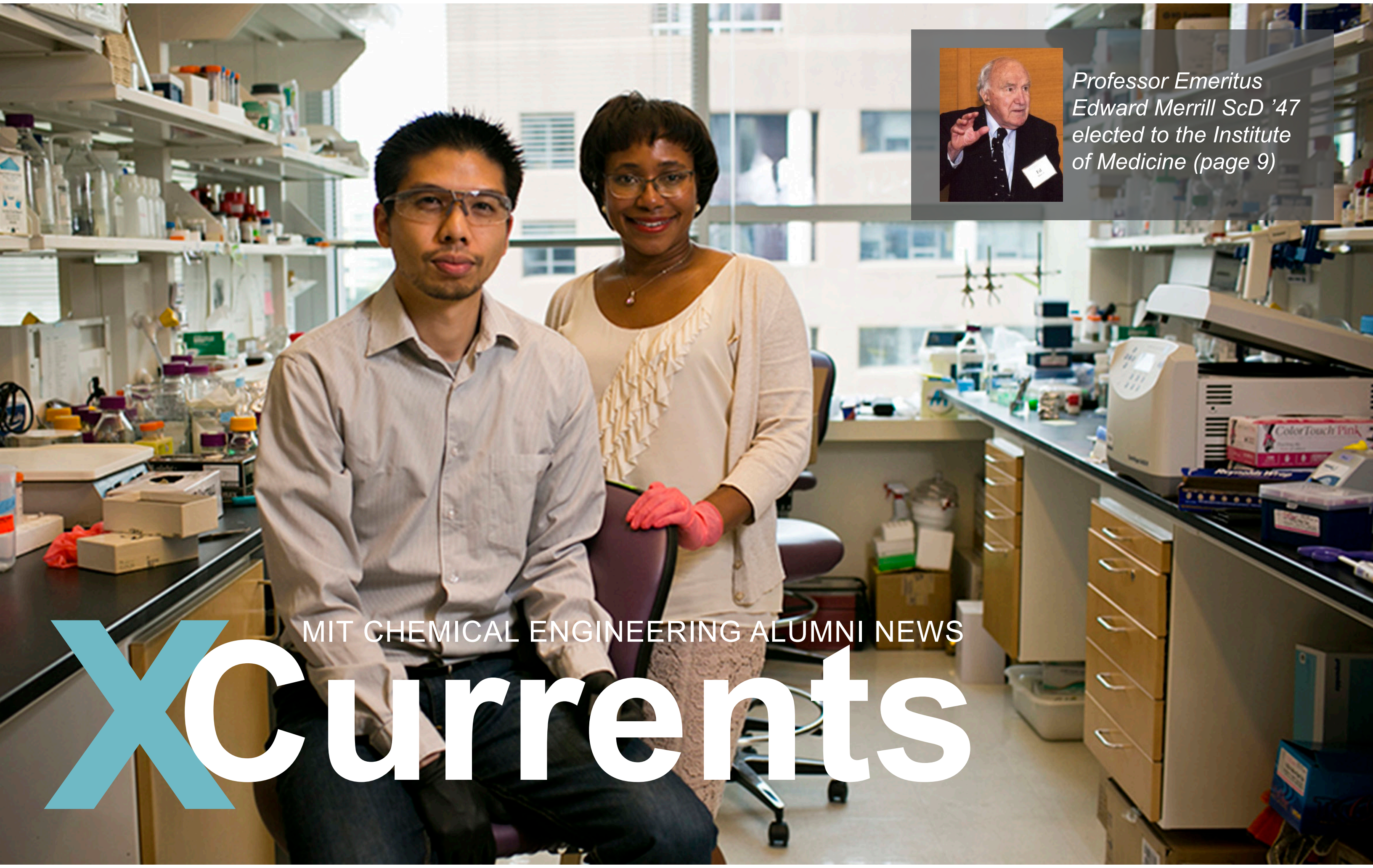


Professor Emeritus Edward Merrill ScD '47 elected to the Institute of Medicine (page 9)

MIT CHEMICAL ENGINEERING ALUMNI NEWS

XCurrents

Letter from *Department Head Klavs F. Jensen*

As I write, the huge snowdrifts around Building 66 are melting. Despite a record snowiest winter with challenges of navigating building-size snowdrifts and temporarily crippled commutes, the Department's vital work in chemical engineering research and education remains "unquenched."

The rejuvenation of Building 66 is in its final weeks, and already it has greatly improved our environment and literally brought new light into offices and corridors. Interior windows now let in and distribute natural light throughout the building. Antireflective coatings on the outer windows of the building allow us to enjoy the brilliant sunlight without broiling. We have created new offices for our graduate students with windows through to the adjoining labs, allowing them to work in safety while keeping a close eye on their experiments. Moveable workspaces replace fixed benches, allowing us to easily change out the equipment and respond to evolving research interests in the coming decades. There are new social spaces, including an expanded undergraduate lounge. In addition, a new state-of-the-art air-handling infrastructure provides safety and comfort. A group of young alumni visited the department for an event in early March, and it was gratifying to watch their enthusiastic reactions

Highlights

find the latest news online:

web.mit.edu/cheme/

MITChemEng MITChemE

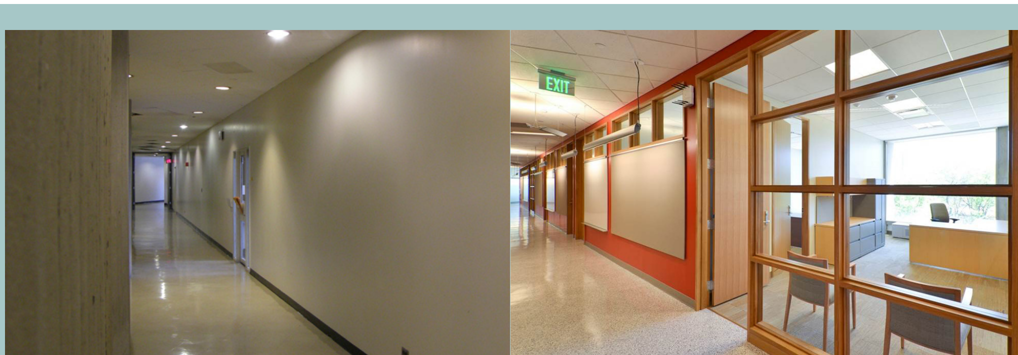
Massachusetts Institute of Technology

Letter from the Department Head continued

as they admired the renovations. The results of this project will enable our students and faculty to push forward with their remarkable work addressing today's challenges in manufacturing, energy, and health, which you will see illustrated in this issue of XCurrents. I am delighted that they will continue to do this work in our landmark home, and am confident that we will make good use of this space for years to come.

This exciting and vital rejuvenation was made possible by the generous support of the Institute, who provided $25 million in general funding to finance the much-needed infrastructure replacements and address the building's safety concerns. The Department has also committed to raising $20 million to cover the lab and classroom renovations, and our new development officer, Heather Upshaw, is assisting in these efforts.

You, our alumni, are the legacy that our current students follow. I cannot say enough how grateful we are to you; your support is integral in our continued success as a department. This is a great time for MIT Chemical Engineering, thanks to our many alumni and friends. We are grateful for your support and are proud of the MIT Chemical Engineering community around the world.



A before-and-after look at the fourth floor hallway of Building 66.

I would like to thank Bill Green who, in his role as executive officer, provided effective day-to-day management of the Building 66 project along with Steve Wetzel. Throughout the project, Bill, Steve Wetzel, and Bill's assistant (first Alison Martin, then Sandra Lopes) participated in weekly construction-related meetings as well as numerous side meetings with faculty and construction workers. When construction work peaked in August 2014, more than 100 contractors were working in every floor of the building including the roof. When problems occurred, such as flooded offices and labs, Bill worked hard to press the construction people to respond appropriately, and to try to keep the conversations between the construction people and the Building 66 residents affected constructive. We thank them for their enormous efforts in the realization of the beautiful newly renovated spaces we now enjoy. After his great service as executive officer, Bill has returned to teaching and research, handing the baton to Patrick Doyle. Pat's experience as graduate officer and deep commitment to our educational mission will be a great asset to the Department as we are finally able to refocus all our attentions on our core missions of research and teaching.

For the 25th year in a row, the Department topped the ranking of chemical engineering programs by US News and World Report. While such rankings should be interpreted with a grain of salt, it is gratifying to see the hard work of students, faculty, and staff recognized by the general community. The new extra space in buildings E17/18/19 and the renovated space in 66 create the modern environment necessary to sustain the Department's momentum and to attract the best new faculty and student talents.

Our young faculty have become major contributors to the Department. This spring Brad Olsen and Yuriy Roman were promoted to Associate Professors (without Tenure). Brad was named the 2015 Herman F. Mark Young Scholar by the American Chemical Society and Yuriy won a NSF CAREER Award. With Patrick Doyle, Fikile Brushett received the Mike Mohr award for outstanding undergraduate teaching for fluid mechanics (10.310), and Will Tisdale received the Institute-wide Everett Moore Baker Memorial Award for excellence in undergraduate teaching for his efforts in heat and mass transfer (10.301).

This fall we celebrated establishment of the Raymond F. Baddour, ScD, (1949) Chemical Engineering Professorship with the Baddour family and alumni. Bernhardt Trout is the first holder of the chair. We are deeply grateful to the Baddour family for their generosity and dedication to the Department at MIT. Raymond Baddour, the Lammot du Pont Professor of Chemical Engineering, Emeritus, was head of the chemical engineering department from 1969 to 1976. With the above Building 66 project, it is important to remember that Building 66 was conceived and built during his tenure. In fact, he led the fundraising for the building.

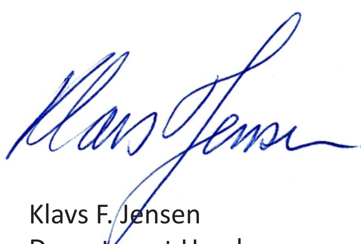
At AIChE's Annual Meeting, we remembered Howard Brenner at a special session. The alumni reception had strong participation and provided a venue for celebrating faculty AIChE awards and Greg Stephanopoulos's election as President of AIChE (more on page 9). The faculty continues to receive recognition of their extraordinary accomplishments. Ed Merrill was elected to the Institute of Medicine (IOM) and is now among a select group who are members of both IOM and NAE. Karen Gleason has been elected to the NAE for contributions to chemical vapor deposition of then polymer films. Examples of her work appear several times in the newsletter. Bob Langer won the Queen Elizabeth Prize for Engineering. The global £1 million prize celebrates the engineers responsible for a groundbreaking innovation that has been of global benefit to humanity. Greg Rutledge received the 2014 Founder's Award from the Fiber Society. (Additional faculty news and awards are on page 16)

Mark your calendars for the Centennial Celebration of the Practice School, coming in 2016. Alan speaks to this in his letter on the next page, and we sincerely hope to see all our Practice School alumni attend to help celebrate the anniversary of this unique and significant program. It will be a wonderful weekend to be on campus and see all that is new (including our wonderful new spaces in 66) while celebrating what is not new: our commitment to training students to address real-world challenges and to succeed across the academy and industry.

We will have our annual alumni reception during commencement on Friday, June 5. It would be great to see you there. Watch our website, web.mit.edu/cheme/ for the latest updates; you can find us on Facebook (MIT Chemical Engineering) and Twitter (MITChemE) for live updates on the goings on around the Department and the Institute.

I would like to end with a personal note. After eight and a half exciting and challenging years, I have decided to step down as department head on July 1 of this year. It has been wonderful to work with so many outstanding faculty, staff, and students, but renewal of leadership is important for new ideas and directions. It has been an honor to serve this outstanding department. It is in a great position of strength, having modern facilities and an exceptional cohort of both junior and senior faculty. I have thoroughly enjoyed working with the Department's outstanding students and postdocs. I am grateful to our faculty and staff for having worked hard to ensure that we provide the superior education and research expected of the top ranked chemical engineering program. Dean Ian Waitz has appointed a search committee to identify the next department head. We are fortunate to have a deep bench of academic and administrative talent as candidates for the next department head. I plan to re-engage full time with teaching and research in the Department.

In the past eight and half years, I have had the opportunities to meet many of you, the alumni, at MIT and across the country at many different formal and informal events. It has been a pleasure to come to know you and experience first-hand your deep interest in and steadfast support for the Department. Thank you! We hope you enjoy this issue of the newsletter. Please do write to us to let us know how you are doing and how we can continue to improve.



Klavs F. Jensen
Department Head
MIT Chemical Engineering Department

XCurrents is a semi-annual newsletter for alumni and friends of the MIT Chemical Engineering Department.

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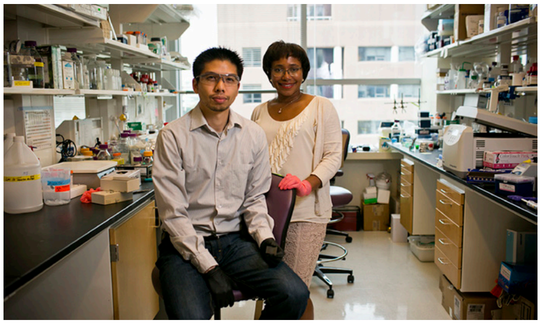


On the cover: MIT professor Paula Hammond (right) and Bryan Hsu PhD '14 have developed a nanoscale film that can be used to deliver medication, either directly through injections, or by coating implantable medical devices. For more on this and other current research, go to page 20.
Photo: Dominick Reuter for the MIT News Office

Practice School News

Warm greetings from the Practice School as we approach yet another milestone in its long and colorful history! Next year we will be celebrating 100 years of chemical engineering student engagement with industry to solve some of its most complicated and challenging problems. Since 1916, our students – including many of you – have helped organizations like General Mills, Corning Glass, Novartis Pharmaceuticals, BP, Cabot Corporation, and many other energy, materials, manufacturing, food, pharmaceutical and research companies.

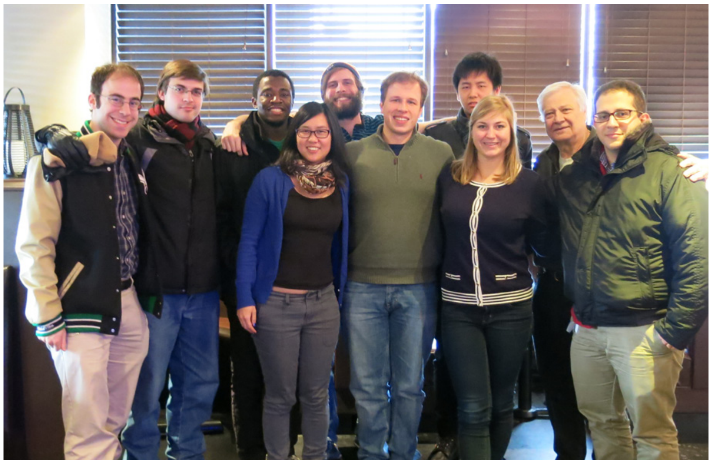
The centennial event is scheduled for the weekend of September 30 – October 2, 2016, so mark your calendars! We are planning a weekend of fun, fellowship, and looking towards the future of the program with fellow alumni, students, faculty and friends of the Practice School. The main event will take place all day Saturday, Oct. 1, on the top floor of the Media Lab where the view of the Charles is wonderful.

This past fall, we sent out an online survey to all Course X alumni, asking to hear about your Practice School experiences. Hundreds of people responded with memories from their time at Oak Ridge, Lackawanna Steel, Bangor and Bound Brook, among others. It is very exciting to see what an impression the Practice School made on so many of you, and we want to hear from those who have not yet responded.

To facilitate this, we have included in this edition of XCurrents a postcard for you to fill out and return back to us. This is very important: During the past 100 years, there have been changes in the way MIT records Practice School attendees, so this effort will help ensure we have a comprehensive directory of all who have benefited from and helped to shape the Practice School.

If you would rather fill out the survey online, just go here: https://www.surveymonkey.com/s/6MWCYMK

We have one exciting project for the centennial that is well under way: a documentary of the past, present and future of the Practice School. Bob Hanlon, who directed our recent station at Corning Glass, explains more on the next page. His station and students are being filmed as part of the documentary; I doubt he expected part of his job description to be "film star," but I hear he's adapting well to the role.



The Fall 2014 GMI Practice School students (including some of our future film stars) with director Bob Fisher.

We will be sending out more information on the event in the next few months – I sincerely hope you will be able to join us for the celebration next year.

Now let me share with you the work of our current Practice School students following in your footsteps:

Summer 2014 Stations

Mallinckrodt Pharmaceuticals, St Louis, MO
Directed by Claude Lupis

This was our first station at Mallinckrodt Pharmaceuticals. The company is based in St Louis, Missouri, and has a rich history. It was established in 1867 to supply local pharmacists with much needed drugs and, at the time, was the first chemical company west of Philadelphia. The company is best known for its production of pain relief medications, which it started in 1898 with morphine and codeine. It also produces diagnostic imaging agents, and, interestingly, it purified all of the uranium oxide used in the Manhattan Project.

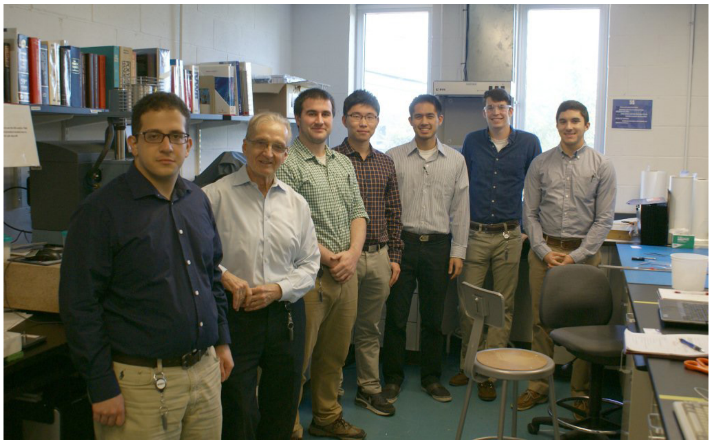
Eight students attended the station. As some of the Mallinckrodt equipment is old and the company wishes to update its facilities to meet increasing demands, several of the projects dealt with the redesign of processes with particular emphasis on continuous processes and their economic feasibility. Other projects dealt with the optimization of a specific operation, such as separation by chromatography, or the investigation of crystallization for better flowability.

Much enjoyed by all was the hospitality of the company personnel. Of particular note, was a delightful evening devoted to a “Cajun Shrimp Boil” organized at the house of one of our Mallinckrodt colleagues. Other highlights of our stay were the visits to the iconic St Louis Arch, the Fine Arts Museum, the astounding mosaics of the Cathedral Basilica and, of course, a baseball game at the home of the St. Louis Cardinals.

SGC Energia, Houston, TX
Directed by Kathryn Mumford

Heading to Houston, Texas, for the Summer 2014 session of Practice School at SGC Energia promised to be a great adventure for the eight fortunate students and director. Many of the students had never visited the Southern States or had the opportunity to work in a gas to liquids processing facility; the excitement and energy was palpable. SGC Energia has been running Practice School stations for approximately five years, with previous stations in Austria in addition to the main Technology Research Center at Houston. Championed by CTO John Hemmings and supported by committed and enthusiastic consultants Lindsay Hernandez, Bruce Logue and Anca Sauciuc and the ready and talented Support Team of Kat, Luis and many others, the projects were well constructed, challenging and met with robust and innovative ideas by the students.

Specifically, the focus of the station was the reactor system



Students take a quick break in their workspace at the Madico Practice School Station.

with projects focused on improved catalysts, thermosiphon operation and predictive modelling of reactor performance. The challenges were met with extensive laboratory trials of potential catalysts, pilot scale constructions of thermosiphon systems, Aspen models of performances and Matlab models of the reactor itself. Great value was gained by the students and the company, with the models developed adopted by the company engineers.

Throughout the month we were also able to get involved in some of what Houston and the surrounding area had to offer. SGC Energia organized trips to see a baseball game; to Louisiana to see SGC Energia’s full scale gas to liquids facility currently under construction, and a facility that manufactured the largest heat exchanger equipment that the director had ever seen. The group also visited mission control at NASA, attended numerous group dinners and even attended Wednesday night “turtle racing” (apparently a Houston specialty).

The Practice School was also a wonderful experience for Kathryn, a first time Station Director with no previous experience of what Practice School entailed. She is an academic from the Department of Chemical and Biomolecular Engineering, University of Melbourne, Australia, and others in her Department who had previously acted as Station Directors had described the experience as “drinking from a fire hose.” It was certainly that and very enjoyable. She considers herself fortunate to have had the opportunity to be involved.

Fall 2014 Stations

General Mills (GMI), Minneapolis, MN
Directed by Robert Fisher

Six projects in two sessions were undertaken at this recognized giant of the food industry. To date, a total of over 140 projects have been sponsored by GMI at various locations, involving bench, pilot and commercial scale processes. These most recent efforts were based at their James Ford Bell Technology Center (JFB TC) in Golden Valley, MN; a suburban area in close proximity to center city Minneapolis, and with the Riverside TC, the former Pillsbury facility in downtown Minneapolis on the Mississippi river front.

All three of the first session work efforts were extended to refocus and stress different aspects for multiple particular product lines. Transport mechanisms and appropriate profiles within the multiple components of these food matrices comprised a major effort, as with past projects. The physicochemical characteristics for a major product needed to be evaluated and refined post mixing process steps. Technology assessment and determining mechanisms involved comprised our major emphases. This required understanding material property interactions in a multi-component product. Another two session project was related to consumer safety concerns with both an existing product and potential new one thus establishing a platform technology for microwaveable "treats". Heat transfer mechanisms and product quality improvements dominated our efforts. The third project sequence focused on improving the shelf storage life related to oxidative processes; again, a potential platform technology.

All projects were related to GMI's emphasis on nutritional value and customer perceptions of all their product lines by reducing or eliminating certain high profile ingredients. They involved use of Design of Experiments techniques to determine process control variables along with the development of mechanistic models based on the fundamentals associated with energy input schemes and transport processes. Of course, we were involved with technology assessment and the rheological behavior of both complex media and nano-emulsions. The existence of multiple phases in these systems provided very interesting and challenging problems. Some of the modifications could be implemented during our "residence time" at the station and proved to be successful or suggestive of further modifications or processing changes.

Our group activities took advantage of such a culturally enriched region. This includes professional sports, theatrical performances at the world renowned Guthrie Theatre, and fall foliage excursions to quaint towns in both Minnesota and nearby Wisconsin. This session our group activities expanded somewhat to include entertainment at an all-you-can-do Bowling Club, which we thoroughly enjoyed, and many coffee café gatherings to escape from the unfortunately unusually frigid weather. We all especially enjoyed our group Thanksgiving Day outing at an Indian restaurant.

Madico, Inc., Woburn, MA
Directed by Claude Lupis

Madico, Inc., offered another new station to the Practice School. The precursor to the company, Hi-Sil, was founded in 1903, and began then the development of a technical expertise in multilayer materials, such as paper and postcards. Today, Madico is a world leader in multilayered films for applications in energy-related markets, such as solar control window films (for buildings as well as cars) and photovoltaics backsheets. The window films also provide an important measure of safety and security. Madico is now a subsidiary of a Japanese company, Lintec, another leading manufacturer in the field of pressure-sensitive adhesive materials.

Madico is based in Woburn, MA, and six students attended the station there. They worked on two projects in teams of three. The first project optimized the shapeability of films for automotive curved windows, while the second optimized the physical properties of a thin film separating electrodes in electrochemical batteries. In both projects, the students introduced innovations of significant importance to the company.

While Woburn is within commuting distance from MIT, the traffic on working days would consume large amounts of time. Consequently, the students were housed in Woburn, at the local Marriott Residence Inn and welcomed the free breakfasts and dinners offered by the hotel. The station also allowed us to enjoy the fall in New England.

National Renewable Energy Laboratory, Golden, CO
Directed by Randall Field

The National Renewable Energy Laboratory (NREL) is a great station for the Practice School. It has fantastic research scientists and engineers, well-equipped pilot plants, state-of-the-art instrumentation in their labs and a beautiful location near the foothills of the Rocky Mountains. Most importantly, NREL has a compelling and inspiring mission. NREL develops renewable energy technologies to address the nation's energy and environmental goals. Although NREL's mission covers many different renewable energy options including solar, wind, biomass and geothermal, the projects in Fall 2014 were entirely with the National Bioenergy Center.

Our projects during this session involved a blend of experimental work, literature research, and theory. Our projects at NREL took on many of the major questions for biofuels production: 1) Which pathways are most promising? 2) How does the biomass feedstock affect the conversion process? 3) How should feedstocks be characterized? 4) How can we engineer microorganisms to enable more efficient conversion processes?

In one of the projects, the team ran a biomass gasification pilot plant to discern how the feedstocks and operating conditions affect syngas yield and tar formation. This project was very special because it involved intense collaboration with various parties. Fluidized bed biomass gasification has been the focus of substantial research by Professor Ghoniem, Ronald C. Crane (1972) Professor of Mechanical Engineering at MIT. Professor Ghoniem's team has developed detailed models of these fluidized bed reactors with funding provided by BP. The modeling team at MIT was in search of new experimental data with which to validate

Practice School letter continued on page 11

2014 Practice School Dinner

On October 22, 2014 at the Cambridge Marriot, the Department held its annual Awards Banquet for the Practice School, attended by industrial sponsors, MIT administration officials, and students, faculty and staff of the Department. Our speaker was Sanjoy Mahajan, Acting Director of Digital Residential Education at MIT, who discussed MITx and how people learn.

2014 Practice School Award Winners

William C. Rousseau Award for the continual demonstration of outstanding leadership skills in project teamwork, while adhering to highest standards of integrity and ethics

Min Hao Wong

Rosemary Wojtowicz Award for the kindness and concern for the well-being of others

Tsai-Ta Christopher Lai

J. Edward Vivian Prize for outstanding leadership and management of project work

Harry Watson

Jefferson W. Tester Prize for showing the most enthusiasm and leadership

Jennifer Lewis

2014-2015 Graduate Fellowships

Graduate financial support continues to be an essential ingredient for maintaining the quality of our graduate programs. This funding helps MIT Chemical Engineering recruit the very best students by providing support for the first academic year so they can concentrate on core graduate level coursework, free of the demands of teaching and research. The result is a firm base in engineering science on which to build future graduate studies.

Fellowships come from many different arenas: industrial and research organizations, as well as alumni individuals and groups. We are very grateful for this support!

Wechsler fellow Christy Chao and Dr. Alfred Wechsler (SB'55 ScD'61) at the annual Practice School Dinner, October 2014.

Arkema Inc. Fellows
Michael A. Lee, Princeton

Alkermes Fellows
Laura Ellen Crowell, Tufts
Lisa Rae Volpatti, Pittsburgh

Arch Chilton Scurlock '43
Benjamin Niswonger, MIT
Timothy D. Yee, Berkeley

BP MIT Energy Fellow
Ryan A. Shaw, Virginia Tech

ChemE Practice School
Christy Chao, Brown
Jonathan Ju-En Chou, UPenn
Te-Chun Chu, National Taiwan U

Charles & Hilda Roddey
Akshar Wunnava, MIT

Landau Practice School
Jonathan Ju-En Chou, UPenn

David H. Koch '62 Fellows
Mary C. Bartlett, Princeton
Alexander L. Brayton, U Houston
Wentao Dong, UW Madison
Michael Andrew Lee, Princeton
Mengjie Liu, GaTech
Michael Julian Orella, U Delaware
Yinying Ren, Northwestern
Qingying Zeng, Tsinghua

Wm. & Margaret Rousseau
Maria Zhong-lan Tou, MIT
Shankul Shisheer Vartak, IIT Bombay

John C. Sluder ('41) Fellow
Moo Sun Hong, Seoul National Univ

R. C. Reid ('54) & G. Williams
IYaqi Lyu, Hong Kong Univ-Science & Tech

Haas Family Fellows
Li-Chiun Cheng, Nat Taiwan U
Shuting Feng, U Delaware
Fan He, Zhejiang Univ
German Alberto Parada, Iowa State

H. '53 & L. Stern Practice School Fellow
Zhequan Xu, Columbia

Jerry '40 & Geraldine Mcafee
Ryan Alex Shaw, Virginia Tech
Miao Wang, UM Minneapolis

MITSCEP 1936 Course Xa
Krishna Shrinivas, IIT-Madras

ODGE Diversity Awards
Daniela Espinosa Hoyos, Polytechnic Univ of Puerto Rico
Mariana Rodriguez, MIT
Justin Mark Swaney, UW Madison

Saudi Aramco MIT Energy
Nian Liu, UCBerkeley

Walsh'37 Memorial Presidential
Mark Jacob Goldman, UT Austin
Tianxiang Liu, CalTech
Sarah Jane Shapiro, U Oklahoma

Robert T. Haslam '11 ChemE
Zongyu Gu, U Auckland
Shuaili Li, Caltech
Yiming Mo, Tsinghua
Jennifer C. Moffitt, Clemson
Nicholas Walter Schickel, U Iowa

Robert T. Haslam '11 Presidential
Connor W. Coley, CalTech
Stephanie Doong, Stanford

Keith & Helen Rumbel Fellows
Kassi Taylor Stein, Northeastern
John William Swalec, WPI
Kai-Jher Tan, U Waterloo

NSF
Michael Julian Orella, U Delaware
Jennifer Caroline Moffitt, Clemson
Connor Wilson Coley, CalTech
Mark Jacob Goldman, UT Austin

Dow Grad Fellowship For URM & Women in ChemE
Patricia Carolina Mayer, MIT

ILJU Foundation of Education & Culture
Moo Sun Hong, Seoul National Univ

Lemelson Minority Engineering
Daniela Espinosa Hoyos, Polytechnic Univ of Puerto Rico
Mariana Rodriguez, MIT
Justin Mark Swaney, UW Madison

Rosemary Wojtowicz
Emily Anne Patt, SUNY Buffalo

Wechsler Graduate Fellowship For Women
Christy Chao, Brown

Professor Emeritus Edward Merrill elected to the Institute of Medicine

On October 20, 2014, the Institute of Medicine elected 70 new members, including Edward W. Merrill ScD ’47, C.P. Dubbs Professor of Chemical Engineering, emeritus. This new honor comes on the heels of his election to the National Academy of Engineering in 2013. A founder of biomedical engineering, Merrill is also a member of the American Academy of Arts and Sciences and has received many awards, including AIChE’s Founders Award, the Society for Biomaterials’s Founders Award, and the American Institute of Medical and Biological Engineering’s Pierre Galetti Award, the highest honor in the bioengineering field.

Election to the IOM is considered one of the highest honors in the fields of health and medicine and recognizes individuals who have demonstrated outstanding professional achievement and commitment to service. It is unique in its structure as both an honorific membership organization and an advisory organization. Established in 1970 by the National Academy of Sciences, IOM has become recognized as a national resource for independent, scientifically informed analysis and recommendations on health issues. With their election, members make a commitment to volunteer their service on IOM committees, boards, and other activities. Projects during 2014 included studies on meeting the needs of those nearing the end of life, analyzing the treatment of post-traumatic stress disorder in military and veteran populations, and enhancing governance and accountability in graduate medical education. ◊

Merrill lectures at the 2010 symposium honoring his sixty years with MIT. Photo by Barry Hetherington. For more from the Merrill Symposium, go to web.mit.edu/cheme/news/merrill.html.

Greg Stephanopoulos named 2015 President-Elect of AIChE

Gregory Stephanopoulos, W. H. Dow Professor of Chemical Engineering at MIT, has been elected as AIChE’s president for 2016. He has been a member of AIChE for 40 years and served as a leader of the Food, Pharmaceutical and Bioengineering Division (FPBE); a member of the Board of Directors; and co-founder and chairman of the Society for Biological Engineering (SBE).

In his statement of goals, Stephanopoulos says, “During this period, I have witnessed the evolution of chemical engineering and AIChE from a process-oriented discipline and fuels and chemicals-based organization, to a field that recognizes molecular engineering and multi-scale optimization as critical elements of process development. Chemical engineering is unique in that it is founded on a tripod of sciences (physics, chemistry and biology), which makes it attractive for many diverse areas of application such as microelectronics, biotechnology, food and pharmaceuticals.”

We look forward to his work expanding the reach of AIChE and strengthening its role as a global home of chemical engineers. ◊

Lights! Camera! Action!

MIT Practice School at Corning, Inc., Fall 2014

Bob Hanlon, Station Director

How can we possibly get a film crew into the most secret of facilities at a Fortune 500 company? That's the question we immediately asked ourselves when we came up with the idea to film students going through the Practice School experience at Corning's R&D Center.

Corning Inc.'s headquarters building in Corning, NY.

Why did we even want to film the students, you ask? Well, we're looking to create a fun and inspiring Practice School Centennial Celebration for Fall '16. As part of this weekend celebration, we're planning to present a documentary of the program late afternoon on Saturday, on the top floor of the Media Lab. Recognizing the long lead time involved, we moved fast to hire the producer, Chris Boebel, New England Emmy Award winner from MIT Video Productions and currently with MIT's Office of Digital Learning. Chris stepped right in and started helping us structure the project, quickly focusing us on the need for a strong connective thread to tie the whole film together. This led us to the idea of using an embedded film crew to catch students in action, much like MTV's Real World series, but with less focus on the personal drama and more on the challenges involved with solving real problems in an industrial setting. Our strong four-years-and-counting relationship with Corning along with their relatively close proximity to Boston suggested them as an ideal location.

There was just one issue. How many companies do you know who would allow a film crew into the heart of their intellectual property factory (10% of revenue goes into R&D)?

We thought this to be a deal breaker. Thankfully, we were wrong, as Corning quickly and warmly welcomed the idea. Two leaders within Corning were critical to supporting and overseeing the outstanding success of this effort: Pam Strollo, Chief of Staff for Research and Director of Technical Planning, Communications and Events, and Tom Capek, Vice President of Manufacturing, Technology and Engineering and Chief Engineer. Months in advance of our arrival, they and their colleagues worked with us to construct the ground rules that enabled us to film what we needed while not jeopardizing their intellectual property.

Over the course of the students' first-month projects at Sullivan Park, we got hours of footage. (Not to worry. Chris vowed to keep the entire documentary to a tight 30 minutes.) What kind of footage? Great footage! Tom Capek's welcoming pep talk to the students ("To progress in one's career, find the things you're uncomfortable with, and do them"); the welcome dinner; the students' presentations; the students working together at Corning and back in their hotel under (much) stress; the students being challenged and succeeding; the students working with their consultants; the students working with me. As icing on the cake, we multi-tasked by conducting an interview with Jeff Tester up at neighboring Cornell and later, once Corning was behind us, with Sam Fleming back up on campus. As many of you know, both Jeff and Sam were former Directors of the Program.

Chris will use his professional eye to combine this Corning footage with future interview footage of many alumni to craft a good story about the Practice School program: our history, what we stand for, what we teach, and what the students learn through their challenges. We will be reaching out to some of you for the alumni interviews. Stay tuned!

Regarding the actual work we did for Corning, both in Corning NY, and in their Wilmington NC optical fiber plant, all I can say is that we were once again presented with a great and wide array of extremely challenging projects. Two of the criteria we use to help identify suitable projects are: #1 – must be of value to the host company, and #2 – must be somewhat open-ended. While direct 'Do this' projects may be appropriate for undergraduates, indirect 'See what you can do with this' projects are much more appropriate for Practice School. Such projects afford the students an excellent opportunity to wade into uncertain terrain and then figure out how to make a contribution in limited time. Many host companies select projects here, not because it just gives the students something to do, but rather because it's typically an area of real market opportunity for them that is in need of definition or a new set of eyes or a shot of adrenaline. Companies realize that this short, intelligent and intense get-in-and-get-out look by the students is a great way to create value out of hosting the program. As one Corning program director shared while helping to determine projects for this session: "These kids add value. Let's find

Practice School students take in Niagara Falls during their tenure at Corning during Fall 2014.

"How many companies do you know who would allow a film crew into the heart of their intellectual property factory?"

something meaty for them to work on!" That they did.

I recently read comments I wrote to myself in my private notebook back in the fall when I first looked at our set of projects: "open ended," "vague," "nebulous." Welcome to the real Real World! These problem statements pointed the students in a general direction, and the students then had to figure out what to do. Such projects can be very confronting, as they are about as far removed from textbooks as you can get. But this is where the Practice School shines, offering as it does the opportunity for students to learn how to step into a project involving a technology they've never seen before and to then use a tried-and-true, 100-year-old problem-solving methodology to make an impact within four weeks. This indeed is what the students did, on all six projects. It was a pleasure for me to see what they delivered to Corning. The capstone on this session was a comment I got from one of the consultants who was initially hesitant to take on a student group because he didn't believe they could make a difference. He wrote, "These guys have been fantastic to work with. Wow!" That says it all.

The above experience—the essence of Practice School—is what we captured on film. I'm personally excited to see how Chris puts it all together to tell the story of this Corning group and also to tell the larger story of the program itself as revealed through the alumni interviews. I encourage all alums to attend the Centennial to re-connect with the program and with your former classmates and to also enjoy this documentary. I'm sure it will trigger many memories.

p.s. Save the date! Practice School Centennial, Sept 30-Oct 2, 2016. We're holding the main event all day Saturday, Oct. 1, on the top floor of the Media Lab, right across from Building 66.

p.p.s. If you want to see an early snippet of the documentary put together by Chris and don't mind trying to type a bunch of random symbols into your computer, go here:
http://youtu.be/x_2plTtPpo8 ◊

Practice School letter continued from Page 6

their models. With help from BP, the MIT modelers and the NREL experimentalists were connected, and the Practice School project materialized at exactly the right moment. In this project, the Practice School team made excellent use of consultants at NREL, MIT and BP as they developed their design of experiments and analyzed their data. The MIT and BP consultants attended the weekly Practice School presentations either in-person or remotely and provided valuable suggestions throughout the project.

In another project, two students were asked to look into the production of lipids from oleaginous yeast. One challenge with the generation of lipids in yeast is that the yeast cells must be lysed to extract the lipids. In this project the effect of different enzyme cocktails, enzyme loadings and reaction incubation times on the extent of cell lysis was examined. Also, to identify promising genetic engineering targets, an assay was developed to determine the lysis susceptibility of over 5,000 single gene knockouts of Saccharomyces cerevisiae. The results of the assay were used to correlate lysis susceptibility with gene function and identify genes whose removal may enhance lysis susceptibility for oleaginous species of yeast.

In our spare time, we enjoyed experimenting with the physiological impact of low oxygen partial pressures. After adapting to the 5600-foot elevation of Golden Colorado for a week, the group was eager to take on Grays Peak, the highest point on the Continental Divide in North America. We arrived at our trailhead at dawn for an invigorating hike. As we approached the top of the mountain, our pace slowed considerably due to hypoxia and trail conditions. The view from the top was fantastic and well worth the effort. Our second hike was to Royal Arch overlooking Boulder Colorado.

I look forward to sharing with you the highlights of the work our students are doing right now at our Spring '15 stations.

Best regards,

T. Alan Hatton
Director
David H. Koch School for
Chemical Engineering Practice

Faculty News

For more information, go to *web.mit.edu/cheme/news/*

Robert Langer wins QEPrize

Britain's 2015 Queen Elizabeth Prize for Engineering has been awarded to Professor Robert Langer ScD '74 for his revolutionary advances and leadership in engineering at the interface with chemistry and medicine. The QEPrize is a global £1 million prize that celebrates the engineers responsible for a ground-breaking innovation that has been of global benefit to humanity.

The announcement was made by Lord Browne of Madingley, Chairman of the Queen Elizabeth Prize for Engineering Foundation, in the presence of His Royal Highness The Duke of York at the Royal Academy of Engineering in London on February 3, 2015. Her Majesty The Queen will present the prize to Langer at Buckingham Palace later this year.

A chemical engineer by training, Langer was the first person to engineer polymers to control the delivery of large molecular weight drugs for the treatment of diseases such as cancer and mental illness. His unconventional thinking toppled the established view that controlled-release drug delivery would not work for large molecules like proteins, which are very sensitive to their surroundings. From the start, Langer's work has been characterized by a truly interdisciplinary approach. He developed his first drug delivery system during the 1970s while working with Dr. Judah Folkman, a Harvard professor and surgeon at Boston Children's Hospital. Folkman hypothesized that the growth of cancerous tumors could be restricted by stopping angiogenesis, the formation of new blood vessels, and he asked Langer to find a way to inhibit it. Once he had discovered how to create polymer micro- and nano-particles that could support and release sensitive protein-based drugs in the body, he used this technique to test possible drugs to control angiogenesis. He and Folkman isolated the first substances that blocked angiogenesis; such substances have been used to treat over 20 million patients.

Professor Lord Broers FREng FRS HonFMedSci, Chair of Judges for the QEPrize, said: "Robert Langer has made an immense contribution to healthcare and to numerous other fields by applying engineering systems thinking to biochemical problems. Not only has he revolutionized drug delivery, but his open-minded approach to innovation and his ability to think 'outside the box' have led to great advances in the field of tissue engineering. He is a truly inspiring leader who has attracted brilliant people to these relatively new and exciting areas of research and is extremely involved in the commercial development of his group's research."

One of Langer's most recent projects is a microchip-based implant capable of storing and releasing precise doses of a drug on-demand or at scheduled intervals for up to 16 years. Microchips, the company he co-founded to commercialize the development, announced in December 2014 that it has completed clinical demonstration. Unlike traditional drug delivery platforms, Microchips Biotech's implant can respond to wireless signals, which can activate, deactivate, or modify the frequency or dose of the drug, without being removed from the patient. The company is looking initially at three areas for such an implant: diabetes, female contraception, and osteoporosis, which all require regular, long-term dosage. The contraceptive approach is funded by the Gates Foundation, as are new ways of providing single-step immunizations for polio and other vaccines, providing long-acting malaria drugs, and providing essential minerals. ◊

Course X Alumni meet in Atlanta

On Monday, November 17th, 2014, MIT alumni, faculty and students gathered at the AIChE annual meeting in Atlanta.

Course X alumni and friends from around the world gathered to mingle and network, as well as honor the MIT faculty and students who were recipients of AIChE awards:

Paula T. Hammond '84, PhD '93
Alpha Chi Sigma Award for Chemical Engineering Research

Gregory N. Stephanopoulos
William H. Walker Award for Excellence in Contributions to Chemical Engineering Literature

Richard D. Braatz
CAST Computing in Chemical Engineering Award

Bernhardt L. Trout '90
Excellence in Process Development Research Award

(photos by Melanie Kaufman)

Faculty News

For more information, go to *web.mit.edu/cheme/news/*

Catalyzing Greener Products

Yuriy Román earns NSF CAREER Award for Molecular Catalysis for Waste Valorization

Article by Eric Smalley, courtesy of the MIT SPECTRVM.

As a boy growing up in Mexico City, Yuriy Román was curious about how things worked. He'd go to his backyard and mix chemicals in the detergents his mother used to wash clothes to try to understand why some combinations worked and others didn't. His academic trajectory, driven in part by an interest in sustainability, led him to graduate studies at Prof. James Dumesic's laboratory at the University of Wisconsin-Madison. Dumesic is one of the world's leading researchers in the field of biofuels and biomass chemistry.

Today, the core of Román's research is the catalytic conversion of the inedible parts of plant matter, such as cellulose and lignin, into chemicals useful for making fuels and substances like plastics, adhesives, lubricants, detergents, fertilizer, and pharmaceuticals. Catalysts are materials that induce or accelerate chemical reactions, and they're often the key to making chemical processes industrially viable. For decades, research and development in catalysts has focused on making them faster and cheaper. The more active the catalytic material, the faster the chemical reactions. And the cheaper the catalytic material, the lower the cost of the end product of those reactions.

Instead of just speed and cost, the field of catalysis needs to add versatility and efficiency, says Román. The drive to use plants rather than fossil fuels as feedstock means the catalytic materials used to process petrochemicals need to be adapted — or entirely new ones developed — to work with biomass. And the processes need to be as efficient as possible to minimize waste, Román says. "When we typically use the catalysts that we had developed for petrochemicals we can perform some of these transformations, but they are never as effective, they are never as efficient, and the materials are never as stable."

One of the Román group's recent advances remade a process that had traditionally taken multiple steps and used precious metals and high-pressure hydrogen gas to turn plant matter into g-valerolactone, a chemical used to make fuels and polymers. The new process happens in a single step and forgoes the use of precious metals and hydrogen gas. The key was fitting infinitesimal amounts of an acid into the microscopic pores of a highly porous material. The action of the acid removed the need for hydrogen gas.

The challenge to finding effective catalysts for biomass processing is that these processes always involve water, and water, in this case, ruins the acid. Using their materials engineering skills, Román's team tuned the pores of the material to be water repellent. "You can start doing some of this chemistry — this Lewis acid-based chemistry — in the presence of water," says Román. "We use that to process different types of biomass-derived feeds to make new types of chemicals."

Román knew that if he wanted to change the future of catalysis he'd have to cross some boundaries, particularly the boundary between chemical engineering and materials science. Before coming to MIT, Román joined Caltech Prof. Mark Davis's laboratory, where he did cutting-edge research on producing and analyzing microporous and mesoporous materials, which are types of materials commonly used as catalysts.

Developing catalysts used to mean doing kinetics and reactivity studies — the stuff of traditional chemical engineering. Now, cutting-edge catalysis research requires tools and skills from a range of disciplines, including spectroscopy, materials design, and computational modeling. "Boundaries between the different fields are really fading, and I think this is something that's really important to embrace," says Román. "This is something that I feel is very specific to MIT, in that the barriers to interact with people from different departments are low," he says. "As we start working at the interfaces of fields, we should begin to see new game-changing discoveries." ◊

Photo: Len Rubenstein

Named Lecture Series

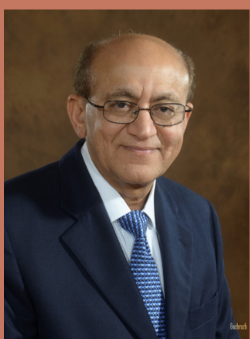
For more information, go to *web.mit.edu/cheme/news/*

This past fall, the Department hosted two leaders in industry and academia. Webcasts of these and other past lectures can be found at ***web.mit.edu/cheme/news/webcast.html.*** We hope you can join us for the upcoming lectures below.

April 10, 2015
3pm in 32-123

22nd Alan S. Michaels Lectureship in Medical and Biological Engineering

Reengineering the Tumor Microenvironment to Enhance Cancer Treatment: Bench to Bedside



Rakesh K. Jain, Ph.D.
Andrew Werk Cook Professor of Tumor Biology
Director, Edwin L. Steele Laboratories for Tumor Biology
Department of Radiation Oncology
Harvard Medical School & Massachusetts General Hospital

Dr. Jain is regarded as a pioneer in the area of tumor microenvironment and widely recognized for his seminal discoveries in tumor biology, drug delivery, in vivo imaging, bioengineering, and bench-to-bedside translation. These include uncovering the barriers to the delivery and efficacy of molecular and nano-medicines in tumors; developing new strategies to overcome these barriers; and then translating these strategies from bench to bedside. He proposed a new principle – normalization of vasculature – for treatment of malignant and non-malignant diseases characterized by abnormal vessels that afflict more than 500 million people worldwide. This concept has fundamentally changed the thinking of scientists and clinicians about how antiangiogenic agents work, and how to combine them optimally with other therapies to improve the treatment outcome in patients.

May 8, 2015
3pm in 32-123

37th Warren K. Lewis Lecture in Chemical Engineering

Challenges and opportunities in the production of renewable chemicals and fuels in Brazil and the US

Bernardo Gradin
Chief Executive Officer, GranBio

Bernardo Gradin was born in Bahia, Brazil in 1964. He is a civil engineer by trade, with an undergraduate degree from Politechnic School of Federal University of Bahia (1988), MA in International Studies from University of Pennsylvania and an MBA from The Wharton School of Business (1993).

He worked at the Odebrecht Group from 1988 to 1999 in Brazil and the U.S. In 2000 he moved to Braskem, where he was CEO from 2008 to 2010.

In 2011 Gradin founded and became CEO of GranBio, an industrial biotechnology company and became president of Inspirare Institute, a non-profit organization oriented to foster basic education in Brazil.

Gradin is a board member of ABIQUIM (Brazilian Chemical Association), board member of CNPEM (Brazilian National Labs), leader of the CNI Bioeconomy Commission and chairman of the Chemistry & Advanced Material Community at the World Economic Forum.

Faculty News

For more information, go to *web.mit.edu/cheme/news/*

Karen Gleason '82 elected to National Academy of Engineering

Karen K. Gleason, Associate Provost and Alexander and I. Michael Kasser Professor of Chemical Engineering, is one of the newest members of the National Academy of Engineering. She has been cited for " invention, application development, scale-up, and commercialization of chemically vapor deposited polymers."

Election to the NAE is among the highest professional distinctions accorded to American engineers. Academy membership honors those who have made outstanding contributions to "engineering research, practice, or education, including, where appropriate, significant contributions to the engineering literature," and to the "pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering, or developing/implementing innovative approaches to engineering education."

Greg Rutledge receives Fiber Society Founder's Award

This summer, Greg Rutledge was honored with the Founders Award from the The Fiber Society, which is dedicated to the advancement of knowledge pertaining to fibers, fiber-based products, and fibrous materials. The Society comprises individuals who are chemists, physicists, engineers and designers with interests in the field of fiber science engineering and technology.

The society's annual Founders Award acknowledges a member whose outstanding contributions to the science and technology of fibers, fibrous materials, and fiber-based products reflect the vision of its founders.

Yuriy Román earns NSF CAREER Award for Molecular Catalysis for Waste Valorization

NSF has recognized Román for his work in alternative energy sources. This recent project "is aimed at advancing the use of abundant domestic energy sources for liquid transportation fuels and chemicals to reduce greenhouse gas emissions by improving the utilization of renewable carbon. The PI proposes to valorize biomass-derived waste streams, a long-standing challenge in the chemical/biological conversion of lignocellulosic biomass.

The approach uses a coupled synthetic and reaction engineering approach to develop catalytic materials capable of selectively upgrading waste biomass fractions and links advanced synthesis and characterization techniques with rigorous reactivity measurements. Catalyst design efforts are focused on reducible and tunable metal oxides that feature the appropriate properties required to upgrade complex macromolecules at scale."

Bob Langer earns Cornell honor

Cornell has named Robert Langer ScD '74, the David H. Koch Institute Professor, the Cornell Entrepreneur of the Year 2015. He will be honored in November 2015 during Cornell's annual Entrepreneurship Summit in New York City.

The Cornell Entrepreneur of the Year award is given annually by Entrepreneurship at Cornell to "a Cornellian who exemplifies entrepreneurial achievement, community service and high ethical standards."

Langer holds nearly 1,100 patents issued or pending worldwide, which have been licensed or sublicensed to more than 300 pharmaceutical, chemical, biotechnology and medical device companies. He is the most-cited engineer in history. Langer has also founded more than 25 companies, many of which have grown into successful ventures.

Kwanghun Chung research team receives NIH BRAIN grant

Chung, Picower Institute principal investigator and assistant professor in the Department of Chemical Engineering and the Institute for Medical Engineering and Science (IMES), is co-PI of a team studying cortical circuits and information flow during memory-guided perceptual decisions.

NIH's Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative is part of a new Presidential focus aimed at revolutionizing our understanding of the human brain. By accelerating the development and application of innovative technologies, researchers will be able to produce a revolutionary new dynamic picture of the brain that, for the first time, shows how individual cells and complex neural circuits interact in both time and space. Long desired by researchers seeking new ways to treat, cure, and even prevent brain disorders, this picture will fill major gaps in our current knowledge.

Pat Doyle named new Haslam Professor

Pat Doyle has been named the new Robert T. Haslam (1911) Professor of Chemical Engineering.

A major theme of Doyle's research is the translation of molecular understanding of transport phenomena into new microfluidics-based processes. His lab studies a number of problems in soft matter with an emphasis on single molecule DNA dynamics, polymer physics, microrheology, and microfluidic processes. He has developed new methods for the synthesis of complex microgel particles by combining microfluidics and lithography in a process called Flow Lithography. One application is barcoded microgel particles for multiplexed biosensing. In 2010 he cofounded the company Firefly Bioworks which is commercializing these barcoded particle technologies.

For the most updated ChemE faculty news, go to web.mit.edu/cheme/. ◊

Two MIT ChemE startups earn awards

In October 2014, 12 MIT-affiliated startups that participated in MassChallenge, the world's largest startup accelerator, took home top prizes — ranging from $10,000 to $100,000 — from the program's annual awards ceremony. Two of these companies came from MIT ChemE beginnings.

A top $100,000 diamond prize went to SQZ Biotech. Based on research from MIT labs, the startup has invented a microfluidics system that can "squeeze" molecules into cells for easy and efficient molecule-delivery. (SQZ Biotech was also awarded a CASIS/Boeing Prize for Technology in Space, and will split $775,000 with two other winners.) MIT ChemE affiliates are Armon Sharei PhD '13; Jonathan Gilbert SM '11, PhD '14, Institute Professor Robert Langer, and Klavs Jensen, the Warren K. Lewis Professor of Chemical Engineering and head of the Department of Chemical Engineering.

Dropwise, which aims to save millions of dollars in fuel and thousands of tons of carbon dioxide annually through a durable hydrophobic coating for power-plant condensers, earned a $50,000 gold prize. The Dropwise team included David Borrelli SM '11, PhD '14 and Professor Karen Gleason. ◊

Cover Story

For more information, go to *web.mit.edu/cheme/news/*

Advanced thin-film technique could deliver long-lasting medication

Nanoscale, biodegradable drug-delivery method could provide a year or more of steady doses.

Article by Peter Dizikes, courtesy of the MIT News Office.

About one in four older adults suffers from chronic pain. Many of those people take medication, usually as pills. But this is not an ideal way of treating pain: Patients must take medicine frequently, and can suffer side effects, since the contents of pills spread through the bloodstream to the whole body.

Now researchers at MIT have refined a technique that could enable pain medication and other drugs to be released directly to specific parts of the body — and in steady doses over a period of up to 14 months. The method uses biodegradable, nanoscale "thin films" laden with drug molecules that are absorbed into the body in an incremental process.

"It's been hard to develop something that releases [medication] for more than a couple of months," says Paula Hammond, the David H. Koch Professor in Engineering at MIT, and a co-author of a new paper on the advance. "Now we're looking at a way of creating an extremely thin film or coating that's very dense with a drug, and yet releases at a constant rate for very long time periods."

In the paper, published today in the *Proceedings of the National Academy of Sciences*, the researchers describe the method used in the new drug-delivery system, which significantly exceeds the release duration achieved by most commercial controlled-release biodegradable films.

"You can potentially implant it and release the drug for more than a year without having to go in and do anything about it," says Bryan Hsu PhD '14, who helped develop the project as a doctoral student in Hammond's lab. "You don't have to go recover it. Normally to get long-term drug release, you need a reservoir or device, something that can hold back the drug. And it's typically nondegradable. It will release slowly, but it will either sit there and you have this foreign object retained in the body, or you have to go recover it."

Layer by layer

The paper was co-authored by Hsu, Myoung-Hwan Park of Shamyook University in South Korea, Samantha Hagerman '14, and Hammond, whose lab is in the Koch Institute for Integrative Cancer Research at MIT.

The research project tackles a difficult problem in localized drug delivery:

MIT professor Paula Hammond and Bryan Hsu PhD' 14 (photo at left) have developed a nanoscale film that can be used to deliver medication, either directly through injections, or by coating implantable medical devices.

Photos: Dominick Reuter

Any biodegradable mechanism intended to release a drug over a long time period must be sturdy enough to limit hydrolysis, a process by which the body's water breaks down the bonds in a drug molecule. If too much hydrolysis occurs too quickly, the drug will not remain intact for long periods in the body. Yet the drug-release mechanism needs to be designed such that a drug molecule does, in fact, decompose in steady increments.

To address this, the researchers developed what they call a "layer-by-layer" technique, in which drug molecules are effectively attached to layers of thin-film coating. In this specific case, the researchers used diclofenac, a nonsteroidal anti-inflammatory drug that is often prescribed for osteoarthritis and other pain or inflammatory conditions.

Course X Seniors named SHASS Burchard Scholars

The School of Humanities, Arts, and Social Sciences (SHASS) named 35 exceptional MIT undergraduates as Burchard Scholars for 2015; five of these coming from Course X - the largest group from any one department. The award honors sophomores and juniors who demonstrate academic excellence in the humanities, arts, and social sciences, as well as in science and engineering.

Named in honor of the first dean of MIT SHASS, John Ely Burchard, the Burchard Scholars Program brings undergraduates together with distinguished members of the SHASS faculty for a series of eight dinner seminars that reflect the range of MIT's research in the humanities, arts, and social sciences. Past gatherings have featured talks on: how American social policies really work; the politics of aid to Haitian trauma survivors; what philosophy tells us about how to make big decisions; U.S. grand strategy in foreign policy; and the art of discovery.

The 2015 Burchard Scholars from Course X are:

Casey Crownhart '17, chemical engineering with a minor in literature
Skylar Goldman '16, chemical engineering with a minor in comparative media studies
Shahrin Islam '16, chemical engineering
Moriel Levy '17, chemical engineering
Githui Maina '16, chemical engineering with a minor in history

They then bound it to thin layers of poly-L-glutamatic acid, which consists of an amino acid the body reabsorbs, and two other organic compounds. The film can be applied onto degradable nanoparticles for injection into local sites or used to coat permanent devices, such as orthopedic implants.

In tests, the research team found that the diclofenac was steadily released over 14 months. Because the effectiveness of pain medication is subjective, they evaluated the efficacy of the method by seeing how well the diclofenac blocked the activity of cyclooxygenase (COX), an enzyme central to inflammation in the body.

"We found that it remains active after being released," Hsu says, meaning that the new method does not damage the efficacy of the drug. Or, as the paper notes, the layer-by-layer method produced "substantial COX inhibition at a similar level" to pills.

The method also allows the researchers to adjust the quantity of the drug being delivered, essentially by adding more layers of the ultrathin coating.

A viable strategy for many drugs

Hammond and Hsu note that the technique could be used for other kinds of medication; an illness such as tuberculosis, for instance, requires at least six months of drug therapy.

"It's not only viable for diclofenac," Hsu says. "This strategy can be applied to a number of drugs."

Indeed, other researchers who have looked at the paper say the potential medical versatility of the thin-film technique is of considerable interest.

"I find it really intriguing because it's broadly applicable to a lot of systems," says Kathryn Uhrich, a professor in the Department of Chemistry and Chemical Biology at Rutgers University, adding that the research is "really a nice piece of work."

To be sure, in each case, researchers will have to figure out how best to bind the drug molecule in question to a biodegradable thin-film coating. The next steps for the researchers include studies to optimize these properties in different bodily environments and more tests, perhaps with medications for both chronic pain and inflammation.

A major motivation for the work, Hammond notes, is "the whole idea that we might be able to design something using these kinds of approaches that could create an [easier] lifestyle" for people with chronic pain and inflammation.

Hsu and Hammond were involved in all aspects of the project and wrote the paper, while Hagerman and Park helped perform the research, and Park helped analyze the data.

The research described in the paper was supported by funding from the U.S. Army and the U.S. Air Force. ◊

Research Highlights

For more information, go to web.mit.edu/cheme/news/

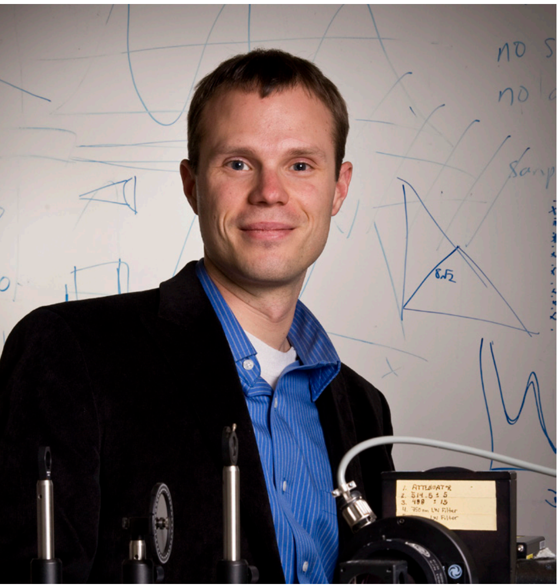
Following biological clues to better materials

Brad Olsen '03 creates bioinspired and biofunctional materials for widely diverse applications.

Article by Eric Bender, courtesy of MIT Industrial Liaison Program.

In one project, Brad Olsen's lab seeks to engineer soaps that can be sprayed onto a toxic chemical release and not only wash off the chemical, but detoxify it. In another, he is joining with numerous collaborators to lay the foundations for "sustainable biorefineries" that can turn solid waste or algae into a renewable feedstock for a wealth of new materials. A third effort aims to develop new kinds of injectable hydrogels that can stabilize a deep wound, or carry treatments into diseased tissues.

These are just a few of the Olsen lab's investigations, driven by new materials that are derived from, or inspired by, biology. "We focus on engineering new materials out of proteins, protein-polymer hybrids, and different types of polymers, with a particular focus on materials that can be processed in water," says Olsen, an assistant professor of chemical engineering at MIT. "We apply these materials to a variety of applications, from biomaterials to new sustainable polymers to technologies that address concerns in national defense and in energy."



The new materials "can act as interesting models for testing fundamental scientific questions," Olsen adds. "For example, we can build polymers with new shapes, or new sequences of monomers that endow them with specific properties. We try to understand how construction of these molecules leads to changes in the mechanics of the material, or the way in which material self-assembles, or aspects of how the material might undergo certain dynamic processes. And then by understanding these fundamental scientific questions, we can move the capabilities of the materials forward to address many different applications."

Defending against toxic threats

In several programs for MIT's Institute for Soldier Nanotechnologies, Olsen and colleagues are addressing chemical and biological threats with innovative biological materials, which potentially offer "a selectivity for compounds within diverse environments that is hard to get with other types of technologies," he says.

One initiative, in which his lab collaborates with the Army's Natick Soldier Research, Development and Engineering Center (NSRDEC), is developing soaps that can decontaminate large areas in an environmentally friendly manner.

"Many toxic chemicals are hydrophobic, so they don't easily dissolve in water," Olsen explains. "One needs to use some kind of soap to get the chemical off the surface and into water. One would also like to be able to degrade this chemical, rather than having to recover the water, which can be very difficult if you're trying to wash large areas or complex structures, and treat it as a toxic waste."

Olsen's lab and NSRDEC are pursuing a solution in which soap forms a "nanoreactor" whose outside is coated with enzymes that can actively degrade the toxic chemical. "In an ideal situation, the chemical becomes a harmless solution that won't have to be recovered for wastewater treatment," he says. "The great thing is that if you use both soaps and enzymes that are environmentally friendly, potentially you won't have a toxic soap formulation either."

With working prototypes in the lab, the researchers are now tuning the nanoreactor chemistry to be faster and more stable, and testing how well the approach functions against a broader set of toxins.

Two other security projects look at producing new protective barrier membranes that respond only to dangerous threats in the environment.

One effort "is to make smart membranes that will protect you when you are in the presence of a toxic chemical, but be breathable and easy to wear in the absence of a toxic chemical," he says. This effort is a partnership with researchers at MIT, NSRDEC, and UC Santa Barbara.

A second study, with Katharina Rib-

"We hope that these new materials will lead to a more secure, healthier, and more sustainable world."
- Brad Olsen, Paul M. Cook Career Development Professor

beck, the Eugene Bell Career Development Assistant Professor of Tissue Engineering in the MIT Department of Biological Engineering, aims to understand the biology of certain biological barriers, and to find ways to copy them to keep people free of pathogens.

Building a sustainable biorefinery

Another major theme in Olsen's research is tapping biological feedstocks to supplement petroleum feedstocks for the next generation of chemical processes. "As these new processes and products start to be identified, the chemical industry will see important near-term impact," he predicts.

Olsen has joined in a major collaboration with Professor George Stephanopoulos, Associate Professor Kristala Prather, and Assistant Professor Yuriy Román of MIT's chemical engineering department, along with researchers at the Masdar Institute in Abu Dhabi. The project will examine the use of biomass from Abu Dhabi municipal and agricultural waste and algae to explore chemical and biochemical pathways and processes that can help in producing biofuels and other advanced biomaterials.

"We're hearing from many companies about the strong interest in exploring this wider variety of feedstocks in chemical processing," Olsen says. "What really excites my group is looking at how these biological feedstocks can help us develop the next generation of materials, with more favorable lifecycle analysis, or less use of toxic monomers, or better combinations of properties than those of existing materials."

Healing wounds with hydrogels

On the medical front, one leading project is to engineer different kinds of hydrogels with mechanical properties that haven't previously been achievable in a biomaterial system, Olsen says.

"Hydrogels are traditionally quite brittle and quite fragile," he points out. "If you want a hydrogel to be more like human tissue, there's a long way to go between Jell-O and human tissue. So we work on targeting some of those technology gaps."

In an Institute for Solider Nanotechnologies collaboration with Ali Khademhosseini of the Harvard-MIT Division of Health Sciences and Technology and Professor Gareth McKinley from MIT's Department of Mechanical Engineering, Olsen's team focuses on injectable hydrogels that are designed to stop bleeding in battlefield wounds. Their goal is to create a nanostructured protein hydrogel for an implant that can not only stop the flow of blood but aid in subsequent healing, and then be absorbed by the body.

Existing "shear-thinning" hydrogels have the ability to switch from solidlike to liquidlike states when under mechanical stress, Olsen notes. When injected in the body, they can switch from liquidlike form in the syringe into solidlike form for the implant. However, the hydrogels then must durably maintain that form despite any mechanical stresses they encounter.

Olsen and his colleagues are developing a hydrogel that reinforces a network of proteins with polymers that are soluble in water at lower temperatures but are insoluble when heated to body temperature, so that they form a grid that makes the hydrogel much stiffer and slower to degrade. Additionally, the proteins in the hydrogel are chosen partly for their role in promoting wound healing.

Seeking sustainability

Other work in the Olsen lab, funded by the Department of Energy, the Air Force Office of Scientific Research, and the National Science Foundation, focuses on advances in sustainability, with an emphasis on biocatalysis.

"We're looking at ways to control the structure and self-assembly of proteins that allow you to put them together to make a biocatalyst that looks a lot like a traditional heterogeneous catalyst used in the chemical-processing industry," Olsen says. "But instead of using transition metals, we want to use proteins, and enable the very effective enzymatic properties of proteins to be leveraged in chemical conversions."

"Biocatalysis is already a very active area in the pharmaceutical industry," he notes. "People also have been investigating this for applications such as biofuel synthesis and biofuel cells. Additionally, there are many potential applications in biosensing — in medicine, industrial practice, and detection of harmful compounds in the environment that are relevant to national security."

"Our group has many different efforts at the interface of natural and synthetic materials, trying to understand the fundamental science of bioinspired and biohybrid polymer systems and to bring these capabilities to bear on a wide variety of industrially and societally important challenges," Olsen says. "We hope that these new materials will lead to a more secure, healthier, and more sustainable world." ◊

Research News

For more information, go to *web.mit.edu/cheme/news/*

New analysis reveals tumor weaknesses

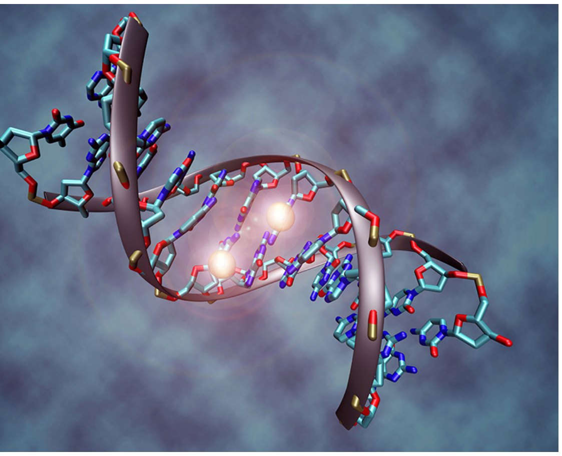
Identifying epigenetic markers in cancer cells could improve patient treatment.

Article by Anne Trafton, courtesy of MIT News.

Scientists have known for decades that cancer can be caused by genetic mutations, but more recently they have discovered that chemical modifications of a gene can also contribute to cancer. These alterations, known as epigenetic modifications, control whether a gene is turned on or off. Analyzing these modifications can provide important clues to the type of tumor a patient has, and how it will respond to different drugs. For example, patients with glioblastoma, a type of brain tumor, respond well to a certain class of drugs known as alkylating agents if the DNA-repair gene MGMT is silenced by epigenetic modification.

A team of MIT chemical engineers has now developed a fast, reliable method to detect this type of modification, known as methylation, which could offer a new way to choose the best treatment for individual patients.

"It's pretty difficult to analyze these modifications, which is a need that we're working on addressing. We're trying to make this analysis easier and cheaper, particularly in patient samples," says Hadley Sikes, an assistant professor of chemical engineering and the senior author of a paper describing the technique in the journal Analyst. The paper's lead author is Brandon Heimer, an MIT graduate student in chemical engineering.



This image shows a DNA molecule that is methylated on both strands on the center cytosine.

Image: Christoph Bock

Beyond the genome

After sequencing the human genome, scientists turned to the epigenome — the chemical modifications, including methylation, that alter a gene's function without changing its DNA sequence.

In some cancers, the MGMT gene is turned off when methyl groups attach to specific locations in the DNA sequence — namely, cytosine bases that are adjacent to guanine bases. When this happens, proteins bind the methylated bases and effectively silence the gene by blocking it from being copied into RNA.

"This very small chemical modification triggers a sequence of events where that gene is no longer expressed," Sikes says.

Current methods for detecting cytosine methylation work well for large-scale research studies, but are hard to adapt to patient samples, Sikes says. Most techniques require a chemical step called bisulfite conversion: The DNA sample is exposed to bisulfite, which converts unmethylated cytosine to a different base. Sequencing the DNA reveals whether any methylated cytosine was present.

However, this method doesn't work well with patient samples because you need to know precisely how much methylated DNA is in a sample to calculate how long to expose it to bisulfite, Sikes says.

"When you have limited amounts of samples that are less well defined, it's a lot harder to run the reaction for the right amount of time. You want to get all of the unmethylated cytosine groups converted, but you can't run it too long, because then your DNA gets degraded," she says.

Rapid detection

Sikes' new approach avoids bisulfite conversion completely. Instead, it relies on a protein called a methyl binding domain (MBD) protein, which is part of cells' natural machinery for controlling DNA transcription. This protein recognizes methylated DNA and binds to it, helping a cell to determine if the DNA should be transcribed.

The other key component of Sikes' system is a biochip — a glass slide coated with hundreds of DNA probes that are complementary to sequences from the gene being studied. When a DNA sample is exposed to this chip, any strands that match the target sequences are trapped on the biochip. The researchers then treat the slide with the MBD protein probe. If the probe binds to a trapped DNA molecule, it means that sequence is methylated.

The binding between the DNA and the MBD protein can be detected either by linking the protein to a fluorescent dye or designing it to carry a photosensitive molecule that forms hydrogels when exposed to light.

The MIT team is now adapting the device to detect methylation of other cancer-linked genes by changing the DNA sequences of the biochip probes. They also hope to create better versions of the MBD protein and to engineer the device to require less DNA. With the current version, doctors would need to do a surgical biopsy to get enough tissue, but the researchers would like to modify it so the test could be done with just a needle biopsy.

The research was funded by a David H. Koch fellowship, a National Science Foundation fellowship, a Burroughs Wellcome Fund Career Award, the National Institute for Environmental Health Sciences, and the James H. Ferry Fund for Innovation.◊

New drug-delivery capsule may replace injections

Pill coated with tiny needles can deliver drugs directly into the lining of the digestive tract.

Article by Anne Trafton, courtesy of MIT News.

Given a choice, most patients would prefer to take a drug orally instead of getting an injection. Unfortunately, many drugs, especially those made from large proteins, cannot be given as a pill because they get broken down in the stomach before they can be absorbed.

To help overcome that obstacle, researchers at MIT and Massachusetts General Hospital (MGH) have devised a novel drug capsule coated with tiny needles that can inject drugs directly into the lining of the stomach after the capsule is swallowed. In animal studies, the team found that the capsule delivered insulin more efficiently than injection under the skin, and there were no harmful side effects as the capsule passed through the digestive system.

"This could be a way that the patient can circumvent the need to have an infusion or subcutaneous administration of a drug," says Giovanni Traverso, research fellow at MIT's Koch Institute, a gastroenterologist at MGH, and one of the lead authors of the paper, which appears in the *Journal of Pharmaceutical Sciences*.

Although the researchers tested their capsule with insulin, they anticipate that it would be most useful for delivering biopharmaceuticals such as antibodies, which are used to treat cancer and autoimmune disorders like arthritis and Crohn's disease. This class of drugs, known as "biologics," also includes vaccines, recombinant DNA, and RNA.

"The large size of these biologic drugs makes them nonabsorbable. And before they even would be absorbed, they're degraded in your GI tract by acids and enzymes that just eat up the molecules and make them inactive," says Carl Schoellhammer, a graduate student in chemical engineering and a lead author of the paper.

Safe and effective delivery

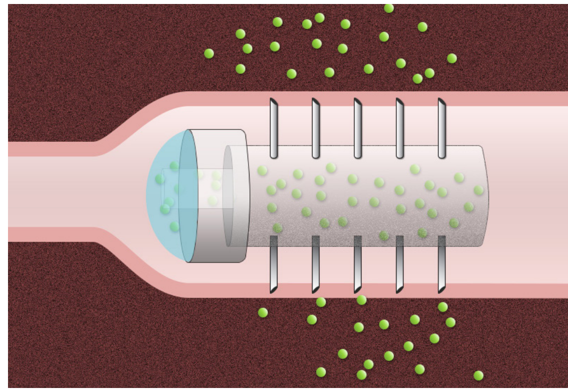
Scientists have tried designing microparticles and nanoparticles that can deliver biologics, but they are expensive to produce and require a new version to be engineered for each drug.

Schoellhammer, Traverso, and their colleagues set out to design a capsule that would serve as a platform for the delivery of a wide range of therapeutics, prevent degradation of the drugs, and inject the payload directly into the lining of the GI tract. Their prototype acrylic capsule, 2 centimeters long and 1 centimeter in diameter, includes a reservoir for the drug and is coated with hollow, stainless steel needles about 5 millimeters long.

To test whether this type of capsule could allow safe and effective drug delivery, the researchers tested it in pigs, with insulin as the drug payload. It took more than a week for the capsules to move through the entire digestive tract, and the researchers found no traces of tissue damage, supporting the potential safety of this novel approach.

They also found that the microneedles successfully injected insulin into the lining of the stomach, small intestine, and colon, causing the animals' blood glucose levels to drop. This reduction in blood glucose was faster and larger than the drop seen when the same amount of insulin was given by subcutaneous injection.

"The kinetics are much better, and much faster-onset, than those seen with traditional under-the-skin administration," Traverso says. "For molecules that are particularly difficult to absorb, this would be a way of actually administering them at much higher efficiency."



A schematic drawing of a microneedle pill with hollow needles.

Image: Christine Daniloff

Further optimization

The team now plans to modify the capsule so that peristalsis, or contractions of the digestive tract, would slowly squeeze the drug out of the capsule as it travels through the tract. They are also working on capsules with needles made of degradable polymers and sugar that would break off and become embedded in the gut lining, where they would slowly disintegrate and release the drug. This would further minimize any safety concern.

Avi Schroeder, a former Koch Institute postdoc, is also a lead author of the paper. The senior authors are Robert Langer, the David H. Koch Institute Professor at MIT and a member of the Koch Institute, the Institute for Medical Engineering and Science (IMES), and the Department of Chemical Engineering; Daniel Blankschtein, the Herman P. Meissner Professor of Chemical Engineering; and Daniel Anderson, the Samuel A. Goldblith Associate Professor of Chemical Engineering and a member of the Koch Institute and IMES.

The research was funded by the National Institutes of Health. ◊

Research Highlights

For more information, go to *web.mit.edu/cheme/news/*

Progress on a Powerful New Way to Generate Electricity

A powerful new way to generate electricity could eventually make electric cars and electronic gadgets run longer.

Article by Kevin Bullis, courtesy of the MIT *Technology Review*

About four years ago, researchers in Michael Strano's chemical engineering lab at MIT coated a short piece of yarn made of carbon nanotubes with TNT and lit one end with a laser. It sparkled and burned like a fuse, demonstrating a new way to generate electricity that produces phenomenal amounts of power.

At the time, no one understood how it worked, and it was so inefficient that it was little more than a "laboratory curiosity," Strano says.

Now, Strano has figured out the underlying physics, which has helped his team improve efficiencies dramatically—by 10,000 times—and charted a path for continued rapid improvements. One day, generators that use the phenomenon could make portable electronics last longer, and make electric cars as convenient as conventional ones, both extending their range and allowing fast refueling in minutes.

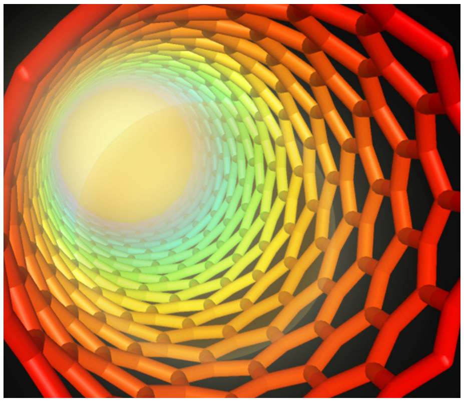
The efficiencies of the lab devices made so far are still low compared to conventional generators. Strano's latest device is a little over 0.1 percent efficiency, whereas conventional generators are 25 to 60 percent efficient.

But Strano says they could be useful in some niche applications, where a sudden burst of power is needed. And Strano says that the further improvements in efficiency mean broader applications could soon be feasible.

The new generators exploit a phenomenon that Strano calls a thermopower wave. The conventional way to generate electricity by burning a fuel is to use heat to cause expanding gases to drive a turbine or a piston. In Strano's system, as the fuel burns along the length of his nanotubes, the wave of combustion drives electrons ahead of it, creating an electrical current. It's a much more direct and efficient way to generate electricity, since no turbines or conventional generators are required.

Since the nanogenerator runs on liquid fuels—which store far more energy than batteries—there's hope that they could allow electric cars to go much farther than they do now.

It's a setup not unlike the one in an internal combustion engine, in which bursts of fuel are sprayed into combus-



A carbon nanotube (shown in illustration) can produce a very rapid wave of power when it is coated by a layer of fuel and ignited, so that heat travels along the tube.

Graphic: Christine Daniloff

tion chambers to drive pistons. Power electronic circuits could take the bursts of power from several nanotube generators and smooth it out, using it to drive electric motors in a car, for example. The fuel tank could be refilled like one in a conventional car. And because the carbon nanotubes aren't consumed in the process, they can be used over and over again.

Recently, Strano discovered that switching from nanotubes to flat sheets of nanomaterials—such as single-atom-thick graphene—improves efficiency. Shaping the sheets to direct the energy of the thermopower wave also boosts performance. ◊

Other Spring 2015 Course X Research News

- Paula Hammond and colleagues develop technology to recycle old batteries into solar cells
- Alan Hatton and graduate student Aly Eltayeb earn Clean Energy Research Grant for “Electrochemically-mediated CO2 Capture”
- Greg Stephanopoulos and colleagues develop a new approach to boosting biofuel production
- The Langer lab helps find a new way to make batteries safer
- Paula Hammond engineers new bone growth with coated tissue scaffolds

For more information on these stories and other Departmental news, go to *web.mit.edu/cheme/news/*. ◊

Bionic Plant Named 2014 “Amazing Tech Innovation”

International Business Times (IBT) has named the Strano Lab’s work with plants as one of its “10 Amazing Tech Innovations in 2014,” along with invisibility cloaks and smart contact lenses. IBT reports, “Carbon nanotubes were integrated into the leaves of several lab plants to allow them to absorb light 30% more efficiently than normal plants.

“ ‘They repair themselves, they’re environmentally stable outside, they survive in harsh environments, and they provide their own power source and water distribution,’ said lead researcher of the MIT team Michael Strano.”

Plants have many valuable functions: They provide food and fuel, release the oxygen that we breathe, and add beauty to our surroundings. Strano and his team aim to make plants even more useful by augmenting them with nanomaterials that could enhance their energy production and give them completely new functions, such as monitoring environmental pollutants. The researchers have reported boosting plants’ ability to capture light energy by 30 percent by embedding carbon nanotubes in the chloroplast, the plant organelle where photosynthesis takes place. Using another type of carbon nanotube, they also modified plants to detect the gas nitric oxide.

Together, these represent the first steps in launching a scientific field the researchers have dubbed “plant nanobionics.”

“Plants are very attractive as a technology platform,” says Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering and leader of the MIT research team. “They repair themselves, they’re environmentally stable outside, they survive in harsh environments, and they provide their own power source and water distribution.” ◊

Alumnus Highlight

For more information, go to web.mit.edu/cheme/news/

Hilton Pryce Lewis PhD '01

Commercializing A New Generation of Polymer Coatings

GVD's vapor deposited polymer coatings improve performance efficiency in critical applications across industries.

Article by Steve Calechman, courtesy of MIT Industrial Liason Program.

In some cases, a company has a product and knows immediately where it should go. GVD Corporation was not one of those cases. The MIT spin-off had developed a new approach to making polymer coatings, which had substantial industry interest. The problem was finding the specific market.

The company had a few things in its favor. The founders had confidence in the technology and had demonstrated its commercial potential on a small scale. They had initial funding from government grants and commercial research and development sponsors. They had patience. And they also found an initial partner who helped them perfect the application.

Eight years after it was founded, GVD finally could hit the market with an innovation that has made tire manufacturing more efficient. By applying the same patience, supplemented with years of experience, it looks to have the same impact on aerospace, gas and oil exploration and electronic circuitry protection.

Making its First Dent

The roots of GVD started in an MIT lab over a decade ago. Karen Gleason, Professor of Chemical Engineering, now Associate Provost, had developed a vapor deposition process that produced thin, durable polymer coatings. Gleason and Hilton Pryce Lewis, a Ph.D. student working in her lab, teamed up and founded GVD Corporation in 2001, just as Pryce Lewis was graduating with his doctorate.

Initially, the company was virtual; in 2003, GVD established its first lab facility less than a mile from campus. As Gleason and Pryce Lewis developed their business plan and finalized licensing agreements with MIT, they also decided to raise funds through sponsored R&D and commercial revenue instead of venture capital. Pryce Lewis says that move gave the company the autonomy to explore every opportunity and to reach its ultimate goal. "We wanted to make an impact in the coating industry," he says.

Traditionally, applying a polymer coating is wet and messy. The process makes it difficult to control the finish and thickness. The coating often doesn't stick well, and, because it needs high processing temperatures, it only works on high-temperature materials, such as metals, ceramics, and a few plastics. Simply put, it's fairly crude, Pryce Lewis says.

GVD's process was something new. It used a dry chemical reaction, required no liquids or solvents, and could change the surface properties of parts on the nano-level. Because it didn't require a heating step, it was able to coat a greater range of materials, including organic materials like rubber, textiles, paper, and almost any plastic.

The first success for the company was in the automotive industry, working with a tire manufacturer. The key reason was GVD's PTFE fluoropolymer coating, which works like Teflon®, Pryce Lewis says. The coating is applied to the tire molds; because it's thin and non-stick, the layer maintains the integrity of fine features, does not block air vents, and facilitates rapid release. The result is less scrap, higher quality tires, and less downtime due to cleaning, allowing the company to produce more tires and use more advanced rubbers and features. "They see a significant economic upside," Pryce Lewis says.

Building a Relationship

It sounds pretty straightforward, but the GVD-automotive marriage wasn't pre-ordained. In 2002, the tire company sensed that over the coming years its manufacturing processes were going to become more difficult as the complexity of tire designs evolved. In a preemptive attempt to find a solution, the company approached MIT and was introduced to a company that held potential, the nascent GVD, Pryce Lewis says.

There was risk on both sides. The tire manufacturer was relying on an untested company. GVD was faced with having to scale up in size and capacity and make the enterprise economically viable. At the beginning of the relationship, GVD was only able to accommodate parts similar in size to an envelope — flat and just a few inches square, Pryce Lewis says. The company needed to get the process working for three-dimensional parts that were several feet in diameter.

"MIT, and its ecosystem, is a place that expects you to keep learning, seek new frontiers, and rewards you for taking risks."

- Hilton Pryce Lewis

After promising initial testing, the tire company provided funds for GVD to design and build bigger equipment. By 2006, GVD had a large enough machine to coat molds at a commercial scale. In 2009, the application became a commercial reality, and, in 2010, GVD established a facility near its partner's plant in the southeastern United States, shifting GVD from a technology-based R&D entity to a service business.

The set-up has been mutually beneficial; the company can manufacture quickly and GVD has a revenue stream to re-invest in further applications. While success wasn't a guarantee, the elements were there. "Any successful industry-small business partnership needs to come with a healthy dose of patience, a willingness to understand your partner's needs and concerns, and a commitment to the long-term," Pryce Lewis says.

Looking for the Next Market

With its success in the automotive industry, GVD is making other market inroads. One is with internal components, particularly rubber seals used in aerospace and oil and gas exploration. In harsh environments, and with constant exposure to aggressive fluids at high temperatures, sealing reliability is essential. The thin coating gives chemical resistance, lubricity, and extends the life without compromising performance. "This improves uptime and reliability in high-value industries, allowing customers to focus on maximizing their production," Pryce Lewis says.

The company is now looking to expand existing markets and break into new ones. A specific target is encapsulation for high-frequency electronics, like those used in radar systems. The thinness and chemistry of GVD's coatings mean they don't interfere with signal transmission or heat management, allowing manufacturers to do away with industry-standard heavy protective encasements, says Pryce Lewis, adding that the reduction in size, weight and power requirements are especially critical in defense applications. GVD has funding from the Department of Defense and is currently working on qualifying its coatings with several large defense contractors.

As with the tire manufacturer, the company is looking for industry partners to help shape applications and bring them to market. And, as before, the relationship will take patience, feedback, and internal support to create a mutually beneficial product. The difference is that this time, GVD brings 13 years of experience. It also, as it always has, brings its MIT credentials and philosophy. "MIT, and its ecosystem, is a place that expects you to keep learning, seek new frontiers, and rewards you for taking risks," Pryce Lewis says. ◊

Prepare to Save the Date for the second annual Alumni TG!

Last April, the Department hosted a special Alumni-themed "TG," -- short for "TGIF" -- an informal monthly Friday-afternoon gathering of students, faculty and staff. Over 100 local alumni, students, staff and faculty celebrated the weekend. Building on that success, the Graduate Student Council for Course X would like to invite all ChemE alumni to a summer BBQ to be held (tentatively) in August 2015.

As soon as plans are settled, you should receive an invitation from our students for the summer event. We hope to see you there!

Alumni News

We want to hear from alumni like you! Please send us your news and photos.
Please direct news to: ***Melanie Kaufman, Editor***
Email: ***chemealum@mit.edu***, Phone: ***617-253-6500***, Fax: ***617-258-8992***

Special note: The alumni donor honor roll for the period of July 1, 2014, through June 30, 2015, will be in the Fall 2014 edition of the alumni news. *We sincerely appreciate everyone who has supported us throughout the year!*

John Pohl ScD '76 is retired now and lives in Laguna Woods Village, CA. He spent his 40-year career in Research and Development on combustion processes, mostly coal, but also flare flame combustion efficiency, needs in research and development, and evaluation of coal combustion properties. He was a lecturer at MIT in Course X and Director of the Fuels Research Laboratory, Building 31. He was a Director of Fossil Fuels at Energy and Environmental Research, Irvine, CA. He was a Professor of Chemical Engineering at the University of Queensland, St. Lucia, Australia and Coordinator for the State of Queensland for the Black Coal Utilisation Research Association. He later became a Research Professor in Mechanical and Mining and Mineral Engineering Department at Virginia Tech in Alexandria, VA. His work on combustion efficiency of flare flames was used to write the EPA standards. He is also co-inventor on five patents and inventor on a number of provisional patents.

Pohl continues to consult on Combustion Properties of Fuels and Flare Flame Emission. Lately he has worked on destruction of off-gas from a coal deposit in Troom, QLD, Australia, performance of an Australian Coal in a Malaysian Boiler in Jorhor, Malaysiar, soot emissions from destruction of waste gases from an oil field in Denver, CO, and combustion properties of an Australian Coal in a Japanese Boiler.

Elliot L. Chaikof PhD '89, surgeon in chief and chairman of the Roberta and Stephen R. Weiner Department of Surgery at Beth Israel Deaconess Medical Center and the Johnson & Johnson Professor of Surgery at Harvard Medical School, has been elected to the Institute of Medicine, one of the highest honors in the field.

As a surgeon and biomedical engineer, Chaikof is internationally known for his many contributions to vascular surgery. His work has been pivotal in the development of new practice guidelines for evaluating and treating patients with aortic aneurysms and developing minimally invasive endovascular therapies for carotid disease and peripheral arterial disease. In the areas of biomedical engineering and materials science, Chaikof's work has led to the development of an advanced generation of cardiovascular materials, devices, and cell- and drug-based therapies based on the principles of biomimetics and molecular and tissue engineering, as well as micro- and nanofabrication technologies.

Steven Little, PhD '05, associate professor, CNG Faculty Fellow and Chair of Chemical and Petroleum Engineering at the University of Pittsburgh's Swanson School of Engineering, has been named the 2015 Curtis W. McGraw Research Award recipient by the American Society of Engineering Education (ASEE).

Little's citation reads, "For exceptional contributions to fundamentals in the field of controlled release and contributions to the establishment of the nascent field of biomimetic delivery...Dr. Little has developed new approaches to program controlled release devices to behave in defined ways, leading to systems that mimic the way cells accomplish complex tasks. His work also led to the founding of the first custom controlled-release formulation startup company in Pittsburgh. Dr. Little's approach as an educator has led to numerous teaching awards and achievements that are unprecedented in the history of his institution." Little joined Pitt's Swanson School of Engineering in 2006, where his research focuses on the controlled release of drugs.

Vedanta Biosciences, a company developing therapies to modulate the human microbiome, co-founded by **Bernat Olle PhD '07**, licensed its first drug candidate to Johnson & Johnson for a potential total of upwards of $241 million. "We are very pleased that Vedanta's discovery platform has generated such an exciting candidate and collaboration," said Olle, COO of Vedanta. "We've shown that we can start with complex biology and mine the microbiome for potent pharmaceutical products."

Armon Sharei PhD ’13

Alumnus Highlight

After winning the diamond prize at the 2014 MassChallenge (more on page 17), Armon Sharei was profiled in the February 11, 2015 edition of Science Careers. He discussed his efforts and success at starting his company SQZ Biotech:

“It began by accident. Chemical engineer Armon Sharei was working on his Ph.D. at the Massachusetts Institute of Technology (MIT), developing a microfluidic gun to, as he termed it, ‘shoot stuff into cells.’ The gun didn’t pan out, but the idea of squeezing molecules into cells looked promising. Sharei hooked up a gas-pressure system to a chip and used it to deliver molecules of interest. He thought, ‘Ok, it looks like we might have the start of something useful. But what do we do about it?’

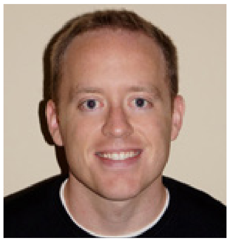
In 2013, with the help of mentors and some legal advice, Sharei and his friend Agustin Lopez Marquez launched SQZ Biotech. Since then, they’ve won top honors and $550,000 in prize money, raised $1 million from investors, generated substantial revenue, and set a course toward establishing a novel drug-delivery method for therapeutics. ‘I believed in the science and wanted to push it hard,’ Sharei says.

Sharei isn’t alone in his entrepreneurial ambitions; many young scientists are veering off traditional paths to launch companies. In doing so, they are overturning the view that scientific startups are daunting, rare, and mercenary and that scientific entrepreneurs are fearless, endowed with special skills, and selling out.

The movement is fueled by a new ‘lean startup’ culture replete with scientific contests, co–working opportunities, rent-a-bench incubators, and a slew of eager professionals—lawyers, investors, advisers, consultants—willing to donate time or defer payment.

For Sharei, the company’s CEO, and Lopez Marquez, its president, scientific entrepreneurship is less like buying a lottery ticket and more a means of propelling an idea forward. They started by collecting $100,000 from their own savings, relatives, and mentors—including Robert Langer and Klavs Jensen, both chemical engineers and MIT inventors. Sharei and Lopez Marquez then took their idea to MIT’s tech transfer office—and so began their startup odyssey.”◊

The development of the lead pharmaceutical candidate originated from work conducted initially at the University of Tokyo, and published in Nature and Science, by Dr. Kenya Honda, who showed that specific gut-dwelling bacteria control key immune cells that combat autoimmune diseases.



Kris Wood PhD ’07 is a recipient of the 2015 Liz Tilberis Early Career Award from the Ovarian Cancer Research Fund. A former member of the Hammond Research Group, Wood is now an assistant professor at Duke University. Wood’s lab at Duke focuses on two related themes: (1) the development of new functional and computational genomic approaches for cancer research and (2) the application of these approaches to define new therapeutic strategies in high-grade serous ovarian cancer and other malignancies. Launched in December 2000, the Liz Tilberis Early Career Award (formerly called the Liz Tilberis Scholars Award) is for junior faculty with a strong commitment to an investigative career in ovarian cancer research. These awards support a substantial time commitment to research and academic endeavors in ovarian cancer. Each grantee will receive a three-year grant of $150,000 per year. The program honors OCRF’s late president, Liz Tilberis.

Keith E. J. Tyo PhD ’08, a former member of the Greg Stephanopoulos Research Group and currently an assistant professor of chemical and biological engineering at Northwestern University, has received an NSF CAREER award for “Engineering Non-Growth Metabolism for High-Yield Biochemical Production.” His award proposal is to address a key challenge to realizing microbial catalysts, namely increasing the rate and efficiency that a microbial catalyst can produce the fuel or chemical. ◊

In Memoriam

John Hancock Howell III ’35

John Hancock Howell III, longtime resident of South Charleston, WV, passed away peacefully December 9 in San Francisco, CA. He was 101 years old.

Mr. Howell, born in New York City, graduated with honors from MIT in Cambridge, MA with an undergraduate and Master’s Degrees in Chemical Engineering. While attending MIT, he was an active member of Phi Delta Theta and Alpha Chi Sigma fraternities. During his senior year he was editor-in-chief of *Technique,* the college’s yearbook.

Offered a position in 1936 by Union Carbide Chemical Company in South Charleston, WV, in the new field of coal hydrogenation, Howell devoted his entire business career of 42 years to the company, serving later as an associate director until his retirement.

Howell married Dorothy Annie Michie of Boston, MA, in 1938 and they were married for 56 years. Their children are John Hancock Howell IV of Genoa, NV; Peter Moore Howell (passed away in 1991); and Dorothy Forbes Daugherty of Sudbury, MA. 6 grandchildren in New Zealand, Phoenix, AZ, Morgantown, WV, and Boston and Sudbury, MA, and 13 great grandchildren survive him.

Toward the end of World War II, Howell as a Navy 1st Lieutenant, along with several other Carbide personnel, was sent by the US Government to investigate Germany’s synthetic fuel processes at chemical plants. Shortly after his return from Germany, he and several other Carbide employees undertook in their “spare moments” to develop plans for a new residential community of 105 homes called Weberwood. Howell built their family home – much of it himself – and enjoyed living there for 48 years.

John was an avid lover of nature from early childhood – trees, birds, flowers. His property in Weberwood, So. Charleston, contains over 100 trees that are native to WV, most of them planted by Howell and his two sons.

Upon discovering old family letters and genealogy information, Howell spent years pulling together and tracing his family’s ancestry to John Hancock the Revolutionary Patriot, and even further to Edward Howell of Marsh Gibbon in Buckinghamshire, England arriving in Lynn, MA in 1639. This ancestry project resulted in Howell’s participation in organizing the Edward Howell Family Association, an active historical group.

Edward Tiffin Cook SM ’40

Edward Cook passed away on August 28, 2014 in Wilmington, DE, after a long illness. He was 98. Born in Chillocothe, OH, on December 17, 1915, he graduated from Williams College in 1938. He joined DuPont in Charleston, WV, where he met and married Betsy Blundon, who died in 1987. He is survived by eight children, 10 grandchildren, and his second wife, Trudy English Cook.

Jeremiah A. Lott ’48

Jeremiah Lott was born in Newark, NJ and spent his formative years as a resident of Maplewood, NJ. He was a graduate of Seton Hall Preparatory School and the Massachusetts Institute of Technology, earning a degree in chemical engineering. His education was interrupted during World War II as he served several years, in the Army of the United States, seeing action in the European theater of operations with the 94th Cml. Mortar Bn., attached during different periods to the 1st, 7th and 3rd Army.

His professional career began in 1948, following graduation, with Chas. Pfizer & Co. Inc. (now Pfizer Inc.), at the time located in Brooklyn, NY. He headed several manufacturing departments and during the early ‘50s was Vice President of Production of two Pfizer related pharmaceutical plants in Puerto Rico. His Pfizer career ended with retirement in 1985 as Director of Package Design and Development, serving most corporate divisions. Upon retirement, Mr. Lott served as a packaging consultant within the pharmaceutical industry.

Mr. Lott was a career long professional member of Packaging Institute International, serving as chairman of many technical committees. Additionally, he was a member of the American Management Association and its National Packaging Council, a member of the Editorial Advisory Board of Pharmaceutical Executive Magazine, presented papers and moderated many programs relative to industry problems relating to packaging, and was a member of the NJ Packaging Executives Club.

He was elected a trustee of The Westfield Foundation, serving six years as secretary and executive director; a trustee of Contact-We-Care and worked on several committees of the United Fund of Westfield through his thirty-five years as a Westfield resident. Social affiliations included membership at Echo Lake Country Club, the Nassau Club of Princeton, Alpha Tau Omega and Alpha Chi Sigma fraternities.

Surviving are his three children: Patricia Kelly of Kingman, AZ; Priscilla Cafaro of Downingtown, PA, Bruce Lott of Pacific Grove, CA; six grandchildren and two great grandchildren ◊

Continued on page 31

Blast from the Past

Last time, we focused on Holiday Party fun and several readers were able to help us out.

For the photo to the left, former Academic Administrator Janet Fischer recalls this was fall of 1992. She says, “I remember this skit like it was yesterday. They were running a barbership. Steffen played Klavs! Glen Bolton PhD ’98 portrayed Jonathan Harris. Sachiko cut their hair!”
She recalls, from left to right, Steffen Ernst PhD ’98, J-P Armond, Ravi Srinivasan PhD ’98, Glen Bolton, Sachiko Hirosue ScD ’00, Caroline ?, Lori Anger Ray SM ’93, Shahin Ali PhD ’99.
Anita Parkinson SM ’94 recalls the skit as well: “The photo is from my first year...1992. Looks like we got an award for our skit at the holiday party. I don’t remember the award but it only took a few minutes to remember the names of my classmates, and some of the profs they were spoofing. On the far left, Steffen was Klavs Jensen with his longish hair and the chalk dust (I guess that dates us!) that seemed to get everywhere.”

In the photo to the right, Janet Fischer also identified Bob Brown, department head at the time, and Howard Covert PhD ’99 on his left.

Graduation time! Who are these bright-eyed young people about to go out into the world?

Do you have photos or images you’d like to share? Email *chemealum@mit.edu*.

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Doing anything special on Friday, June 5th?

Come help us celebrate our newest alumni!

You are invited to attend the

Annual MIT ChemE Alumni Reception

Friday, June 5th, 2015, at 1pm

(immediately following Commencement)

Tent in McDermott Court