

"I went into cancer research because I had always drawn a lot of satisfaction from helping people," Professor Langer said. "I wanted to use my science and engineering background in a way that would help people live longer and healthier lives."

The **Charles F. Kettering Prize** is given for the most outstanding recent contribution to the diagnosis or treatment of cancer, and is named in honor of the inventor, former General Motors Director, and pioneer of the General Motors Research Laboratories. Mr. Kettering was a generous supporter of basic research in both industry and medicine. He and Alfred P. Sloan, Jr., established the **Sloan–Kettering Institute for Cancer Research** in New York in 1945.

Other major awards have included the **2002 Charles Stark Draper Prize** from the National Academy of Engineering, the **2002 Othmer Gold Medal** from the Chemical Heritage Foundation (CHF), and the **1998 MIT–Lemelson Prize**.

For more about Professor Robert S. Langer...
http://web.mit.edu/cheme/people/faculty/langer.html

For more about the John Fritz Medal…
http://www.aaes.org/news_center/5_5_03.asp

For more about the Charles F. Kettering Prize…
http://www.gm.com/company/gmability/philanthropy/cancer_research/history.htm

Lauffenburger Lands AIChE 2002 Walker Award

The Department of Chemical Engineering wishes to congratulate Chemical Engineering Professor ***Douglas A. Lauffenburger***, who was awarded one of the AIChE's most prestigious honors, the **William H. Walker Award for Excellence in Contributions to Chemical Engineering Literature**.

Professor Lauffenburger was chosen for this award based upon his intellectual leadership in combining chemical engineering with molecular cell biology and for developing innovative biotechnologies based on molecular cell-level design principles.

For more about Professor Douglas A. Lauffenburger...
http://web.mit.edu/cheme/people/faculty/lauffenburger.html

For more about the AIChE William H. Walker Award...
http://www.aiche.org/awards/awarddtl.asp?AwardID=63

Faculty Awards Highlights

Gregory Stephanopoulos Elected to NAE, AIChE Board of Directors

Congratulations to Professor ***Gregory Stephanopoulos***, Bayer Professor of Chemical Engineering and Biotechnology, and Taplin Professor of Health Science and Technology, who in 2003 was elected to the **National Academy of Engineering (NAE)**! The NAE cited his pioneering contributions in defining and advancing metabolic engineering, as well as his leadership in incorporating biology into chemical engineering research.

Professor Stephanopoulos was also recently elected to a three-year term on the AIChE Board of Directors.

We also congratulate 2003 **NAE** electee and emeritus faculty member Professor ***Adel F. Sarofim***, now at the University of Utah. Professor Sarofim was recognized for advancing our understanding of the mechanisms and modeling of processes that control radiation in and pollutant emissions from combustors.

For more about Professor Gregory Stephanopoulos...
http://web.mit.edu/cheme/people/faculty/steph.html

For more about Professor Adel F. Sarofim…
http://www.combustion.utah.edu/People/Sarofim.html

For more about the National Academy of Engineering...
http://www.nae.edu

Clarkson Bestows Honorary Doctoral Degree upon Brenner

ChemE Professor ***Howard Brenner*** received an honorary doctor of science degree at **Clarkson University's** 111th Commencement on Sunday, May 9th, 2004. The degree was awarded for "his outstanding intellectual achievements during a distinguished half-century career as a chemical engineering academic, and for his boldness in questioning the most basic assumptions of continuum fluid mechanics."

Addressing the more than 500 graduates, Professor Brenner explained that as a first-generation college graduate, it was a particular honor to receive this recognition. "I came from humble origins. My father went to school only to the eighth grade, my mother to the first grade."

"I am a theoretician in the field of fluid mechanics," Professor Brenner said. "And I was fortunate to come to this early in my life. In high school, I had a difficult time in geometry, perhaps like many of you. But I had a wonderful teacher, Mr. Woods, who did a theorem proving that the interior angles of a triangle added up to 180 degrees. This was a purely theoretical exercise, one that I had never thought about before. It was hard to believe that you could use your own mind to predict something and then go into the world or the laboratory and measure it. I had a protractor because I was taking a course in mechanical engineering. After class, I drew some triangles and they added up to 180 degrees, and I was amazed. And I have been amazed ever since."

In September of next year, Professor Brenner will begin his 50th year as a faculty member in Chemical Engineering. His research and educational activities have been honored by numerous awards from professional societies, including the **American Institute of Chemical Engineers**, the **American Chemical Society**, and the **American Society of Engineering Education**. Most recently, he received the **Fluid Dynamics Prize** of the **American Physical Society**. He is one of a small group of scientists and engineers elected not only to both the **National Academies of Science and Engineering**, but also to the **American Academy of Arts and Sciences**.

For more about Professor Howard Brenner...
http://web.mit.edu/cheme/people/faculty/brenner.html

For more about the American Academy of Arts and Sciences...
http://www.amacad.org

Hammond Honored as Great Mentor

We all know someone who inspired, coached, or guided us in honing our skills and in shaping our career path, our ideas about the world, and our own potential to help shape its future. These experiences can spark the beginning of a lifelong path of self-growth and discovery.

In honor of National Mentoring month, and her dedication as a mentor in the MIT and Cambridge African–American communities,

ChemE Professor ***Paula T. Hammond*** was named a ***Great Mentor*** by *US Black Engineer* online magazine in their January 2004 issue.

In an illuminating interview, Professor Hammond spoke about her inspiration to pursue chemical engineering, how she got started in the field, and her upbringing and current mentoring activities, both at the St. Paul AME Church here in Cambridge, Mass., and in the larger MIT community. She also described some of the exciting projects now underway in the Hammond research group. These include cancer-fighting cell-specific nano-containers, ultra-thin films for lightweight fuel cells and related technologies, electrochromic materials that may become usable for foldable displays, and chemical and/or bio agent sensors with multiple possible applications.

We congratulate Professor Hammond on her inspirational role in the Cambridge and MIT communities, serving as a needed mentor and as a role model for young African–American scholars.

For more about Professor Paula T. Hammond...
http://web.mit.edu/cheme/people/faculty/hammond.html

To read the interview with Professor Paula T. Hammond...
http://www.blackengineer.com/artman/publish/article_190.shtml

Stephanopoulos Wins 2003 Dual AIChE Honors

Professor ***George Stephanopoulos***, who in 2003 returned from a two-year stint as Mitsubishi Chemical Corporation's Chief Technology Officer, received dual honors from the AIChE, garnering both the 2003 **Institute Lecturer** and the **William H. Walker Awards**.

These two awards are among the most prestigious in the field, and Professor Stephanopoulos's selection for both in the same year is a fitting tribute to his uniquely vital and ongoing contributions.

Professor Stephanopoulos's **Institute Lecture**, presented at the 2003 National Conference in November, highlighted a character shift in the chemical industry, from a process to a product emphasis. He outlined the far-reaching ramifications of this shift, found in virtually every aspect of the industry's operations, and in the educational preparation of future scientists and engineers. He also used examples from his experience in the rejuvenation of Mitsubishi Chemical's R&D operations, and analogous activities of other chemical companies.

The 2003 William H. Walker Award was presented to Professor Stephanopoulos in honor of his recent outstanding contributions to chemical engineering literature.

His work in the areas of product and process development and design, process operations and control, and integrated computer-aided environments for process systems engineering have also led to numerous other honors over his distinguished career, including AIChE's 1993 Computing in Chemical Engineering Award, the 1987 and 1992 Best Paper Award, Computers and Chemical Engineering, and the 1982 Alan P. Colburn Award. ▫

Faculty Distinctions

In the Department of Chemical Engineering

Robert C. Armstrong continued as Head of the Department of Chemical Engineering during the academic year 2003–04. He serves as Vice-Chair of the Governing Board of the Council for Chemical Research (CCR) for 2004, and will chair this organization in 2005. In April, he ran the CCR Annual Meeting in Tampa, Fla., on "Chemical Research Opportunities for the Global Energy Economy." He has been working through CCR to organize broad discussions across chemical engineering regarding the evolution of the discipline. These discussions are driven by the significant impact of biology on research and education in chemical engineering today and by the breadth of industries into which our graduates now go. These meetings have led to a very interesting series of curriculum workshops funded by the National Science Foundation (NSF) to take a bold, in-depth look at the future of chemical engineering undergraduate education. These workshops are described in detail on the department's website. Professor Armstrong gave the Distinguished Lecture at the University of Texas and the Harry G. Fair Lecture at the University of Oklahoma, among other seminars. Professor Armstrong currently serves on the External Advisory Boards and/or Visiting Committees of the respective Departments of Chemical Engineering at Carnegie Mellon University, the Georgia Institute of Technology, the University of Michigan, and the Virginia Polytechnic Institute, and in the Departments of Chemical and Biological Engineering at Northwestern University and the University of Wisconsin.

Janos Beer was presented with the US Secretary of Energy's Lowry Award at a January ceremony in Washington, D.C. The Lowry Award is the highest honor given by the US Department of Energy for outstanding contributions to fossil energy science and technology. The citation of the Award reads: "For pioneering research and development in fossil fuel technology, inspirational teaching, and service to the government and industry; for contributions in combustion science exemplified by the development of a fundamental understanding of heat transfer, NOx formation, and mineral matter transformation in flames; and for leadership that continues to be critical to the design and commercialization of high-efficiency low-NOx combustion systems widely used in the fossil-fuel power industry."

Daniel Blankschtein was on sabbatical leave in the Boston area during 2003, and continued to serve as Graduate Officer in the department. His research group conducts fundamental theoretical and experimental research in the area of Colloid and Surfactant Science with emphasis on practical and biomedical applications. Professor Blankschtein delivered a plenary talk at the 12th International Conference on "Biopartitioning and Purification" held in Vancouver, BC, and gave an invited talk at the Gordon Research Conference on "Barrier Function of Mammalian Skin" held in Bristol. Professor Blankschtein and his students also presented talks and posters at meetings of the American Institute of Chemical Engineers (AIChE), the Society of Cosmetic Chemists (SCC), the Gordon Research Conference on "Chemistry and Physics of Liquids," and the 7th US–Japan Symposium on "Drug Delivery Systems" held in Maui, Hawaii. Professor Blankschtein continues to serve on the editorial board of Marcel Dekker's Surfactant Science Series.

Howard Brenner prepared a paper, taught an advanced topics course entitled, "Fluid Mechanics Revisited," and presented numerous seminars and lectures on this topic. The underlying theme of this controversial work asserts that the basic foundations of continuum fluid mechanics and thermodynamics should, in the case of compressible fluids, be based upon the transport of volume, rather than of mass, as is currently assumed. Professor Brenner received an honorary doctoral degree from Clarkson University and spoke at their graduation ceremonies.

Charles Cooney returned from a year's sabbatical at the University of Cambridge, UK, and continues to serve as the Faculty Director of the Deshpande Center for Technological Innovation and as the Co-director of the Program on the Pharmaceutical Industry. During the past year, he was a CMI Fellow and co-taught the CMI pilot course, "TEEMS (Technology-based Entrepreneurship for Engineering and Management Science Students)," for Engineering and Management Science undergraduates. Professor Cooney was appointed a Co-leader of the BP–MIT Projects Academy, which was created by the Sloan School of Management and the School of Engineering.

William H. Dalzell continued as the Department of Chemical Engineering's Environmental, Health, and Safety (EHS) Coordinator. His primary efforts this year have been to ensure that all people working with chemicals or biological materials have participated in appropriate EHS training and that all laboratories are in compliance with EHS regulatory requirements. He was Director of the Chemical Engineering Practice School Station at PlugPower in Latham, N.Y., during August 2003. He gave a presentation at Tokushu Kika Kogyo Co., Ltd. in Tokyo, Japan, entitled, "Evaluation of Novel Mixing Technology" on November 6th, 2003.

William M. Deen was an invited speaker at the First International Symposium on Albuminuria in New York City, N.Y., in May 2004. Papers from his research group also were presented at the annual meeting of the AIChE in San Francisco, Calif., in November 2003. In the 50th anniversary issue of the *AIChE Journal*, one of his papers was recognized as the 15th most-cited paper in the history of

that journal. As an invited speaker at the Tufts Workshop on the Integration of Chemical and Biological Engineering in April 2004, he shared his ideas on the teaching of transport phenomena with faculty from a number of participating universities. He was the co-recipient of this year's Outstanding Faculty Award from the graduate students in the Department of Chemical Engineering, in recognition of his teaching. His group continued its investigations of physiological transport phenomena, which are supported by the National Institutes of Health. Their research topics centered on the hindered transport of macromolecules in biological hydrogels, water and protein filtration in kidney capillaries, and the reaction and diffusion of nitric oxide in cell culture systems used for toxicity studies.

Patrick S. Doyle received a Career Award from the National Science Foundation to study the "dynamics of polymer collisions" using single molecule fluorescence microscopy and computer simulation. He was an invited lecturer at several meetings, including universities and hospitals such as Tufts University Department of Chemical and Biological Engineering, Massachusetts General Hospital, the New England Complex Fluids Meeting, and the Lab Automation Conference.

Karen K. Gleason completed her third year as Executive Officer for the department, gaining Institute approval for a new bachelor's degree program, "Chemical and Biological Engineering–Course XB." Professor Gleason also oversaw several space renovations, including the refurbishment of Gilliland Auditorium (66-110), the department's main lecture hall. Her group's research on chemical vapor deposition to create ultrahydrophobic surfaces was featured in the November 2003 issue of *Technology Review* and on NBC News programs in August 2003. Professor Gleason gave presentations at the University of California at Berkeley, Cornell University, Rennselaer Polytechnic Institute, Honeywell, Dupont, Wright–Patterson Air Force Base, and the International Society for Plasma Chemistry in Taormina, Italy. She also continues as Chief Scientific Advisor for GVD Corporation, a company she co-founded in 2001.

William H. Green, Jr., gave invited plenary lectures at the Foundations of Molecular Modeling and Simulations Conference in Keystone Resort, Colorado, and at the International Bunsen-Discussion of Dynamics of Molecular Phenomena in Supercritical Fluids in Bavaria, Germany. He received the American Chemical Society Fuel Division's Richard A. Glenn award at the ACS National Meeting in Philadelphia, Pa., in August 2004. Professor Green was recently promoted to Associate Professor with tenure.

Robert S. Langer received a number of awards in 2003, including the Heinz Award for Technology, Economy, and Employment; the Harvey Prize, election to the Academy of Achievement; and the John Fritz Award (given previously to inventors such as Thomas Edison and Orville Wright). He was also honored as the Founders' Lecturer (University of Wisconsin), the Rohm and Hass Lecturer (Stanford University), the Tripathy Endowed Memorial Lecturer (University of Massachusetts, Lowell), the Skinner Memorial Lecturer (Northwestern University), the Maurice and Yetta Glicksman Lecturer (Brown University), the FMC Lecturer (Princeton University), the Seymour J. Kreshover Lecturer (National Institutes of Health), and the Whitaker Lecturer (American Society of Artificial Organs); and he received an Honorary Doctoral degree from the University of Liverpool, England. Dr. Langer also received the General Motors Charles F. Kettering Prize for Cancer Research (2004). *Parade Magazine* (2004) selected Dr. Langer as one of six "Heroes whose research may save your life." He also joined the Board of Directors for Wyeth Pharmaceuticals, Inc. in 2004.

Gregory C. Rutledge continued to serve as Director of MIT's interdepartmental Program in Polymer Science and Technology, as a team leader of the Institute for Soldier Nanotechnologies, and as an Editorial Board member and Special Editor for the journal *Polymer*. In July 2004, he assumed the role of Executive Officer in the Department of Chemical Engineering. Over the past year, he organized the third ACS workshop on "Modeling of Macromolecules," in Hilton Head, S.C. He delivered invited talks at the "International Workshop on Thermodynamics and Complex Fluids" and at several other conferences and universities. His research entails the molecular engineering of soft matter, through the development of molecular simulations, materials characterization, and electrospinning of nanofibers.

Kenneth A. Smith has continued his research on the roles of fluid mechanics and transport phenomena in a number of contexts. These include the use of the supercritical water oxidation process for the destruction of organic wastes, a joint effort with Professor Jefferson W. Tester. With Professor T. Alan Hatton, he has been studying the dynamics of micellar self-assembly and the properties of a remarkable new class of photo-responsive surfactants. He is also engaged in the development of an instrument that can determine the size-segregated chemical composition of an aerosol in real time. This has the potential of greatly enhancing our understanding of the origins, evolution, and dispersion of atmospheric contaminants that are found in the submicron particle size range. He is also participating in the Molecular Engineering of Biological and Chemical Systems (MEBCS) Program within the Singapore–MIT Alliance (SMA).

Faculty Distinctions

George Stephanopoulos presented the 2003 AIChE Institute Lecture at the Annual Meeting in San Francisco, Calif., in November 2003. The title of his lecture was, "Invention and Innovation in a Product-Centered Chemical Industry: General Trends and a Case Study." He received the 2003 William H. Walker Award for Outstanding Contributions to the Literature of Chemical Engineering. Professor Stephanopoulos was re-elected to the Board of Directors of Mitsubishi Chemical Corporation. He made six presentations in international workshops and symposia on the "Reformation and Rejuvenation of the R&D in Mitsubishi Chemical Corporation."

Gregory Stephanopoulos continued his service on the Advisory Boards of five academic institutions and on the Board of Directors of the American Institute of Chemical Engineers (AIChE), where he spearheaded the formation of the new Society for Biological Engineering (SBE). In October 2003, he was inducted into the National Academy of Engineering for his pioneering contributions in defining and advancing metabolic engineering as well as for his leadership in incorporating biology in chemical engineering research and education. Professor Stephanopoulos also gave the Cary lectures at Georgia Tech, the Holtz lectures at Johns Hopkins University, and the Centennial lecture at Clarkson University. He was also a distinguished lecturer at the University of Utah. He continued his educational and research activity in Bioinformatics and Metabolic Engineering and his work as Editor-in-Chief of the journal *Metabolic Engineering*, published by Elsevier. In addition, he continued to serve on the editorial boards of seven other scientific journals. He co-chaired a Gordon Research Conference on Bioinformatics held at Queen's College, Oxford, England, and delivered keynote lectures at the International Symposium of Chemical Reaction Engineering (ISCRE) in Chicago, Ill., and at the ASM IMAGE Conference in Montreal, Canada. At MIT, he continued his teaching of courses on Bioinformatics and Kinetics of Chemical and Biological Reactions.

Jefferson W. Tester continues to be active in the energy and environmental area with both his teaching and research. He is the Chair of the National Advisory Council of the Department of Energy's (DOE) National Renewable Energy Laboratory, and is the Co-chair of the Governor's Advisory Board for the Massachusetts Renewable Energy Trust. Professor Tester also continued as a member of the advisory groups for the Paul Scherrer Institute, Eidgenossische Technische Hochschule (ETH/Swiss Federal Institute of Technology) in Zurich, Switzerland; the Energy and Environmental Systems Division of the Idaho National Engineering and Environmental Laboratory (INEEL); the Governing Board of the Midwest Research Institute; and the Division of Earth and Environmental Sciences at the Los Alamos National Laboratory (LANL). He gave invited lectures at the Virginia Polytechnic Institute, at the Council for Chemical Research, and at MIT on various energy topics, including methane and carbon dioxide gas hydrates, transitioning to a hydrogen economy, universal heat mining, advanced drilling methods, and hydrothermal conversion of hydrocarbons and biomass. A new 850-page textbook, *Sustainable Energy—Choosing Among Options*, co-authored by Professor Tester, Professors Driscoll and Golay of Nuclear Engineering, Dr. Drake of the Laboratory for Energy and the Environment, and Dr. Peters of the Institute for Soldier Nanotechnology, will be released by MIT Press this coming Fall. Professor Tester received this year's Outstanding Faculty Award from the graduate students in the Department of Chemical Engineering.

Bernhardt L. Trout was promoted to Associate Professor. He has given invited talks at Stanford University, Princeton University, and many other engineering institutes, in addition to the American Institute of Chemical Engineers (AIChE) and the American Chemical Society (ACS). Funding for his projects on chemical and process design via molecular understanding is provided by the National Science Foundation (NSF), the Department of Energy (DoE), the National Aeronautics and Space Administration (NASA), the Government of Singapore, Merck, Inc., and Amgen, Inc.

Daniel I.C. Wang was the Keynote Lecturer at the Trends in Biotechnology Conference held in Vienna, Austria, in November 2002. He also presented a series of lectures at the Department of Biochemical Engineering, Catholic University in Valparaiso, Chile, in March 2003. At the Catholic University Valparaiso, he was bestowed an Honorary Doctoral Degree in biochemical engineering. He presented a Keynote Lecture at the Bayer's Strategic Research and Development Retreat in April 2003 at Beaufort, N.C. In June 2003, he was invited by the Ministry of Education, People's Republic of China, to deliver a series of lectures in biochemical engineering and biotechnology at Tsinghua University, Beijing, in China.

Professor Wang continues as a Faculty Fellow in the SMA Program, where he delivered his course "Bioprocess Engineering" at the National University of Singapore in January and March 2003. In addition, Professor Wang is the co-advisor to three PhD candidates in the SMA Program. During 2002 and 2003, he was in charge of presenting a new laboratory course, "Biological Engineering Laboratory 10.28" as part of the department's curriculum for the new course, "XB."

Jackie Y. Ying delivered 15 invited lectures at various international conferences and national meetings during the past year, including keynote lectures at the 10th International Conference on Composites/Nano Engineering, the International Conference on Materials for Advanced Technologies, the TMS Annual Meeting, and the 7th International Conference on Nanostructured Materials. She served as a symposium organizer for the 18th North American Catalysis Society, and is the Conference Chair for the 1st Society of Bioengineers International Conference on Bioengineering and Nanotechnology. Professor Ying was an invited seminar speaker at the University of California, Berkeley, and at the National University of Singapore, and delivered the Linsay Lecture at Texas A&M University. She serves on the Editorial Boards of eight journals/book series, as well as on the Advisory Boards of the Leibniz-Institut für Festkörper-und Werkstoffforschung Dresden (Germany), the University of Queensland Nanomaterials Centre (Australia), the National Research Council Steacie Institute for Molecular Sciences (Canada), and the Institute of Materials Research and Engineering (Singapore). Professor Ying is an Honorary Professor of Chemistry of Jilin University (China), and serves on the Canvassing Committee of the American Chemical Society for their Award for Creative Research in Homogeneous or Heterogeneous Catalysis. Professor Ying is currently on professional leave in Singapore as the Executive Director of the Institute of Bioengineering and Nanotechnology, a new national research institute under the Agency of Science, Technology, and Research.

INFINITE MILE AWARDS GO TO FIVE FROM ChemE!

The Department of Chemical Engineering is proud to commend the following staff members who have received MIT's Infinite Mile Awards for Sustained Excellence:

2003 Award Winners

Robin C. Elices, Director, Administrative Services Organization

Constance J. Beal, Lab Administrator for Professor Robert S. Langer

JoAnn B. Sorrento, Administrative Assistant to Professor Douglas A. Lauffenburger

2004 Award Winners

Jean-François Hamel, Lecturer and Lab Supervisor

Erminia Piccinonno, Personnel Administrator, Administrative Services Organization

ChemE Connection

The Year in Review at a Glance

For the Department of Chemical Engineering, 2002–04 has been a period of continued excellence and transformation. Promotions included ***Gregory C. Rutledge***, who was promoted from Associate Professor to Full Professor [polymer science and engineering, statistical thermodynamics and molecular simulation]. Two faculty members received promotions this year from Assistant Professor to Associate Professor: ***William H. Green, Jr.*** [reactive chemical engineering], and ***Bernhardt L. Trout*** [kinetics of aqueous and biological systems, theoretical heterogeneous catalysis, molecular-level design of products and processes, emissions control and sustainable development] *(See articles, page 6)*.

Faculty Award Highlights

Our outstanding faculty continues to garner recognition from across the US and around the globe. ***Robert S. Langer***, Germeshausen Professor of Chemical and Biomedical Engineering, received another major award in 2003—the **John Fritz Medal** from the American Association of Engineering Societies *(See article, page 7)*.

The department honors Bayer Professor ***Gregory Stephanopoulos***, who in 2003 was elected to membership in the ***National Academy of Engineering (NAE)***. Election to the NAE is one of the highest professional distinctions that can be accorded an engineer! The NAE cited him for his pioneering contributions in defining and advancing metabolic engineering and for his leadership in incorporating biology into chemical engineering research *(See article, page 8)*.

Congratulations to Emeritus Professor ***Marcus Karel*** (PhD '60), who received an honorable Doctorate-Ing. from the **Technical University of Munich**. Professor Karel's interests focus on food and pharmaceutical engineering and preservation.

For the second consecutive year, we are proud to announce that the **AIChE**'s prestigious **William H. Walker Award** for Excellence in Contributions to Chemical Engineering Literature for 2003 went to one of our own—Arthur D. Little Professor ***George Stephanopoulos***. The 2002 Walker Award went to Professor ***Douglas A. Lauffenburger***. Congratulations to these and all our many award-winning faculty members!

Student Award Highlights

2003 was a repeat win for ChemE students, as Grad Student ***Todd C. Zion*** led the winning team in the MIT 50K Entrepreneurship Competition! *(See article, page 28)*. The 2001 award was also won by a team led by a ChemE duo, then grad students ***Edward S. Ahn*** and ***Darren D. Obrigkeit*** and their company, Angstrom Medica.

Congratulations to Senior ***Philip J. Lee***, who was elected to the honorary **Phi Beta Kappa Society**. Membership is conferred in recognition of excellent academic performance and a demonstrated commitment to the objectives of a liberal education.

Professor ***Paula T. Hammond's*** lab received major press attention in 2003, with articles in the *Washington Post* and the *Chemical & Engineering News*, featuring collaborations with recent PhD graduate ***Dean Delongchamp*** and with current grad student ***Kristoffer Stokes***.

Alumni/ae Highlights

Brown University faculty member ***Dr. Michael Lysaght '64*** recently received Brown's **Elizabeth LeDuc Award for Outstanding Teaching in the Life Sciences.**

Department News

The School of Engineering honored three ChemE staff members in 2003, with School-wide Infinite Mile Awards for Sustained Excellence going to ***Constance J. Beal, JoAnn B. Sorrento***, and ASO Director ***Robin C. Elices***, and in 2004 with Awards going to ***Jean-François Hamel*** and ***Erminia Piccinonno*** *(See photos, page 13)*.

Changing Faces

We are very pleased to announce three recent staff additions. In ChemE headquarters, ***Melanie L. Miller*** joined us as Administrative Assistant to the Department Head. In the ChemE Computing Support office, we introduced three new staff members, Systems Administrator ***James Hardsog***, Technical Assistant ***Jean Belbin***, and Web Developer ***Rick Smith***. Jim and Jean's extensive experience and expertise have proven to be an asset to the department in this critical area! Special thanks to ***Brett Groshong*** and ***Ruben Madrigale*** for their devoted service in these positions, and good luck to both in their graduate studies.

We are looking forward to an exciting year of growth and improvement in 2004–05! ▫

Named Lectures

In the Department of Chemical Engineering

Frontiers in Biotechnology Lecture

2002

This year's Frontiers in Biotechnology Lecturer, Dr. ***William H. Rastetter***, presented his seminar, **"Molecules, Mechanisms, and Monoclonals"** in the department's Gilliland Auditorium on Friday, November 1st, 2002.

Dr. Rastetter guided us through a history of his 32-year journey in the pharmaceutical industry, with a focus on timelines for drug development from discovery to commercialization, using as examples Rituxan® (the first monoclonal antibody found to be effective and safe for the treatment of cancer in the United States) and Zevalin [for treatment of relapsed or refractory low-grade, follicular, or transformed B-cell non-Hodgkin's lymphoma (NHL)]. In reflecting upon the nature of science, he outlined the differing paradigms for academia and industry, particularly in the ways that each uses science.

Dr. ***William H. Rastetter***, Chairman and Chief Executive Officer of IDEC Pharmaceuticals, was appointed Chairman of the Board of Directors of the Company on May 22nd, 1996. He served as President and Chief Executive Officer of the Company from December 1986 until January 2002. In January 2002, he turned over the title of President to Bill Rohn. Dr. Rastetter was also Chief Financial Officer from 1988 to 1993, and has served as a Director of the Company since 1986. From 1984 to 1986, he was Director of Corporate Ventures at Genentech. From 1982 to 1984, Dr. Rastetter served in a scientific capacity at Genentech, directing the Biocatalysis and Chemical Sciences groups. From 1975 to 1982, he held various positions at MIT. Dr. Rastetter received a PhD in chemistry from Harvard University in 1975.

2003

Phillip A. Sharp

Once dismissed as nothing more than comic book fantasy, the development of a gene-based antiviral miracle drug may occur sooner than you think.

The exciting promise shown by the control of gene expression through RNAi (RNA interference) as a means of combating viruses was the focus of the **2003 Frontiers in Biotechnology Lecture**, presented on Friday, October 3rd. An enthusiastic Gilliland Auditorium reception greeted presenter MIT Biology Institute Professor and Nobel Laureate Phillip A. Sharp, Director of MIT's McGovern Institute for Brain Research.

Speaking to an overflow crowd, Sharp said using double-stranded small RNAs to silence genes "will fundamentally change the way we do cell biology. We have to understand how an organism's genes interact if we are to understand these disease processes." Sharp then presented a brief chronology of DNA research from the 1953 discovery of DNA by Watson and Crick through the surge in interest in interferon applications in 1975, and then the discovery in 1998 of the RNAi principle.

Interferons are a family of proteins that human cells release when invaded by a virus. Small interfering RNAs (siRNAs) are 21- to 23-nucleotide RNA molecules that can cause targeted gene silencing without triggering any interferon response, leading researchers on a quest to create RNA medicines to treat a host of disorders, from high cholesterol to cancer, as well as viral diseases such as AIDS.

Sharp's longtime goal has been to silence genes in mammalian cells. His own recent work in the field uses RNAi methods to interfere with cell surface receptors to make an individual more resistant to viral infections like HIV. He is one of the founders of a Cambridge, Mass., company started in 2002 that aims to use small RNAs to silence genes in disease states.

Institute Professor ***Phillip A. Sharp*** is Founding Director of MIT's McGovern Institute for Brain Research. Much of Professor Sharp's scientific work has been conducted at MIT's Center for Cancer Research, which he joined in 1974 and directed from 1985 to 1991. He subsequently led the Department of Biology from 1991 to 1999. His research interests have centered on the molecular biology of gene expression relevant to cancer and the mechanisms of RNA splicing; his landmark achievement was the discovery of RNA splicing in 1977. This work provided one of the first indications of the startling phenomenon of "discontinuous genes" in mammalian cells. The discovery that genes contain nonsense segments that are edited out by cells in the course of utilizing genetic information is important in understanding the genetic causes of cancer and other diseases. Professor Sharp's research opened an entirely new area in molecular biology and forever changed the field. For this work, he received the 1993 Nobel Prize in Physiology or Medicine.

A native of Kentucky, Sharp earned a BA degree from Union College, Ky., and a PhD in chemistry from the University of Illinois, Champaign-Urbana in 1969. He did his postdoctoral training at the California Institute of

Technology, where he studied the molecular biology of plasmids from bacteria in Professor *Norman Davidson's* Laboratory. Prior to joining MIT, he was the Senior Scientist at Cold Spring Harbor Laboratory.

Professor Sharp co-founded Biogen, Inc. with ChemE Institute Professor ***Daniel I.C. Wang*** in 1978, and is also the co-founder of Alnylam Pharmaceuticals (2002).

Frontiers in Biotechnology was established in 1999, to acknowledge the enabling technologies which have sustained the growth of biotechnology and life sciences, and to honor the achievements of distinguished scientists and engineers in the field. The department warmly thanks Dr. ***Noubar B. Afeyan '87***, whose generous donation made this visionary new series possible.

Hoyt C. Hottel Lecture

2002

On Friday, December 6th, 2002, California Institute of Technology Professor ***John H. Seinfeld*** presented this year's **Hoyt C. Hottel Lecture** on the topic **"Aerosols and Climate,"** in Gilliland Auditorium.

Airborne particles such as ship exhaust, dust storms, forest fire and industrial plumes; their links to human activity; and the potential for the interaction of these particles to affect our global climate were the primary focal points of Professor Seinfeld's fascinating seminar.

He emphasized the importance of examining the interactions of different types of particles with one another and with light, and of accounting for the numerous sources of airborne particles worldwide. Dramatic satellite photos, showing earth-orbit views of particles and their sources, revealed their ubiquitous nature and potentially climate-altering migration patterns. Seinfeld emphasized that the role of particles stands as the single least understood factor with regard to their effects on climate change. In closing, he made the guarded prediction that current aerosol and greenhouse gas trends point to increased visible and infrared surface radiation in coming decades.

Professor ***John H. Seinfeld*** is widely acknowledged for his research on the chemistry and physics of the atmosphere. Through both experimental and theoretical studies, he has made numerous contributions to the knowledge of urban atmosphere chemistry, atmospheric aerosol formation, growth, and dynamics, and to the role of aerosols in the climate. He is one of the founders of the field of mathematical modeling of the atmosphere, work that eventually became written into the United States Clean Air Act. He is a member of the National Academy of Engineering and a Fellow of the American Academy of Arts and Sciences.

Seinfeld received a BS degree from the University of Rochester and a PhD from Princeton University, both in chemical engineering. He joined the faculty of the California Institute of Technology in 1967.

For more about research in Professor Seinfeld's lab…
http://www.che.caltech.edu/faculty/seinfeld_j/index.html

2003

Charles E. Kolb, President and CEO of Aerodyne Research

Think of crystal-blue horizons, brilliant sunsets, or the night sky's soaring black vault of heaven awash in twinkling astral pinpoints. Vistas of Earth's enveloping and protective atmosphere easily inspire the illusion of infinite beauty—and infinite airborne pollutant absorption capacity.

Dr. ***Charles E. Kolb '67***, our **2003 Hottel Lecturer**, and a former student of Professor Hottel's, sees the atmosphere in more quantitative terms; a complex, dynamic system with a volume of about 2.5 x 10^{10} km^3 (stratosphere and troposphere combined). Kolb captivated this year's audience for the October 24th lecture with his presentation, **"The Impact of Combustion Emissions on the Atmosphere: New Tools and Techniques."**

Kolb started by introducing us to cartoon character "Bobby Badair"—a sort of poster-child for the range of multiple atmosphere-related maladies—shortness of breath, acid rain burns, and skin lesions due to depleted stratospheric ozone. He then presented detailed quantifications of various types of emissions by source, and some of the likely phenomena associated with their effects on the troposphere and stratosphere. Kolb also introduced a few of the latest tools now being used to gather emissions data, including Aerodyne's second-generation Mobile Laboratory, which has spent significant time on the move, particularly in Mexico City, Mexico, but also in Boston, Mass., and Manchester, N.H. The Mobile Laboratory, a retrofitted delivery van boasting a

state-of-the-art arsenal of tools for real-time emissions analysis, is used for stationary sampling, mobile sampling and mapping, and "vehicle chasing" for on-road emissions quantification under typical operating conditions.

Kolb's systematic and lucid presentation gave us an intriguing look at our atmosphere, and how an impressive array of new tools is yielding data and trends that can help mankind shape a healthier future. His numerous acknowledgments included a number of MIT collaborators, among them ChemE's Professor *Gregory J. McRae* and Nobel Laureate and former MIT EAPS Professor (now at the University of California, San Diego) *Mario Molina*.

Dr. ***Charles E. Kolb '67***, President and CEO of Aerodyne Research, has been a prolific contributor on energy, the environment, and atmosphere physics. He has published more than 120 papers in areas related to combustion atmospheric science and user physics. Kolb is a fellow of the American Physical Society, the Optical Society of America, the American Geophysical Union, and the American Association for the Advancement of Science. He has been a member of numerous government and National Academy of Sciences/National Research Council committees dealing with atmospheric and environmental chemistry issues.

Kolb holds a BS degree in chemistry from MIT, and received an MS degree (1968) and a PhD from Princeton (1971). In addition to his numerous professional activities, he has been a tireless contributor to programs at MIT. His many awards include the Harold E. Lobdell '17 Distinguished Service Award and the Bronze Beaver Award in recognition of his sustained service to MIT and the MIT Alumni Association.

Kolb and his team at Aerodyne Research have served as collaborators with many researchers, including MIT faculty members such as Professors *Kenneth A. Smith, Herbert H. Sawin*, and *Adel F. Sarofim*.

For more about Dr. Charles E. Kolb and Aerodyne Research…
http://www.aerodyne.com

A video of Dr. Charles E. Kolb's lecture is available at…
http://mitworld.mit.edu/video/37/#

The **Hoyt C. Hottel Lectureship** was established in early 1985 to recognize Professor Hottel's contributions to the intellectual climate of the Department of Chemical Engineering, 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 combustion and energy technology scholars to MIT for short residencies, in order to stimulate future generations of students. The inaugural Hottel Lecture was presented in April 1985 by Professor Hottel, himself.

Warren K. Lewis Lecture

2003

Honeywell Specialty Materials President Dr. ***Nance Dicciani*** conducted a lively examination of the evolution of the US chemical industry as the focus of the 2003 **Warren K. Lewis Lecture**, held on Friday, May 2nd, 2004 in 66-110.

Dr. Dicciani's seminar, **"Engineering Engineers Tomorrow,"** traced the industry's history from experimental 18th century beginnings to its dramatic growth over the past 300 years. Along the way, she detailed Honeywell's "Triple Bottom Line," which prioritizes economic, environmental, and social concerns as the foundation for sustainable, responsible industry practices, occasionally springing "pop-quiz" questions upon audience members to test their savvy about historically significant people, places, products, and trends.

She spotlighted nanotechnology, microprocessors, and sensors as major areas of predicted growth, and the rising importance of China to global business strategy.

> *"Chemistry and chemical engineering are right at the heart of all these future trends."*

Marking the passing of the Iron, Steel, and Silicon Ages, she hailed the imminent coming of the "Molecular Age." Along with a concurrent rise in demand for harnessing real-world solutions to breakthrough molecular research outcomes, she predicted a rise in the need for imaginative, highly skilled chemical engineers who are dedicated to the betterment of mankind through the application of economically, environmentally, and socially sensitive engineering principles.

Dr. ***Nance Dicciani*** is President and CEO of Specialty Materials, a strategic business group of Honeywell that serves as a world leader in the production of nylon, polyester, polyethylene, fluorocarbons, caprolactam, electronic materials, and specialty chemicals.

Named Lectures

Dicciani joined the company in November 2001 from Rohm and Haas, where she held the position of Senior Vice President and Business Group Executive of Chemical Specialties and Director, European Region. As Regional Director, Europe, she was responsible for the company's operations and infrastructure in Europe, the Middle East, and Africa. Dicciani joined Rohm and Haas in 1991; and during her tenure, she served as Vice President and General Manager of the Petroleum Chemicals Division and headed the company's worldwide monomers business.

Dicciani holds a BS degree in chemical engineering from Villanova University, an MS degree in chemical engineering from the University of Virginia, and a PhD in chemical engineering from the University of Pennsylvania. She also received an MBA degree from the Wharton School of the University of Pennsylvania.

A video of Dr. Nance Dicciani's lecture is available at…
http://mitworld.mit.edu/video/118/

2004
Frank S. Bates

On April 30th, 2004, the department welcomed alumnus ***Frank S. Bates***, Distinguished McKnight University Professor and Head of Chemical and Materials Engineering at the University of Minnesota/Twin Cities, as the presenter of the **2004 Warren K. Lewis Lecture**. Gilliland Auditorium hosted a capacity crowd for this year's lecture, **"Polymer Science and Engineering: Slow and Delicate."**

Introduced by his former research supervisors, Professor *Robert E. Cohen* and Professor Emeritus *Edward W. Merrill*, Bates first shared some memorable recollections of his work here. He then presented a captivating survey of polymer history, crediting "Doc" Lewis's book, *Industrial Chemistry of Colloidal and Amorphous Materials*, as a major influence. This was followed by a look at current directions, including a new material for less costly CD manufacturing, a synthetic cell membrane whose applications include near-infrared medical imaging.

Frank S. Bates received a BS degree in mathematics from SUNY Albany in 1976, and an MS degree and an ScD in chemical engineering from MIT in 1979 and 1982, respectively. Between 1982 and 1989, Bates was a member of the technical staff at AT&T Bell Laboratories, and then joined the University of Minnesota as an Associate Professor. He was promoted to Professor in 1991 and was named a Distinguished McKnight University Professor in 1996. Professor Bates conducts research on a range of topics, with a particular focus on the thermodynamics and dynamics of block copolymers and blends. In 1988, Bates was named a Distinguished Member of the Technical Staff at Bell Labs; in 1989, he received the Dillon Medal and in 1997 the Polymer Physics Prize, both from the American Physical Society where he is a Fellow. In 2002, Bates was elected to the US National Academy of Engineering.

For more about research in the Bates Lab…
http://www2.itdean.umn.edu/faculty/detail.jsp?facultyID=18

This lecture series is a tribute to Professor ***Warren "Doc" Lewis***, who is well known as one of the Department of Chemical Engineering's most revered members. Also, the AIChE **Warren K. Lewis Award**, established in his honor, recognizes outstanding educators in chemical engineering.

Alan S. Michaels Lecture

2003
Leroy Hood

"After the Genome: Systems Biology" was the title of the 2003 **Alan S. Michaels Lecture**, presented by Dr. **Leroy Hood** on Friday, April 25th, 2003, in the Media Lab's Bartos Theater. Dr. Hood is the President of the **Institute for Systems Biology (ISB)**, of Seattle, Wash. The mission of the ISB is twofold: the revolutionizing of biology through a systems approach; and predictive and preventative medicine.

Introduced by Professor *Robert S. Langer* as the "true pioneer in protein and gene sequencers and synthesizers," Dr. Hood, the 2003 Lemelson–MIT Program's $500,000 prize winner—the world's largest single cash prize for invention—presented an engaging exploration of the past, present, and future of the relatively new discipline of systems biology.

Systems biology emerged out of three forces: the Internet, the Human Genome Project, and cross-disciplinary science. A systems approach to biology analyzes a living thing as a whole, rather than one gene or one protein at a time. According to Hood, it holds the secret to understanding diseases at the molecular level, which will have a profound effect on the practice of medicine within the next 10 or 15

years. In 2000, Hood and two colleagues recognized the need to formalize the study of systems biology, and founded the Institute for Systems Biology (ISB).

Hood predicts that the practice of medicine will shift from today's reactive approach—diagnosing and treating a disease after it has manifested itself—to a predictive and preventive approach. Predictive medicine will enable the detection of genes that predispose humans to disease, such as cancer and cardiovascular disease; while preventive medicine will enable the isolation of the problem gene, and design medicine to block the effects of the defective gene.

Dr. ***Leroy Hood*** is one of the world's leading scientists in molecular biotechnology and genomics. Dr. Hood earned an MD from Johns Hopkins University in 1964 and a PhD in biochemistry from the California Institute of Technology in 1968. Dr. Hood has published more than 500 peer-reviewed papers and has co-authored textbooks in biochemistry, immunology, molecular biology, and genetics. He also co-edited *Code of Codes*, a book discussing the scientific, social, and ethical issues raised by genetic research. Dr. Hood is a member of the National Academy of Sciences, the American Philosophical Society, and the American Association of Arts and Sciences.

His professional career began at Caltech, where he and colleagues pioneered four instruments that constitute the technological foundation for contemporary molecular biology. One of the instruments has revolutionized genomics by allowing the rapid automated sequencing of DNA. Dr. Hood also was one of the first advocates of, and is a key player in, the Human Genome Project—the quest to decipher the sequence of human DNA.

Dr. Hood joined the University of Washington in 1992 to create the Department of Molecular Biotechnology, and in 2000 he founded the Institute of Systems Biology.

For more about Dr. Leroy Hood and the Institute for Systems Biology...
http://www.systemsbiology.org

2004
Noubar B. Afeyan

This year's **Alan S. Michaels Lecturer**, Dr. ***Noubar B. Afeyan***, was a returning alumnus and is the sponsor of ChemE's Frontiers in Biotechnology lecture series launched in 1999. An enthusiastic reception greeted Dr. Afeyan's intriguing presentation, **"BioSystems Engineer: Harnessing the Logic of Life,"** which took place on Friday, April 16th, 2004, in Bartos Theater.

Dr. *Noubar B. Afeyan*, Senior Managing Director and CEO of Flagship Ventures, is a recognized technologist and entrepreneur. He is a Senior Lecturer at MIT's Sloan School of Management, and is a frequent guest speaker at technology forums throughout the country. Dr. Afeyan has authored numerous scientific publications and patents. He earned a BS degree in chemical engineering from McGill University in Montreal, Canada, and a PhD in biochemical engineering from MIT.

Prior to co-founding Flagship Ventures in 1999, Dr. Afeyan was the Founder, Chairman, and CEO of PerSeptive Biosystems, a leader in the bio-instrumentation field that merged with Applera Corp. in 1998. During 1996 and 1997, he also served as Chairman of the Board of ChemGenics Pharmaceuticals, a privately held company spun out of PerSeptive and acquired by Millennium Pharmaceuticals in 1997. Until August 1999, he was Senior Vice President and Chief Business Officer of Applera Corporation, where he initiated and oversaw the creation of Applera's subsidiary, Celera Genomics. He has also been a founding team member, investor, and active Board Member/Advisor of Antigenics, Color Kinetics, and EXACT Sciences.

Dr. ***Noubar B. Afeyan*** currently serves as a Director for several Flagship portfolio companies, and he continues to serve on the boards of Antigenics and Color Kinetics. In addition, he serves on Advisory Boards for Boston University Medical School, the Whitehead Institute at MIT, the McGowan Institute at the University of Pittsburgh, the Center for Bits and Atoms at MIT's Media Lab, and the Faculty of Engineering at McGill University.

This Lectureship has been established as part of an endowment fund donated in honor of ***Alan S. Michaels***, a distinguished leader in bioengineering. The series provides a forum for annual lectures dedicated to bringing distinguished engineers from academia and industry to share their views on research and development in medical and biological engineering. ▪

Getting Down to Business: Graduation Arrives for First PhDCEP Class

In Fall 1999, we proudly announced a new PhD program combining rigorous research and chemical engineering practice elements, with an intensive year of management education. In Fall 2000, with the entry of our first class of students to the newly minted PhD in Chemical Engineering Practice (PhDCEP) Program, this exciting new venture was at last underway.

One Student's Journey

After three challenging years of Chemical Engineering coursework and research, current PhDCEP student ***Prem V. Pavoor*** recently completed the management portion of his curriculum through the Sloan School, which he began in Fall 2003.

Reflecting upon his experiences in the program, Pavoor remarked, "I wanted a program in which I could combine groundbreaking research with practical management training. I found that in the PhDCEP Program, which is offered only at MIT. I've been able to do really interesting polymer research for biomedical applications, and this Fall will begin classes at Sloan... . The Practice School part of the program was intense. I worked for two companies: **Alkermes** here in Cambridge, Mass., and **Mitsubishi** in Japan. It taught me a lot about working with deadlines, group dynamics, and how to frame a problem. In textbooks, the problems are all laid out for you to solve; but in the real world, you have to identify and define the problem boundaries before you start to work on them. It was a very valuable experience."

The Business End of the Program

Facing the start of his management studies in Fall 2003, Pavoor reflected upon the exciting and demanding changes that will arise with the start of his management course of study. Although he expressed some regret at the shift away from solitary lab research, he embraced the importance of management skill building and networking as critical elements of the innovative PhDCEP Program.

Pavoor expressed keen interest in learning more about strategic marketing and the process of finding your "niche." He anticipates that post-graduation plans will involve applying his new skills toward either joining or building a startup firm, or developing a consulting practice.

We look forward to hearing more about Pavoor and our other PhDCEP students as their careers develop, enriching the workforce with a unique combination of analytical expertise and foundational business leadership skills. ▪

The PhDCEP Program entails a four-year course of study, having three main parts plus a fourth integrative element:

1. The first year focuses on MSCEP completion, in addition to taking and passing the doctoral qualifying exams and completing the thesis selection process.

2. The second and third years consist of thesis research, which must lead to original, independent research publishable in archival journals.

3. The fourth year consists of the first-year core of the Sloan School MBA Program.

4. The IAP of the fourth year and the final summer is spent with the thesis supervisor writing a "capstone" paper that might, for example, deal with the business opportunities or potential market impact of the technology studied in the year-two and year-three thesis research. This is incorporated as the final component of the student's thesis.

From the Head of the Department

HEAD from page 1

In the 1920s, a group of chemical engineers led by MIT faculty members met to create "The Literature of a Profession." These books and the ones that followed in the 1950s and 1960s, which emphasize engineering science, have become the cornerstones of the current Chemical Engineering curriculum. Unfortunately, these teaching materials do not reflect the dramatic advances that have occurred in the underlying sciences of chemistry and biology, nor do they capture the exciting frontiers of research in modern chemical engineering. Over the past two years, MIT has once again been active in leading discussion on the directions of our discipline and its educational programs. Last year, three workshops entitled, "Frontiers in Chemical Engineering Education," were held to assess our curriculum. Faculty from more than 53 universities and industry representatives from five companies reached strong consensus that there is a need for change, and that extensive change is needed rather than the incremental evolution of the existing curriculum.

Through this process, broad consensus has been developed regarding the basic principles for chemical engineering undergraduate education in the future, which will address the fundamental knowledge, skills and attributes, and methods of engagement with the students. From these principles, a new set of organizing principles emerged: **molecular transformations**, broadly interpreted to include chemical and biological systems and physical as well as chemical structural changes; **multiscale analysis**, from submolecular through supermacroscopic scales for physical, chemical, and biological processes; and a **systems approach**, addressed to all scales and supplying tools to deal with the dynamics, complexity, uncertainty, and external factors. This set of organizing principles provides a flexible platform for educating chemical engineers for the future, when coupled with carefully selected supporting subjects from other fields, an appropriate freshman experience, and extensive laboratory experiences.

I expect it will be a decade-long effort to fully realize a complete restructuring of the Chemical Engineering curriculum, but I believe the rewards will be great. I invite you to read more about this curriculum effort on our website **http://mit.edu/che-curriculum/**.

As a more immediate response to the need to incorporate biology into our curriculum as a core molecular science along with chemistry, we have introduced a new SB degree, XB in Chemical–Biological Engineering. The definition of the intellectual content of this degree and its movement through the MIT approval process has been accomplished over the last year and a half under the guidance of Professors ***Karen K. Gleason*** and ***K. Dane Wittrup***. We are indebted to both of them for this Herculean task *(See page 27 for details).*

Effective July 1st, 2004, Professor ***Karen K. Gleason*** decided to step down as the Executive Officer in the department. During Professor Gleason's three-year tenure as Executive Officer, she achieved major accomplishments in both education and space, two traditional focal points for the Executive Officer. Educational accomplishments included the complete review and revamping of our Course X degree and the creation of the first new undergraduate degree in the department, the SB in Chemical–Biological Engineering (XB), since the 1950s. Examples of space accomplishments are evident to anyone who walks around Building 66 and admires and enjoys the newly renovated spaces on the first floor (Gilliland Auditorium) and on the second floor (graduate student offices and Walker Lounge). In addition, this past year she has driven a major study of existing chemical engineering space and our space needs for the future. This study will be invaluable to us in our future space planning and development.

Also effective July 1st, 2004, Professor ***Gregory C. Rutledge*** became Executive Officer in the department. Professor Rutledge brings invaluable experience to the Executive Office, having just served as the Director of MIT's Program in Polymer Science and Technology (PPST) and prior to that as ChemE's Graduate Admissions Officer. He has taught widely in our curriculum, and has been an active participant and a thoughtful voice in curriculum discussions.

With the academic year that ended in June 2004, we again produced outstanding graduates at both the undergraduate- and graduate-degree levels. We awarded 41 SB degrees in chemical engineering, 70% to women. The 41 bachelor's degrees awarded this year represent the lowest number since 1987. Sophomore class sizes have been increasing for the past three years, with this coming Fall's rising sophomore class comprised of more than 80 students. Also, during the academic year just ended, we granted 36 master's degrees in chemical engineering (most of those in the Practice School) and 28 doctoral degrees.

For this coming Fall, we admitted over 70 new graduate students to study in one or both of the Practice School and doctoral programs. The quality of the students is excellent, as measured by the large number of applicants to our program, the high degree of selectivity exercised in our admissions process, and our unusually high yield (i.e., the percentage of admitted students who accept our offer). We are grateful to Professor ***K. Dane Wittrup*** and the Graduate Admissions Committee for their hard work in recruiting these outstanding students. After three years of exceptional leadership in graduate recruiting, Professor Wittrup handed over the reins of the Graduate Admissions Committee to Professor Paula T. Hammond for 2005.

continue on next page

From the Head of the Department

continued from previous page

An essential asset in our effort to attract the very best students to our department is the generous external support to the Practice School and our doctoral program by our alumni/ae, through the endowed and continuing support of graduate fellowships. 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 targeting fellowship support on Practice School students and beginning doctoral students, we can have these students begin their graduate program focused on the core subjects of Chemical Engineering. This not only provides all students with in-depth study of the fundamentals that underlie whatever specialty they pursue in chemical engineering, but also provides doctoral students with the important opportunity to learn more about the breadth of research opportunities in the department before choosing a thesis topic. This model for educating graduate-level chemical engineers goes hand in hand with the picture of modern chemical engineering as the central engineering discipline embraced by our department.

In the past year, there have also been several significant changes in the faculty, especially in the areas of tenure and promotion. This academic year, Professor ***William H. Green, Jr.,*** received tenure. Last academic year, Professor ***Gregory C. Rutledge*** was promoted to Full Professor, and Professor ***Bernhardt L. Trout*** was promoted to Associate Professor of Chemical Engineering in the department. We are very proud of the accomplishments of these important members of our department *(See page 6 for details)*.

I am also pleased to report that the department hired one new junior faculty member last year, Dr. ***Kristala Jones Prather***, and one new junior faculty member this year, Dr. ***Narendra Maheshri***. Dr. Prather received an SB degree in chemical engineering from MIT and was the winner of the Karl Taylor Compton Prize. She received a PhD in chemical engineering from the University of California, Berkeley, before joining Merck, where she worked in bioprocessing research until the beginning of this summer. She joined the department in August 2004. Dr. Maheshri, who will join us in the Spring of 2006, received SB degrees in chemical engineering and in biology from MIT, where he was a Phi Beta Kappa scholar. He received a PhD in chemical engineering from the University of California, Berkeley, under the direction of alumnus Professor ***David Schaffer***. Before joining the faculty here, Dr. Maheshri will do postdoctoral research with Professor ***Erin O'Shea*** at UCSF. Dr. Maheshri's focus area is cell signaling. The addition of these two outstanding junior faculty members will bolster our already accomplished bioengineering faculty.

During 2003-04 we had from the University of Alberta, Visiting Professor ***Janet Elliott***. During the Fall 2003 semester, Professor Elliot co-taught the sophomore thermodynamics subject with Professor ***T. Alan Hatton***. Professor and University Scholar at the University of Illinois at Urbana-Champaign ***Richard Braatz*** spent a sabbatical with us last year and taught the Systems Engineering subject during the Spring 2003 term. We are also pleased to welcome Professor ***George Stephanopoulos*** back from a leave of absence. Professor Stephanopoulos was Executive Managing Officer and Chief Technology Officer at Mitsubishi Chemical in Tokyo, Japan.

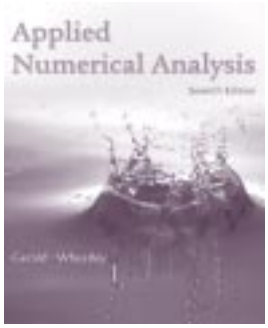
And finally, our faculty members continue to distinguish themselves, as the past two years have produced yet another extensive list of faculty honors and awards. To name just a *few* notable achievements, in 2003 Professor ***Robert S. Langer*** received the Heinz Award for Technology, Economy, and Employment; the Harvey Prize; election to the Academy of Achievement; and the John Fritz Award (given previously to inventors such as Thomas Edison and Orville Wright). In 2004, Professor Langer won the General Motors Kettering Award for Cancer Research (2004). *Parade Magazine* (2004) selected Professor Langer as one of six "Heroes whose research may save your life." In 2004, Professor ***Gregory Stephanopoulos*** was elected into the National Academy of Engineering (NAE) for his pioneering contributions in defining and advancing metabolic engineering and for his leadership in incorporating biology into chemical engineering research and education. Professor Emeritus ***Adel F. Sarofim*** was also elected to the NAE for advancing our understanding of the mechanisms and modeling of processes that control radiation in and pollutant emissions from combustors. Professor **George Stephanopoulos** received two major AIChE Awards in one year. He received the 2003 AIChE William H. Walker Award for excellence in research publications and was the 2003 Institute Lecturer for AIChE. In January 2004, the US Secretary of Energy presented the Lowry Award of the US Department of Energy (DoE) to Professor Emeritus ***Janos Beer***, at a Washington, D.C., ceremony. The Lowry Award is the highest honor given by the DoE for outstanding contributions to fossil energy science and technology. As you can tell, our faculty, in addition to their dedication to research and teaching, are also highly regarded and respected by their peers in the discipline.

I hope that you enjoy this issue of the newsletter, and I encourage you to write to us and let us know how you are doing. Thank you all for your support, and best wishes for the coming year!

News from Alumni/ae

By T. Alan Hatton, Director

Al Armendariz '93 has recently been appointed the J. Lindsay Embrey Assistant Professor of Engineering in the Department of Environmental and Civil Engineering at **Southern Methodist University** in Dallas, Tex.



Curtis F. Gerald '41 is pleased to report that the 7th edition of his textbook, *Applied Numerical Analysis*, is complete and will soon be available!
[PUB: Addison-Wesley]

Gus Griffin '39 presented a paper detailing the principles of his Carbon-Free Fuel Cell design, at the **16th International Forum on Applied Electrochemistry**, held in November 2002 in Amelia Island Plantation, Fla.

The department thanks ***John Grover '48***, whose recent donation funded a new Endowed Fellowship in the department. The funds generated by this endowment will help support graduate students for years into the future.

Prentiss Lobdell '33 is doing well in the Florida Keys, and would love to hear from any classmates who might live nearby—**plobdell@iopener.net**.

2004 ChemE Alumni/ae Reunion visitors From L to R: Prof. Daniel Blankschtein, with Saverio Greco '51 and Phil Townsend '64.

Joseph B. Marx '37 has enjoyed living in Lincoln, Nebr., after moving there in 1992 to be closer to his son David, a professor of statistics at the University of Nebraska. Happily married now for over 60 years, he's proud to report that in his family he's known as father, grandfather, and, most recently, great-grandfather! Marx retired in 1977 after a 40-year career at Hercules, Inc., as their Manager for Chemical Engineering Research.

Hats off to Professor ***Nicholas A. Peppas (ScD '74)*** of the University of Texas/Austin, and MIT ChemE Professor ***Robert S. Langer (ScD '74)***, whose jointly authored *AIChE Journal* article, "Advances in Biomaterials, Drug Delivery, and Bionanotechnology," recently made history! Appearing in the December 2003 issue of the American Institute of Chemical Engineers' *AIChE Journal*, this article is the first *AIChE Journal* article to make the *10 Most Requested Papers List* maintained by the **Chemistry and Related Sciences Division of the American Chemical Society (ACS)** on their "Science Spotlight" website.

Web browsers in the MIT domain can read the article at no charge via the MIT Libraries VERA E-Journals website... http://river.mit.edu/mitlibweb/FMPro?-db=RS_Items.fp5&-Lay=web&-format=ro_search.htm&-findany.

Jim ('54) and Connie Brown relaxing at the 2004 ChemE Alumni/ae Reception

Clyde K. Smith '35, having retired from Bechtel Corporation in 1977, reports that—at 91 years of age—he's still in fairly decent shape.

Otto J. Solis (SM '78) is President of **Serlienaca**, a services company in his hometown of Maracaibo, Venezuela.

The newest book by ***Peter H. Spitz '48,*** *The Chemical Industry at the Millennium: The maturing of commodity and specialty chemicals,* was released in September 2003 by the Chemical Heritage Foundation. This work examines the industry's evolution from the post oil-shock years of the late 1970s through the emergence of "reengineering," environmentally sensitive "Responsible Care" practices, and the impacts of information technology proliferation and market globalization. This is a follow-up to Spitz's 1988 book, *Petrochemicals: The Rise of an Industry*, which covered the unusually rapid growth of the petrochemical industry from the 1920s to the 1970s.

2003 ChemE Reunion Spans Generations From L to R: Karen Hladik '78, Prof. C. Michael Mohr, Eric Reiner '83, Emeritus Prof. Charles Satterfield, Suresh Gupta '78, Javit Drake '94, Zulfikar Tejpar '78, Cordelia Price '78, Natalya Eliashberg '93, and Prof. Robert C. Armstrong (Head).

In a recent review, Alex Tullo of *Chemical and Engineering News* commented, *"Few major events of the past 30 years are omitted in the book. Spitz throws in everything—including the kitchen sink—or at least the McDonald's polystyrene clamshell sandwich container. …Spitz has a tremendous ability to distill events down to their essence."*

After a busy career in the industry, most recently as co-founder of **ChemSystems**, Spitz now works as a consultant for **IBM**. ChemSystems, co-founded by Spitz and *Bob Davis* of **Scientific Design**, was a $20M company by the mid-1990s, and in 1998 was acquired by **IBM** Consulting.

Alex Diaz '91 (L) gets a warm reception from ChemE Events Coordinator Arline Benford (R).

In Memoriam

Lead-Free Gasoline Pioneer, Vladimir Haensel Dies at 88

UMass/Amherst Emeritus Professor Vladimir Haensel **(MS '37)**, who made lead-free gasoline possible, died last Sunday in Amherst, Mass. Haensel invented and developed a process in 1947, known as "platforming"—short for platinum-reforming—which uses a platinum-based catalyst to convert petroleum into cleaner-burning fuel by increasing octane and eliminating the need to add lead.

This process became the key to lead-free fuel for automobiles, which facilitated major strides in improving engine efficiency.

Haensel earned a master's degree in chemical engineering at MIT, between stints at Northwestern University where he earned his undergraduate ('35) and doctoral ('42) degrees. His career in industry began with a summer position at Universal Oil Products (UOP) in Des Plaines, Ill., working with chemist ***Vladimir Ipatieff*** who became Haensel's mentor. Haensel retired from Universal in 1981, dedicating himself to a second career as a professor from which he then retired in 1998. He became known for his skill at making people feel at ease, his receptiveness to ideas from students and colleagues, and his enthusiasm for teaching and mentoring graduate students.

Among Haensel's honors is the **Charles Stark Draper Prize,** sometimes referred to as the "Nobel Prize for Engineering," which he was awarded in 1997 nearly 50 years after the advent of his new platforming process. Other honors included the American Institute of Chemists Chemical **Pioneer Award** and the Society of Chemical Industry **Perkin Medal** (American Section), both for 1967; the **National Medal of Science** in 1973; the **National Academy of Sciences Award for Chemistry in Service to Society** in 1991; and the **UMass Chancellor's Outstanding Teacher Award** for 1994.

Professor Haensel held about 145 US patents and 400 foreign patents, which was impressive to his students but less so to the man himself. "One of the lab technicians at UOP, a guy who only completed two years of community college, had more than 50 patents, too," he said. "That's because nobody oppressed him for not having the right initials after his name, and it's because he got invited to all the department meetings and presentations just like everyone

else. I tell my students and remind them, 'Don't denigrate anybody.'"

John J. O'Neill, Jr. (ScD '51), formerly of Spartanburg, S.C., died in Atlanta, Ga., on October 12th, 2001. John graduated from LSU in 1943 with a BS degree in chemical engineering. He served as a Captain in the Army, on active duty from 1943 to 1946. From 1951 to 1965, he worked for du Pont and was involved in Research and Development. From 1965 to 1996, John was a Research Director and then a Consultant for Milliken & Company in Spartanburg, S.C.

John was an active member of the Industrial Research Institute and the American Institute of Chemical Engineers, and was the founder of the Western Carolina Section of the AIChE. He served on Advisory Boards at Rose-Hulman Institute of Technology, the Textile Research Institute, Georgia Institute of Technology, Tulane University Chemical Engineering Department, and Clemson University Department of Mechanical Engineering. He was an Educational Counselor representing MIT in the Spartanburg, S.C., area for many years.

Arch C. Scurlock '43, Solid-Fuel Rocket, R & D Pioneer

The department regrets to announce the death of research and development/solid-fuel rocket pioneer, ***Arch C. Scurlock (SM '43, PhD '48)***.

Atlantic Research Corporation (ARC), co-founded by Scurlock and ***Arthur W. Sloan*** in 1949, is credited with advances in solid-rocket propellant technology, which helped ensure our nation's security throughout the height of the Cold War era and into the modern era.

Shortly after the founding of ARC, Scurlock was joined by fellow MIT alumnus, ***John H. Grover '49***, with whom he remained close for most of his 50-plus–year professional career.

Scurlock was admired for his uniquely energetic and progressive leadership style. His most recent post had been as President and Chairman of **Halifax Corporation**, a Virginia-based managed services company. In addition to **Atlantic Research**, his career included the startup of several other successful ventures such as **TransTechnology Corporation**, a manufacturer of aerospace defense and other industrial products; and **Research Industries**, a private investment firm.

Also, Scurlock generously established graduate fellowships at both the **University of Texas** and **MIT**. We salute ***Arch Scurlock's*** energetic spirit and pivotal role as a scientist, philanthropist, and business leader, and hope that his example will continue to serve as an inspiration to others.

For further reading about Scurlock and Atlantic Research Corporation...

A fascinating, in-depth history of the founding and rise of **Atlantic Research Corporation** is recorded in the book, *The Rocket Scientists: Achievement in Science, Technology, and Industry at Atlantic Research Corporation,* by ***Philip Key Reily*** (©1999 Vantage Press, Inc., New York, N.Y.).

Ralph Landau (ScD'41)

With deep regret, we commemorate the recent passing of ***Ralph Landau*** **(ScD '41)**, one of our most distinguished alumni/ae. Landau's unsurpassed legacy as an innovative entrepreneur, celebrated intellectual, industry leader, and uncommonly dedicated alumnus, has left an indelible mark on our department. Perhaps the most visible symbol of his decades of support is ChemE's now-familiar 1976 Landau Building. Also critical, though less visible, have been such contributions as his sponsorship of a departmental Graduate Fellowship, participation on the department's Visiting Committee, and his role as a tireless champion of the department and its Practice School.

Early Promise

During his high school years in Depression-era Philadelphia, Pa., Landau was a serious and hard-working student who became captivated by a newspaper article citing chemical engineering as the new "glamour field." His career path then became clear. As a scholarship student at the University of Pennsylvania, he majored in chemical engineering and then earned his doctorate at MIT in 1941.

Career Beginnings

He then worked for **M.W. Kellogg Company**, one of the first engineering firms that specialized in design and development for the oil refining and chemical industries. As head of Kellogg's successor company, **Kellex**, he was asked to build a large-scale facility for the Manhattan Project in Oak

Ridge, Tenn., to separate uranium 235, which was needed for the atomic bomb, from the predominant isotope uranium 238. Landau was given the responsibility of designing the equipment to produce fluorine, a highly reactive substance needed to make the uranium hexafluoride used in the gaseous diffusion process. He also oversaw the production of the fluorinated compounds used to protect surfaces in contact with the uranium hexafluoride.

After the war, he and a construction engineer he had met at Oak Ridge, ***Harry Rehnberg***, started **Scientific Design** with the objective of improving petrochemical production processes. Much of their business in the early days was abroad, and one of their first successes was an improved method of producing terepthalic acid—the main raw ingredient in polyester fiber—by bromine-assisted oxidation of paraxylene. Worldwide rights for this process were purchased by **Standard Oil of Indiana** (now Amoco). Another triumph was an improved process for producing propylene oxide, a substance used in polyurethane foams and in rigid polymers; in this case, the partner in the new corporation, called Oxirane, was **Atlantic Richfield** (ARCO).

Scientific Design and its successor companies, **Halcon International, Inc.** and **Halcon SD** group, became leading sources of modern petrochemical technology around the world. Through Dr. Landau's leadership and innovation, his companies developed processes for producing ethylene glycol by thermal hydration—the chief component of antifreeze and used in the process of making Dacron® polyester fiber—and components in other commercial products such as insecticides, fiberglass, and nylon 66. He earned numerous patents in his own right, in addition to more than 1,400 held by Halcon and its subsidiaries.

Faculty Appointments

After Halcon's sale of its interest in Oxirane to ARCO in 1980, and the sale of Halcon to the Texas Eastern Corporation in 1982, Ralph Landau embarked on a second career—that of academic scholar and advisor. Motivated by his long-standing interest in education and research, he served on Visiting and Advisory Committees at Princeton University, the University of Pennsylvania, the California Institute of Technology, and MIT.

More recently, as a faculty member of the Economics Department at Stanford University and a Fellow at Harvard University's John F. Kennedy School of Government, Landau focused on understanding the political and economic environment necessary to encourage technological innovation—the lifeblood of a successful economy. He has also served as a Senior Fellow in Stanford's Institute for Economic Research, and his MIT responsibilities have been numerous, serving for several decades as a Life Member of the MIT Corporation and as a Member of the Visiting Committees for ChemE and other departments.

Awards

Landau has been globally recognized for his many significant professional papers, speaking at the invitation of chemical industry groups from all over the world, and receiving more than 50 prestigious awards. These include the 1981 Perkin Medal from the Society of Chemical Industry, and the 1987 John Fritz Medal of the American Association of Engineering Societies. In 1985, President Ronald Reagan presented Landau with the country's National Medal of Technology; and in 1997, he became the first recipient of the Chemical Heritage Foundation's Othmer Gold Medal.

Books

Landau authored and edited a number of volumes, with a particular focus on exploring the connections between technology and economics. These include an authoritative book on chemical plants, and his co-authorship of *The Positive Sum Strategy* (PUB: National Academy Press, 1986) on harnessing technology for economic growth.

Honorary Appointments

A fellow of the American Academy of Arts and Sciences, he also served as Vice President of the National Academy of Engineering, to which he was elected in 1972. He served on the National Research Council's Governing Board, was a fellow of the New York Academy of Sciences, and in 1996 was elected to the American Philosophical Society. He was a retired director of the Aluminum Company of America, and a former trustee of Cold Spring Harbor Laboratory.

Chairman of Listowel, Incorporated in New York City, N.Y., Dr. Landau more recently was a Consulting Professor of Economics at Stanford University and a Senior Fellow at the Stanford Institute for Economic Policy Research, positions he clearly enjoyed and to which he brought his keen intellect and his enormous creative energy, in no way diminished by the passing years. As recently as 1997, he was a Research Fellow at Harvard University.

To MIT's good fortune, Ralph Landau brought his perseverance, keen observation, and powerful intellect to his service on the Corporation. He became a member of the Corporation in 1972 and was elected a Life Member in 1976. He was the Chair of the 50th Anniversary Convocation of the Department of Chemical Engineering in 1970, and a member on the national sponsoring committee for the new chemical engineering building, which was

designed by MIT alumnus and former Corporation member I.M. Pei. Dr. Landau's work on both projects culminated in 1976 with the naming of the new building in his honor, citing his "illustrious example." That same year, he was one of the first to receive the MIT Leadership Award.

Ralph Landau served on the Chemical Engineering Visiting Committee from 1965 until his death: actively for 26 years, and as a guest for an additional 13 years. His participation on the Economics Visiting Committee spanned 19 years, from 1983 until 2002. At various times throughout his Corporation tenure, he chaired the Visiting Committees for the Center for International Studies, the Department of Materials Science and Engineering, and the Department of Nutrition and Food Science. He also served a five-year term on the Membership Committee, and was a member of the Development Committee from 1966 and an Honorary Member from 1990. In 1978–79, he served on the Presidential Search Committee, whose work resulted in the selection of Paul E. Gray as MIT's 14th President.

Dr. Landau's distinguished career and professional success reflected great credit on his alma mater. His dedication and his personal generosity helped in significant ways to advance the cause of engineering education. In particular, he was an indefatigable champion of the MIT Department of Chemical Engineering and of its Practice School. Through his own example, he did much to encourage private and corporate support of higher education in our country. As a valued counselor to MIT Chairs and Presidents, one who always took the long view, he was wise, insightful, discerning, and forthright.

Ralph Landau's many colleagues mourn the loss of this indomitable man whose legacy of entrepreneurship and innovation exemplify the best of what the Institute strives for in its alumni/ae. His firm resolve, his acute perceptions of the world, his prodigious energy, and his creative spirit will be sorely missed by those whose lives he touched. He will be long remembered for his exemplary service to MIT and to its governing body.

Dr. Ralph Landau is survived by his wife, *Claire,* and his daughter, *Dr. Laurie J. Landau*. ⊡

Department Boosts Bioengineering Degree and Course Offerings

New Course SB in Chem–Bio Engineering Approved

A major addition to the undergraduate education in Chemical Engineering is the new **SB Degree in Chemical–Biological Engineering: Course XB**, approved by the Institute Faculty in 2003 and offered for the first time in Fall 2004. The educational opportunity afforded by the new XB degree reflects the long-standing recognition of the importance of biology as a fundamental science in biomedical and industrial applications by the Department of Chemical Engineering at MIT, dating back 35 years to the first Biomedical Engineering class at MIT, taught by Professor Emeritus ***Edward W. Merrill***. Interest in biology has been growing among the undergraduate Chemical Engineering students in recent years, as reflected by a significant number of X/VII double majors and students completing the Biomedical Engineering (BME) Minor. The new XB Program provides clear acknowledgment of the education that students receive in both Chemical Engineering and Biology within the units required for a single SB degree.

Students graduating with the XB degree will be well prepared for industrial employment in the life sciences industries, engineering graduate studies, and professional degrees in medicine.

New Chem-Bio Engineering Course XB Brings Curriculum and Facilities Enhancements

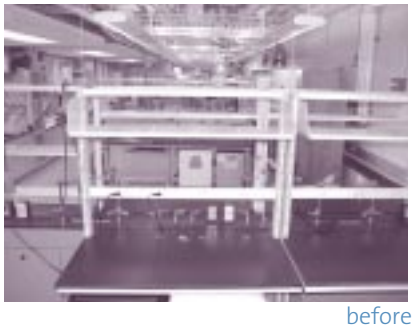
Related to the new XB curriculum will be **10.28 Biological Engineering Laboratory**, started in Fall 2003, and **10.29 Biological Engineering Projects Laboratory**, new for Spring 2005. Either Lab will fulfill a requirement for this new course of study.

10.28 Biological Engineering Laboratory introduces the complete design of the bioprocess: from vector selection to production, separation, and characterization of recombinant products. With the bioreactor at the core of the experiments, students study cell metabolism and biological pathways, kinetics of cell growth and product formation, oxygen mass transport, scale-up, and techniques for the design of process control loops. Also introduced are novel bioreactors, powerful analytical instrumentation, downstream processing, and recombinant product purification. For all students, the semester is split: One half of each class section studies the **microbial process**, while the other half studies **vaccine production**. At semester mid-point, the halves swap places, allowing all students to experience equal emphasis of these interdependent phases.

continued from previous page

10.29 Biological Engineering Projects Laboratory, taught by Professor ***Clark K. Colton*** and Lecturer ***Jean-François Hamel***, is offered in the Spring. In 10.29, students work in teams on a single project for the entire term. These projects, often suggested by local industry, serve as the basis for training in research planning and project management, execution of experimental work, data analysis, oral presentation skills and report writing, and team building.

The department is deeply grateful to alumnus ***James Brown '54***, whose generous donation provided critical new bioreactors and related equipment for use in these courses. His particularly timely gift facilitated a 250% jump in 10.28 enrollment from Fall 2003 to 2004!



before

after

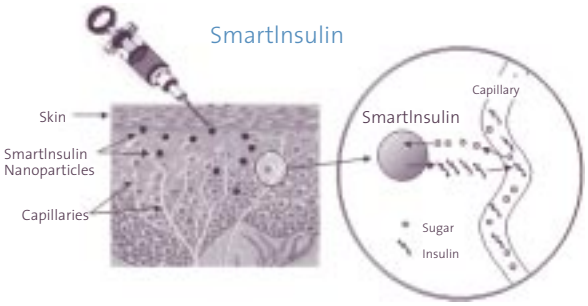
Zion Team Wins 2003 MIT 50K!

A new tradition in ChemE may be on the rise as another member of our department has led a winning team in the prestigious **MIT 50K Entrepreneurship Contest!**

ChemE Grad Student ***Todd C. Zion*** is a lead member of the Grand Prize-winning **SmartCells** team, which consists of five graduate researchers and business students who plan to commercialize the use of nanoparticles to treat diabetes. This team has already filed a provisional patent application, and now plans to secure a license from MIT to commercialize the technology. The SmartCells team also includes Sloan School graduate student ***John Hebert***; Harvard Business School (HBS) students ***Martin Curiel*** and ***Tsafrir Vanounou***; and ***Robert Bruch***, a graduate student at the Sloan School.

SmartCells technology bonds insulin molecules and sugar-sensitive proteins to a biodegradable polymer and injects the nanoparticles into a repository under the skin. Zion explained, "The nanoparticles detect a diabetic's glucose levels and release appropriate amounts of insulin to keep blood sugar levels steady."

The particles themselves can be anywhere from 80 nanometers to 1 micron in size, Zion said. Because they monitor and react to glucose levels on their own, diabetics could administer the treatment with only one daily injection, rather than the several pinprick glucose tests and insulin shots that diabetics now use.



Winning the 50K Contest is a coup of the highest order. Aside from the $30,000 grand prize (the other $20,000 is split between two runners-up), winners get invaluable exposure to venture capitalists, researchers, and business executives. Almost all finalists, regardless of whether they win, proceed to mold their ideas into startup businesses anyway.

Zion, a doctoral candidate in chemical engineering, developed the technology while working at MIT's Nanostructured Materials Research Lab with Professor ***Jackie Y. Ying***. "People have been looking at this for years," Zion said. "It was very difficult."

SmartCells would sell the nanoparticles—dubbed "Smart Insulin"—at a premium, so the cost of the drug would be more expensive than what the nation's 17 million diabetics pay today. But the total cost of caring for diabetes would be lower, since the expense of blood testing and insulin injections would be eliminated.

SmartCells has already done preliminary tests in the petri dish, and is now conducting animal tests at the Joslin Diabetes Center in Boston, Mass.

In 2001, a ChemE team led by ***Edward S. Ahn*** (PhD '01) won the top prize in that year's 50K Contest for their company, **Angstrom Medica**, which is now developing a new bone-healing technology.

MIT ChemE congratulates Todd Zion and the **SmartCells** team on this remarkable accomplishment! ⊡

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For the period July 1, 2002 through June 30, 2004

Thank you for all of your generous support throughout the year!

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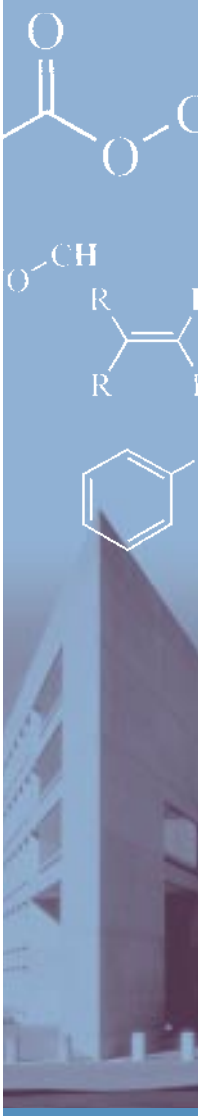

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Research Highlights

From the Department of Chemical Engineering

Toxicity of Endogenous Nitric Oxide

Professor William M. Deen

Researchers in numerous branches of medicine and physiology have discovered in recent years that nitric oxide (NO) is routinely synthesized by cells throughout the body, and that maintaining proper concentrations of it is essential for good health. It helps regulate blood pressure, affects clotting, assists the communication among neurons, and plays a role in the immune response to infections, among other beneficial actions. But, unfortunately, NO is both toxic and mutagenic if present in excess, and there are situations in which its production is apparently overstimulated. The sustained, high rate of NO synthesis by immune cells during chronic inflammations provides an example, and may explain the statistical link between persistent inflammations and certain forms of cancer. Chemical damage to cellular proteins, lipids, and DNA results not so much from NO itself, but from a variety of trace nitrogen oxides formed when NO is oxidized in biological fluids.

Professor Deen's group has been investigating the fundamental aspects of the production and fate of NO and related nitrogen oxides in biological systems in collaboration with several faculty in the Biological Engineering Division. To assess health risks and design interventions, one needs to know which compounds actually mediate the various harmful effects of excess NO. Underlying that effort is the need to know what their concentrations are near an NO source (e.g., an activated macrophage), and over what distances those concentrations remain elevated. A chemical engineering problem emerges: The concentration fields must reflect the interplay between rates of reaction and diffusion. The modeling problems are made challenging by the complex chemistry, which includes enzymatic sources and sinks for NO, a network of inorganic oxidations that yield other reactive nitrogen oxides, and the interactions of the nitrogen oxides with soluble or structural biomolecules. The geometric complexity of tissues, and even of cell culture systems used to study NO toxicity, adds its own difficulties. Experimentally, few of the compounds of interest are present at measurable concentrations, and their levels must be inferred from analyses of oxidation end products and of biomarkers (e.g., trace levels of nitrogen oxide-modified proteins).

This work in Professor Deen's group has yielded several recent insights. A reaction-diffusion model developed to describe the fate of NO released by macrophages cultured on plates revealed that some species will be present only in the immediate vicinity of the cells, but others will exist throughout the culture medium. Accordingly, various chemical reactions will be spatially segregated, even in extracellular fluid. Experiments varying the depth of the liquid medium indicated that NO strongly inhibits its own synthesis by macrophages, a phenomenon that had been demonstrated previously with isolated enzymes but not with intact cells. An analysis of the kinetics of NO production and consumption in macrophages suggested that the maximum NO concentration that can be achieved at any cell number density is about 1 μM. This was the first indication of a possible upper limit for NO concentrations at sites of inflammation. Knowing better what to mimic, an apparatus was designed to permit "target cells" (cells that do not produce NO) to be exposed to controlled, micromolecular levels of NO for up to several days. In collaboration with Professor ***Gerald N. Wogan*** of the Biological Engineering Division, the effects of NO concentration and total dose (area under the concentration-time curve) were then characterized in terms of cell survival and several types of cellular damage. It was found that there are dual thresholds for NO toxicity. Toxic effects were not seen unless a minimum concentration and a minimum dose were both exceeded. The concentration threshold for the cell lines used was about 0.5 μM (about half the inferred physiological maximum). This is the first quantitative demonstration of toxicity thresholds for NO, and is stimulating a new round of experiments to examine the underlying intracellular events. An important objective in the next few years is to develop reaction-diffusion models for tissues that will provide a rational means to extrapolate kinetic, diffusional, and cell culture data to pathophysiological conditions in the body.

Two-Dimensional Protein Crystals: Physics Lessons from Nature

Professor Alice P. Gast

The surfaces of many prokaryotic cells (bacteria and archae) are fully enveloped with an organized layer of proteins. The purpose of these ordered protein coats is not fully understood, although it is postulated that they play a role in the physical integrity and protection of the cell or in sieving materials passing through the membrane. These fascinating structures in nature motivated the Gast group to study model systems of proteins on lipid monolayers or bilayers. In addition to the interesting, naturally occurring assemblies, ordered arrays of proteins on lipid supports are a useful system to study protein structure and interactions. Lipid monolayers and bilayer membranes serve as simplified models to the complex and inhomogeneous properties of actual cell membranes. Appropriately cloaked liposomes also have potential uses as carriers for targeted drug delivery.

Several years ago, we began studying a model system, called streptavidin, a tetrameric globular protein having an

unusually high binding affinity for biotin. We studied the crystallization of streptavidin attached to lipid monolayers spread at the air-water interface. By changing the solution pH, we were able to provoke different crystalline symmetries and shapes due to the changing intermolecular interactions between proteins. We tested our understanding of these molecular interactions by creating point mutations that altered the surface of the protein-enhancing attractions or repulsions and driving the crystallization behavior. The ability to alter single amino acids in this way provides a powerful link to molecular models of protein-protein interactions. These studies have enabled us to learn much more about the two-dimensional crystallization process and how we can tailor lattice structure and crystal morphology through manipulating intermolecular forces.

Our interest in naturally occurring protein crystals such as those enveloping archae led us to create giant unilamellar vesicles as model membranes. We were able to study the same crystallization phenomena on these vesicles of about 50–100 micrometers in diameter through confocal fluorescence microscopy. We find that crystals grow on these surfaces even under conditions of very low ionic strength and in the presence of sugar solutions. A typical series of images shows fluorescently labeled background protein surrounding dark regions of streptavidin crystals.

Streptavidin Crystals

We collaborated with R. Merkel in the Sackmann group in Munich, Germany, to study the effect of a surface crystalline protein layer on the mechanical properties of the membrane. In particular, we used micropipette aspiration to probe the membrane responses and material properties of bare vesicles and those coated with either an amorphous or a crystalline protein layer. The presence of crystals on the vesicle surface transformed them into roughened spheres and prolate ellipsoids. The coated vesicles have a plastic response to deformation as seen in the structure set by aspiration with a pipette shown below. The composite protein-lipid membrane combines the solid characteristics of two-dimensional crystals with the fluid elastic behavior of lipid bilayers to yield a thin, rigid, yet viscoelastic structure. The nature of the protein-lipid and protein-protein interactions plays a key role in determining the overall properties of the composite membrane.

t = 0s t = 0.9s

Coated Vesicles

Crystallizing proteins on giant bilayer vesicles provides us with a well-defined system that is easy to study and manipulate. The unique properties of these structures facilitate a fundamental understanding of molecular self-assembly and protein-membrane interactions.

Design of Therapeutic Protein Formulations via Quantum Mechanics and Statistical Mechanics

Professor Bernhardt L. Trout

Therapeutic proteins encompass a significant and growing fraction of the pharmaceutical market. An example is Amgen's G-CSF, which has annual sales of $2 billion and is used to treat complications arising from chemotherapy. Designing therapeutic proteins like G-CSF and processes to manufacture them are great accomplishments but they are not enough. In order for therapeutic proteins to be useful and to be approved by the FDA, they must be stable for two years in a form that can be conveniently and safely injected into a patient. Typically, this form is an aqueous solution, consisting of water and a variety of cosolutes, such as salts, sugars, surfactants, amino acids, and others.

The major problem in developing the solution formulation is that no one knows how to do it for a particular protein, aside from using heuristics and trial-and-error experimentation. This "Edisonian" approach has failed in many cases, so that there are numerous therapeutic proteins that have the potential to save lives and enhance the quality of lives but that cannot be used because they are not stable in storage. Furthermore, in cases where the Edisonian approach succeeds, it does so after many experiments, the number of which would be sharply reduced if the underlying chemical processes involved in destabilization and stabilization were understood. A major reason why they are not understood is that it is almost impossible using current experimental technology to isolate the individual interactions and reactions among chemical species that lead to destabilization or stabilization. This is because many trillions (actually, roughly 10^{23}) of chemical processes are occurring during any single

experiment, and multiple, very clever and very accurate experiments would need to be performed in order to isolate the chemical processes of interest. Alternatively, accurate mathematical models of the systems would allow the study of the most important chemical events isolated from the less important ones.

The Trout group is developing and solving mathematical models for the design of solutions that will stabilize therapeutic proteins against oxidation and aggregation, the two most common routes of degradation of therapeutic proteins. For these models to be accurate, they must include each atom explicitly and for the most important regions of the protein and solution, each electron explicitly. The latter is essential for the accurate treatment of the breaking and formation of chemical bonds, and requires the use of approaches based on quantum mechanics.

Having an accurate model is not enough. This is because the models that we develop are exceedingly complex, and we must devise clever ways of extracting the information that we want from these models efficiently and with a minimum of numerical noise. In order to accomplish this task, we use sophisticated simulation approaches, some of which are developed in our laboratory. These approaches are based on statistical mechanics, which gives us physical insight into which numerical regions of our model we should focus on. Even using these statistical mechanical methods, each data point takes more than a billion trillion (10^{15}) computations. Together with these computational approaches, we are performing experiments on well-defined model systems in order to validate our theoretical/computational approaches.

In terms of specific results, we have isolated the essential reaction pathway that leads to the oxidation of sulfur sites on methionine residues and demonstrated that the rate of oxidation is proportional to the number of water molecules in the vicinity of the sulfur site. If one can keep water away from the sulfur sites, even with a large amount of oxidizing components present in the system, the sulfur will not be oxidized. We are currently designing chemicals, called excipients, which selectively surround those sulfur sites and block them from water. Our computational modeling approach gives us unique insight into what is happening at the sulfur sites and what properties of the excipients are necessary so that the excipient surrounds the target site selectively.

In the area of aggregation, we have validated our models for the computation of the change in stability of proteins, such as RNase, in the presence of sugars, polyols, and urea. We have also developed a quantitative theory of what the essential properties of an excipient are that makes it a stabilizer. Using this theory, we are designing new molecules that should function better than currently used excipients, and are developing computational methods to aid in the design of these new molecules, in addition to experimental protocols to test them.

Research on Energy and the Environment
Professor Jefferson W. Tester

Several important problems face us in transitioning to a more sustainable energy system. One set of problems relates to the environmental impacts created by the current approach, which relies heavily on fossil fuels—these range across scales from local to regional effects caused by particulate, and sulfur and nitrogen oxide emissions from combustion to global concerns over carbon dioxide. Another important aspect is the maldistribution and depletion of fossil resources (oil, natural gas, and coal). All of this suggests that we should diversify our energy supply options while we seek to minimize the environmental effects associated with fossil fuel use. So far, progress has been slow, in part because the technologies associated with renewable energy capture and recovery cannot compete economically with today's low-cost fossil fuels. A significant fraction of research in the Department of Chemical Engineering is addressing many of these problems. For example, several investigations are aimed at producing cleaner fuels and renewable biomass and geothermal energy systems, while others are focused on processes to remediate environmentally contaminated areas.

Professor Tester's research group—in collaboration with other faculty in chemical engineering, nuclear engineering, and materials science—has been developing a range of experimental and theoretical methods to probe kinetics and transport phenomena in compressed and supercritical media. For example, measurements of reaction rates and product distributions have successfully been linked to *ab initio* quantum chemical calculations to quantify the effectiveness of reforming and oxidation processes in supercritical water to detoxify chemical and military wastes. Improved fundamental understanding of the role of supercritical water, both as a solvent and as a reactant, has been obtained for a number of model wastes ranging from methylene chloride to methyl tert-butyl ether (MTBE) to methyl phosphoric acid (MPA).

Synthetic pathways are also being pursued using mixtures of compressed and supercritical fluids in a collaborative program with Professor ***Rick Danheiser*** in Chemistry and Professor ***Andrew Holmes*** at Cambridge University, UK. The key idea involves a green chemistry approach where environmentally benign solvents such as water and carbon

dioxide are used as the media to carry out selective carbon-carbon bond forming cyclo-addition reactions for producing pharmaceutical intermediates and specialty chemicals. So far, we have been successful in demonstrating the use of power ultra sound to produce emulsified bi-phasic mixtures of near-critical carbon dioxide and water that enhance reaction rates between model Diels-Alder reactants.

In separate studies, Professor Tester, in collaboration with Professor Trout, has developed a refined statistical mechanical model for solid gas hydrates or water clathrates. The goal has been to develop a physically consistent model for use in predicting the properties of important hydrate systems, such as those involving carbon dioxide and methane, which have direct applications to carbon sequestration in the deep ocean and natural gas recovery from permafrost and marine sediments. *Ab initio* calculations are coupled to a statistical mechanical model to capture the effects of intermolecular interactions between water host molecules and enclathrated guest molecules. This first principles approach has successfully predicted the equilibrium and transport properties in multiphase systems containing solid hydrates and fundamentally differs from earlier work, which has relied heavily on fitting parameters to robust experimental data.

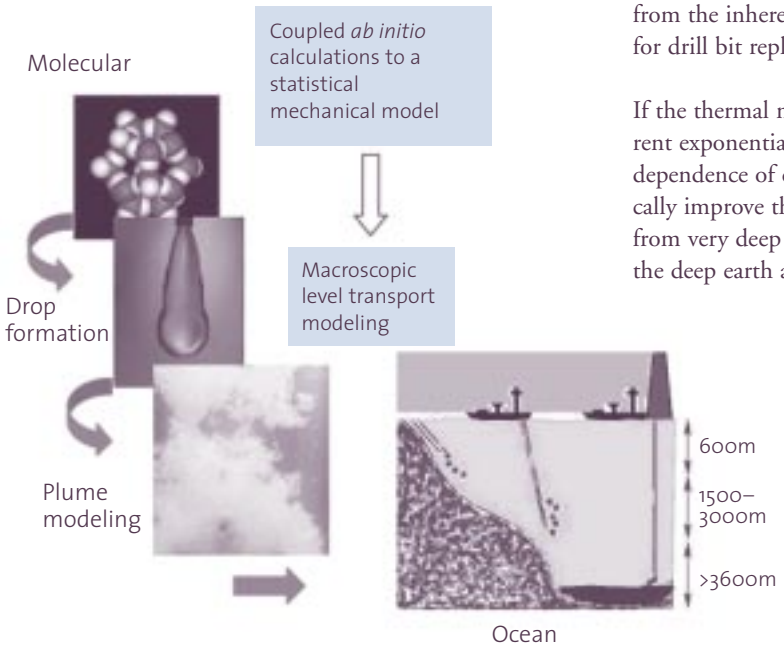

Figure 1: Illustration of the multi-scale nature of the investigation of carbon dioxide sequestration. A key question is whether the rate of nucleation of carbon dioxide hydrate can be controlled.

> *"A significant fraction of the research in MIT ChemE is addressing the problems facing us in the effort to transition to a more sustainable energy system"*

The third area under investigation is the development of a new approach to drilling ultra deep holes in the earth using thermal spallation and fusion rather than the conventional cutting and grinding approach.

Earlier work in our group has quantitatively characterized rock spallation phenomena using supersonic combustion flame jets at low pressures and fluid densities in shallow hole drilling to show that they will penetrate very hard rock at about 5 to 10 times the rate of conventional bits with little or no wear. Ultra deep drilling to 10+ km will require having an intense heat source at high pressures of 1 kbar or more. Building on our experience operating in high-pressure, supercritical water environments, we are analyzing the feasibility of using hydrothermal flames as a heat source to spall and melt rock in confined bore holes. Using conventional drilling technology, an exponential dependence of drilling cost on well depth results in part from the inherent wear to drilling equipment and the need for drill bit replacements.

If the thermal method works, we are optimistic that the current exponential dependence would be replaced with a linear dependence of cost on depth. Such technology would drastically improve the economics of geothermal energy recovery from very deep reservoirs, thus making heat mining from the deep earth a universally accessible energy source. ⊡

GSC-X Activities

By Joel Forrest Moxley,
GSC-X Staff

Howzit from your friends at GSC-X! Things got kicking last August with the Freedom Festival Barbeque to kick off a sizzle-dizzle year. Professor Armstrong took a few plunges in the dunking booth, and we washed down the barbeque with the largest Legal Seafood clam chowder order since The Eagles rolled through town. Before the semester started, we crowned a department putting champion at the Caddyshack welcomepicnic for the First-Years.

We all know that the GSC-X pulls out all the stops for the December holiday party, and 2003 did not disappoint. Sure enough, the First-Years came out of the gates with some solid skits and the Nth-Years did their best to follow. There was even a rumor that Professor Deen cracked a half smile at several points, but I will never believe it. Afterwards, the party moved to 66 where we could discuss the latest faculty jokes and enjoy a veritable feast. And if you have not holiday caroled with the ChemE's, you just haven't lived.

Hopefully, the GSC-X succeeded in easing a bit of the First-Years' pain of impending Quals Exams with bags of candy, a post-test lunch, and critiquing practice oral qualifer presentations. As always, they pulled through. Later that month, in celebration of Adam Vinateri's Super Bowl-clinching kick, we all ate "Vinateriyaki" chicken subs and practiced field goals at the February TG. Some BioEngineering staff were not too amped about the footballs flying to and fro in the hall, but this failed to dampen our spirits and a department place-kicking champion was determined in a sudden death playoff.

March is recruitment month! What better way to attract bright young minds to our department than butchering classics on karaoke, or flailing limbs on Dance Dance Revolution (DDR)—a pad where you dance to club music following instructions on the monitor. The three recruiting TGs in March pretty much tuckered us out, but we mustered up the energy to hold the First Annual ChemE Semiformal in April, which revived every bad reminder of high school dances, including the balloon arch, and took our dates to the Western Sizzler afterwards.

In intramural sports, ChemE's continued to dominate outside 66 capping off an exciting year. Thanks for stopping by. Stay classy, Chem E's! ▪

"ChemE's continued to dominate outside building 66, capping off an exciting year!"

Gregory Sands, Editor
Department of Chemical Engineering

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