FALL 2014 • MIT COURSE X NEWS • WEB.MIT.EDU/CHEME/

MIT CHEMICAL ENGINEERING ALUMNI NEWS

XCurrents

Professors Charlie Cooney and Danny Wang celebrate several milestones. (Page 14)

Letter from *Department Head Klavs F. Jensen*

Fall has descended on Cambridge, but the swirling colors on the trees are not the only change on campus. Inside Building 66, our facilities are being completely reimagined to fit the needs of the next generation of chemical engineers at MIT. These changes include allocated work space for each student, and adaptable research environments that address ever changing needs and projects. Each laboratory will now have a dedicated student office space, and these two spaces are often adjoined by large windows to allow students to keep a watchful eye on their work. Fixed benches are being replaced with moveable units, giving us the flexibility to quickly adapt labs to both the current and emerging interests of our researchers.

Windows are a theme throughout the building. Not only does this mean more natural light to brighten the hallway; these windows between offices, labs, hallways and the outside, help to connect our people to each other and to the work that they do –strengthening the ongoing collaborations within and between research groups. If you are on campus, I encourage you to come and see this transformation for yourself; it is quite striking. I've included a few photos on the next page.

Highlights

find the latest news online:

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MITChemEng MITChemE

Massachusetts Institute of Technology

Letter from the Department Head continued

Speaking of Building 66, it an honor to announce the recent establishment of the Raymond Baddour (1949) Professorship in Chemical Engineering. As Department Head in the late 60s, Ray conceived of the plan to create the current home of the Chemical Engineering Department, the Ralph Landau Building. He also raised the funds for the building completely through private sources, an act that has not been duplicated at the Institute since. He was visionary in his plan to modernize the space for MIT Chemical Engineering and to create an environment that fostered the expansion of programs in applied chemistry, bioengineering, and energy. We continue to expand upon this vision as we prepare Building 66 for the next stage of chemical engineering. The first Baddour Professor is Bernhardt Trout, who spent a lot of time in this building as an MIT undergraduate. More on this new professorship is on page 9; we are deeply grateful to the Baddour family for their generosity and dedication to Chemical Engineering at MIT.

This newsletter has many examples of how our faculty, students, and alumni are integral parts of ChemE, the Institute, and the world around us. From Pat Doyle's counterfeit-fighting micro particles, to Paula Hammond's one-two-punch ovarian cancer treatment, to Michael Strano's bionic plants, our faculty and researchers are doing great research. Bob Cohen, graduate students Siddarth Srinivasan and Shreerang Chhatre, and alumnus and fellow MIT professor Gareth McKinley '91 have discovered attributes of cormorant wings that could lead to next-generation hydrophobic surfaces. The faculty remains be very engaged in energy research and the MIT Energy Initiative with work in a wide range of renewable energy technologies and five faculty wining seed grants. The MIT-Novartis team led by Bernhardt Trout continues to transform pharmaceutical manufacturing and their efforts were recognized with the Collaboration Award from the Council for Chemical Research.

MIT Chemical Engineering headquarters is temporarily vacated and demolished in anticipation of renovations.

Building 66's fourth and fifth floors receive new windows, flooring, lighting and colors to coordinate with the original.

This fall we welcomed another class of outstanding sophomores and graduate students. Thanks to the alumni support over the years, the incoming graduate students are fully supported on fellowships the first two terms so that they can focus on their studies and selecting research advisors.

In the spring, we celebrated the many achievements of Charlie Cooney in connection with his "retirement." Fortunately for us, he continues to teach while enjoying freed space in his calendar for reflection and new endeavors. Charlie got his PhD at MIT in 1970, when biochemical engineering was in its early stages, and since then, he has been an integral part of the evolution of the field. He has played a critical role in the Institute's innovation efforts, not least as the founding director of the Deshpande Center for Technological Innovation.

Early this fall, we celebrated the inaugural Daniel I.C. Wang Lecture on the Frontiers of Technology, sponsored by Noubar Afeyan, an alum and student of Danny. The lectureship continues the previous Frontiers of Biotechnology Lecture that has brought leaders in the field to the MIT. It's wonderful to be able to recognize Danny by this lectureship, and Professor Frances Arnold of CalTech presented a terrific inaugural lecture to an overflow audience. The full webcast is at http://web.mit.edu/cheme/news/wang/. During the summer, Danny participated in the 50th anniversary of his summer short course in fermentation technology. The continued popularity and long running time of this course reflects Danny's tremendous role in shaping the field of biotechnology and underscores his importance as an educator.

Laboratories, like this one on the fourth floor, will receive window treatments to help offset the solar load on the building, while letting in more light through new windows between laboratories and offices.

The Department will host a reception Monday November 17th at the Annual AIChE Meeting and celebrate awards won by Richard Braatz, Paula Hammond, Greg Stephanopoulos, and Bernhardt Trout. We will also host a reception to honor Professor Emeritus Howard Brenner, who pasted away earlier this year. The reception will be on Sunday following a special symposium to commemorate Howard's many pioneering contributions to fluid mechanics. His final paper on shortcomings of the Navier-Stokes equations was published in April of this year, a culmination of ten years' work after his retirement.

Thank you for taking time to read our newsletter and letting us share some of the interesting things going on around campus. Please do write to us to let us know how you are doing and how we can continue to improve. Thank you for your support and best wishes for the coming fall.

Klavs F. Jensen
Department Head
MIT Chemical Engineering Department

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We want to hear from you!
Other ways to connect
email: chemealum@mit.edu
fb: MITChemEng twitter: MITChemE

MIT Chemical Engineering
77 Massachusetts Avenue
Building 66, Room 350
Cambridge, Massachusetts 02139

On the cover: In April of this year, the Department hosted a special Alumni TG (TG is short for "TGIF," the name of an informal monthly Friday afternoon gathering of students, faculty and staff). Local alumni were invited back to campus to help celebrate the beginning of the weekend. We are planning more alumni events for Spring 2015. For more , go to page 17.

Practice School News

Greetings from the MIT Practice School!

I am pleased once again to be able to update you on the latest developments in the Practice School program and the stations we are running. During the Spring of 2014, the David H. Koch School of Chemical Engineering Practice fifteen students and four host companies participated in the Spring session.

We are deep in the planning stages for the Practice School Centennial celebrations to be held in the Fall term of 2016 – look out for the launching of the Centennial website later this fall. As part of the planning for this event, one of our major projects is to create an online community for our Practice School alumni and alumnae, and we're working with MIT's newly hired social media specialist to find the most efficient way to do this. In the meantime, we would really like to hear your ideas as to how you'd like to stay in touch or communicate with your fellow practice school students. Please send any suggestions directly to Melanie Kaufman, the alumni news editor; she is also managing this project, and can be contacted at chemealum@mit.edu.

The next year will be a busy one for us as we continue to look for new ways to enhance the Practice School program through possible new educational initiatives, recruiting of top students for the program, and working with host companies to provide a superlative educational opportunity for these students. In the latter regard, our industrial sponsors really do deserve a hearty 'Thank you!' for all they have done, and will continue to do, for the program – the vignettes of the goings-on at the four stations this past Spring given below give some indication of their dedication to providing a welcoming (and challenging!) home for the student groups.

Spring 2014 Station
SGC Energia, Houston TX
Directed by Robert Hanlon

About 10 years ago in the United States, the production of natural gas from shale started taking off due to technology breakthroughs in drilling, resulting in a tremendous economic boon for the country. But what to do with all that gas? Much is naturally going to electricity generation. But how about our need for transportation fuels? The technologies available, having been invented by German scientists Franz Fischer and Hans Tropsch back in 1925, and having since been commercialized by a small number of players (for example, Germany during WWII, South Africa (SASOL), and Shell in Bintulu, Malaysia), have not been used commercially in the United States… until now.

In 2015, SGC Energia will commercialize a 1,100 barrel per day gas-to-liquids (GTL) process in Lake Charles, Louisiana. Using a steam methane reformer they purchased from Praxair along with their property in Westlake, SGCE will safely and profitably upgrade natural gas to carbon monoxide and hydrogen and then convert this stream to high-molecular-weight liquid products using an advanced F-T catalyst.

With this background, we had the pleasure of operating a two-month Practice School station at SGCE's technology center in Pasadena, Texas, this past spring. Many have spoken about commercializing GTL in North America, and it was exciting to be involved with a company making it happen.

Students at SGC Energia get a personal tour of the facilities in Houston.

SGCE is not new to the Practice School program. We ran a station with them (2011) in Güssing, Austria, where their focus was on biomass conversion to liquid fuels. With the great opportunity presented by the abundance of natural gas in the U.S., SGCE changed direction, moved to Houston, and welcomed us back.

John Hemmings, SGCE's Chief Technology Officer, prepared two excellent projects for our six students, each consisting of theory, experiment and, for lack of a better phrase, "getting ones hands dirty." As the tech center was still getting off the ground, the students were in a great position to help build and shake down experimental equipment, and then to use the fruits of their labors to obtain valuable data on both reactor performance and product upgrading / characterization. They combined their data with the theory and packaged a solid set of final reports that SGCE will be able to use for their process and product development programs.

As an aside, we had expected Houston to offer us pleasant temperatures in the 60s, but the weather had other plans. Apparently, as we learned, cold fronts from Canada can flow relatively unimpeded over the open plains to Houston. The students didn't complain, not once. With this note, I publically thank them for this and for doing what it took to get the job done. They simply donned all the clothing they brought with them, moved forward, and successfully developed as chemical engineers in the process.

Cabot Corp., Billerica MA
Directed by Robert Fisher

Cabot is best known for its carbon black and other fine powders used in many macro-scale products, such as high performance tires and substances requiring controlled rheological properties. All four projects (six students were involved this time for the two sessions) required a thorough understanding and application of fundamental chemical engineering principles. Use of thermodynamics, reaction kinetics and transport phenomena, coupled with novel chemistry associated with emerging technologies, was emphasized. The use of software tools for statistical analysis and digital imaging played an integral role in accomplishing goals.

Two 4-week sessions, with two projects each, were completed successfully. One of the first session's projects focused on developing a more thorough understanding of various facets of an existing application of activated carbon for the removal of contaminates in coal fired power plant flue gases. The other was a proof-of-concept investigation requiring a directional change in the processing technique of an existing product line. The second session also involved proof of concept investigations: (1) nano-mixing requirements of wide particle size distribution materials for inclusion into macro-scale products and (2) the processing of an advanced material for innovative applications for both new and existing product lines. All four projects required major experimental and modeling efforts, each being highly visible platforms within the corporation. Specially, one project focused on the process changes that could impact the rheology of the final product. Another involved incorporation of turbulent mixing phenomena to prepare an additive as a reinforcing agent. The third incorporated sono-chemistry and nano-emulsification techniques to obtain another additive for reinforcement applications. The last one required investigation of various diffusion mechanisms (external vs. internal particle vs. surface mobility), reactive sites and the mechanisms of the surface chemistry associated. Difficult concepts associated with Kelvin-Helmholtz stability, turbulence, and cavitation were once again investigated as in past projects. The results of each project were well received by their sponsors and the general R&D audience that attended our presentations. The corporate-wide interest is obvious from the lively discussions that ensue, both with us and among themselves. These helped greatly in our pursuit to provide the thorough technology transfer requirement of the PS program.

Cabot made special efforts to acknowledge their appreciation for a job well done by hosting social events, both during and after the session. This included an ice cream social each Friday afternoon and multiple meals. These efforts to make us feel a part of a successful collaboration were greatly appreciated and a testament to the commitment on both sides for this to be a win/win endeavor, both professionally and on a personal level. Also, as a routine practice while at Practice School stations, we attempted to take advantage of the local culture and geographical features of that region through group outings and culinary delights. Although close to Boston, we focused our attention on other New England regions. Our outings included a charity Ice Hockey event, a minor league baseball game, and day trips to Salem and surrounding historic towns/sights, which also included a visit to the famous Peabody-Essex museum. Unfortunately, the weather did not cooperate and we were not able to do a planned harbor cruise in Portland, ME. However, we enjoyed celebrating multiple birthdays with ice cream at the famous Bedford Farms dairy shop.

The students at the Novartis practice school station take a break to be tourists in the Swiss town of Basel.

Novartis Pharmaceutical Corp., Basel, Switzerland
Directed by Claude Lupis

This was our second station with the Parenteral and Topical Dosage Form division of Novartis in Basel, Switzerland, and it was attended by nine students. Although we generally have three projects per session with teams of three students per project, the company insisted that four projects be addressed per session, which I hope was a tribute to the productivity of the last group of MIT students!

The range of projects on which the students worked proved to be very wide. Three of the projects were a continuation of the work done by the last group of students: on the optimization of the continuous generation and processing of monodisperse microparticles and on the production of liposomes by high pressure homogenization. The other projects dealt with the control of the properties of powders and their filling into capsules; the investigation of new technologies for smart labels; the applications of X-ray computed tomography and other measurement techniques; and the modeling of syringe and needle flow frictions in automatic injection systems. The results of the work were all gratifying (indeed, at the end of our first session, there was some discussion whether one of the projects should lead to the application of a patent) and our sponsors continued to be very favorably impressed.

The proximity of Basel to Alsace in France and the Black Forest in Germany always provide wonderful touristic opportunities for the students. We maintained our traditional visits to Colmar and Strasbourg, which appear to be always much appreciated. We also enjoyed very mild weather, made all the more pleasing by the reports of a record cold winter in New England!

continued on page 8

On May 12, 2014, The department hosted its annual Award Ceremony and traditional dessert reception. Presided by Department Head Klavs F. Jensen, the ceremony recognized undergraduates, graduate students, staff and faculty for their achievements and contributions to the department during the school year.

A variety of organizations, as well as individuals, outside the department and MIT donated prizes and scholarships to students in chemical engineering. The awards are below.

Course X Awards Day 2014

Robert T. Haslam Cup

Awarded to a student who shows outstanding professional promise in Chemical Engineering

Akshar Wunnava ’14

Roger de Friez Hunneman Prize

Recognizes outstanding scholarship in class and research

Samantha Hagerman ’14

Phi Beta Kappa

William Baysinger ’14
Samantha Hagerman ’14
Benjamin Niswonger ’14
Akshar Wunnava ’14
Devin Zhang ’14

Gates Cambridge Scholar

Michelle Teplensky ’14

Wing S. Fong Memorial Prize

Awarded to a chemical engineering senior of Chinese descent with the highest cumulative GPA, in honor of the memory of Wing S. Fong, his hard work, and dedication to his adopted home, university, and country.

Kevin Wu ’14

(for more on Kevin and the Fongs, go to page 28)

C. Michael Mohr Outstanding Faculty Award

Recognizes excellence in teaching in undergraduate subjects

Professors Fikile Brushett and Patrick Doyle

Edward W. Merrill Outstanding Teaching Assistant Award

Alexander Bourque (G)

Outstanding Graduate Teaching Assistant Award

Ray Smith (G)

Graduate Student Council Outstanding Faculty Award

Professor Bradley Olsen

Fall 2013 Best Student Seminar

Ben Renner (G)

Spring 2014 Best Student Seminar

Eric Zhu (G)

Chemical Engineering Outstanding Employee Award

Gwen Wilcox

Rock Award

Given to a deserving student for showing leadership on the athletic field

Brandon Reizman (G)

BP Outstanding Academic Achievement by Sophomore Women Chemical Engineers

Pamela Cai ’16
Kiara Cui ’16
Kelsey Jamieson ’16

BP Outstanding Academic Achievement by a Junior Woman Chemical Engineer

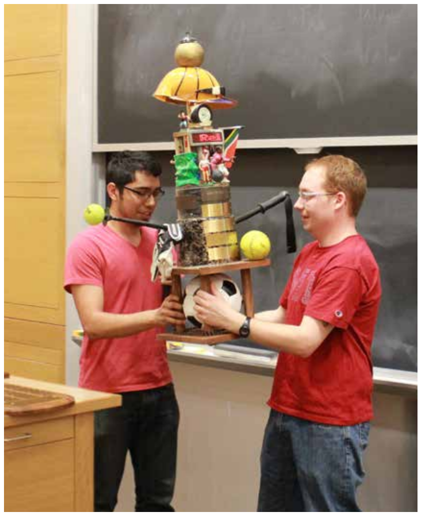
Sarah Mayner ’15

BP Outstanding Performance in the Projects Laboratory Course by a Junior Woman Chemical Engineer

Xingyi Shi ’15

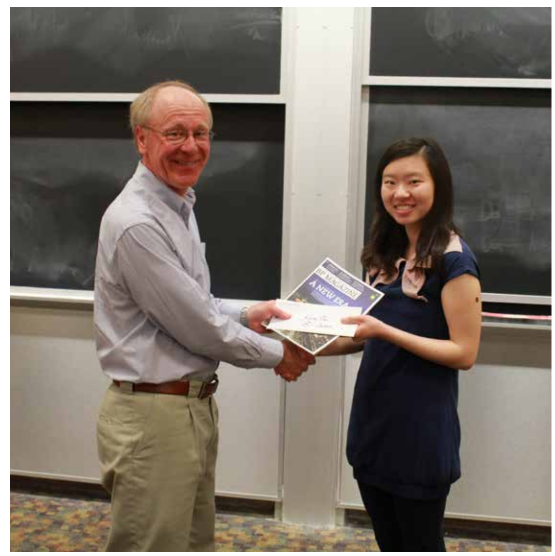
BP Outstanding Performance in Research by a Junior Woman Chemical Engineer

Catherine Liou ’15







Departmental Special Service Awards

Graduate Student Council for Course X (GSCX)

Abel Cortinas
Jose Gomez
Monique Kauke
Nicholas Mozdzierz
Justin Nelson
Sue Zanne Tan
David Emerson
Kevin Kauffman
Kathryn Maxwell
Karthick Murugappan
Issac Roes
Harry Watson

Graduate Student Advisory Board (GSAB)

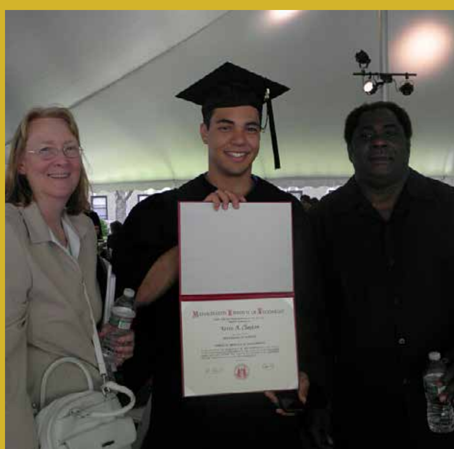
Ankur Gupta
Lionel Lam
Kaja Kaastrup
Brandon Reizman
Andrew Silverman
Jose Gomez
Katie Maass
Sayalee Mahajan
Siddarth Srinivasan

Course X Undergraduate Chapter of AIChE

Michelle Teplensky '14
Samantha Hagerman '14
Whitney Loo '15
Julia Sun '15
Anthony Concepcion '15
Chadd Kiggins '15
Eric Safei '14
Michael Fu '15
Kelsey Jamieson '16
David Hou '15
Brian Alejandro '14
Kali Benevides '15
Allen Leung '15
Pritee Tembhekar '14
Spencer Wenck '15
Joshua Zeidman '14
Joel Schneider '15
June Park '16

Congratulations Class of 2014!

Course X's most recent alumni class was feted at this year's Commencement Reception, Friday, June 6th, 2014. Graduates, families, faculty, friends and alumni mingled and enjoyed the weather at the Chemical Engineering Tent on the McDermott Circle.



(Practice School Letter continued from page 5)

General Mills (GMI), Minneapolis MN
Directed by Justin Kleingartner

In this session, GMI hosted us at their James Ford Bell and Riverside Technical Centers, which are both located in the greater Minneapolis area. The students worked on six projects spread over two 4-week sessions in GMI's One Global Meals, One Global Cereals, One Global Baking and GTECH (internal research) business units. Two of the projects from the first session were modified and extended into the second session as a result of the students' work. The projects entailed extensive experimental and modeling work with the main goal of improving existing food systems. One of the projects that spanned both sessions focused on modeling product quality metrics in dough by describing the leavening reaction kinetics, thermodynamics, and constituent transport phenomena in the system. The resulting model was validated with multiple pilot plant runs and now serves as a tool for plant operators and engineers to use in the production of current and future dough products. In another project, the students tested and optimized machine learning algorithms for implementation in quality control and classification of upstream inputs. The best classification algorithm was identified and optimized for the food application of interest. The other multi-session project focused on using various analytical techniques, including rheometry, tribometry, and microscopy, to differentiate products with the end goal of correlating these measurements with macroscopic sensory attributes. The final project focused on designing a process and corresponding control system to be used with new packaging for an existing product. A comprehensive technological assessment was conducted to determine the best technologies for controlling the packaging process to meet intermediate product specifications that are necessary for assuring food safety. The student's hard work and extensive effort lead to the success of all of these challenging projects.

In addition to the technical work that was done, we had the opportunity to dine at many of the greater Minneapolis area's excellent restaurants, try our hand at curling in Blaine, MN, and attend a Twins-Red Sox game in GMI's executive suite. We were also hosted by the local chapter of the MIT Alumni Association, which provided the students with the opportunity to speak with some of the many MIT graduates who now call Minnesota home.

I look forward to sharing more Practice School work and adventures with you in the next newsletter! Best regards,

T. Alan Hatton
Director

Chemical Engineering establishes Raymond F. Baddour (1949) Professorship

Anne and Ray Baddour

The Department of Chemical Engineering is pleased to announce the establishment of its Raymond F. Baddour (1949) Chemical Engineering Professorship, which will support a distinguished faculty member in the department.

Baddour, the Lammot du Pont Professor Emeritus of Chemical Engineering, received his MS in chemical engineering practice in 1949 and, upon earning his ScD from MIT in 1951, became an assistant professor in the department. He became a full professor in 1963 and founded MIT's Environmental Laboratory in 1970, becoming its first director.

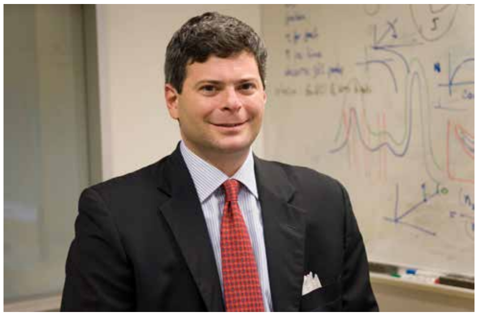
Baddour was head of the chemical engineering department from 1969 to 1976; during that time, he put together and executed a visionary plan to expand the department's programs in applied chemistry, bioengineering, and energy/environmental engineering. He launched a bold and aggressive hiring initiative that broke with longstanding departmental traditions; now, 30 years later, Course X continues to see the positive impact of his vision.

Another impact of Baddour's hard work is more tangible: In order to revitalize and address space concerns for new faculty and research programs, Baddour conceived of the plan to create the current home of the chemical engineering department, the Ralph Landau Building (Building 66). He also raised funds for the building completely through private sources, an act that has not been duplicated at the Institute since.

Baddour is also a role model for entrepreneurship: He started his first company in 1962, and has founded a total of 16 companies, including the 1980 co-founding of California-based biopharmaceutical giant Amgen. He has been on the board of directors of 13 companies, and has influenced some notably successful entrepreneurs, including Noubar Afeyan PhD '87, David Lam ScD '74, and William Koch '62, ScD '71. In 1998, Baddour presented the department's venerable Warren K. Lewis Lecture, entitled, "Start-ups and Letdowns — Reflections of a Professor in Venture Land."

Baddour earned his BS in chemical engineering from the University of Notre Dame in 1945. He has more 65 publications, and holds 16 patents.

The first Raymond F. Baddour Professor of Chemical Engineering will be Bernhardt L. Trout. Trout is currently director of the Novartis-MIT Center for Continuous Manufacturing and co-chair of the Singapore-MIT Alliance Program on Chemical and Pharmaceutical Engineering. He received his SB and SM degrees from MIT and his PhD from the University of California at Berkeley. In addition, he performed postdoctoral research at the Max-Planck Institute.



Bernhardt Trout '90, the first Baddour Professor of Chemical Engineering

Trout's research focuses on molecular engineering, specifically the development and application of both computational and experimental molecular-based methods to engineering pharmaceutical formulations and processes with unprecedented specificity. Since 1999, he has focused on molecular engineering for biopharmaceutical formulation, pharmaceutical crystallization, and pharmaceutical manufacturing. In 2007, with several colleagues from MIT, he set up the Novartis-MIT Center for Continuous Manufacturing, a $85 million partnership that aims to transform pharmaceutical manufacturing.

In addition to Novartis, Trout has worked with many other pharmaceutical companies in research or consulting. He has published more than 150 papers and currently has 17 patent applications. With his MIT and Novartis colleagues in the MIT Novartis-Center and at the U.S. Foods and Drug Administration, he is the recipient of the Council for Chemical Collaboration Award in 2014, and will receive the 2014 AIChE Excellence in Process Development Research Award in November. ◊

Karen Gleason named associate provost

Professor Karen Gleason was appointed associate provost on May 1. She succeeds Martin Schmidt, who was appointed provost in February.

Gleason earned a bachelor's degree in chemistry and a master's degree in chemical engineering from MIT before receiving her doctorate in chemical engineering from the University of California at Berkeley. She has served on the MIT faculty since 1987 and is currently the Alexander and I. Michael Kasser Professor of Chemical Engineering. Previously, she has served MIT as the associate dean of engineering for research, the associate director for the Institute of Soldier Nanotechnologies, and executive officer of the Department of Chemical Engineering. Gleason's pioneering research in chemical vapor deposition (CVD) of polymer thin films makes it possible to fabricate novel organic surfaces and devices. Gleason has authored more than 250 publications and holds 18 issued U.S. patents for CVD polymers and their applications in optoelectronics, sensing, microfluidics, energy, biomedicine, and membranes. She has also been a successful entrepreneur during her time on the MIT faculty.

In her new role, Gleason will have oversight of space planning, allocation, and renovations across the Institute, which includes chairing the Committee for the Review of Space Planning (CRSP). In addition, she will support the Office of the Provost's focus on strengthening MIT's industrial engagements.

In his email to the MIT community, Schmidt expressed gratitude to Gleason for accepting this position, and he noted that her "significant experience working with industry" and experience as an entrepreneur will be very helpful to the Office of the Provost's efforts around collaborations with industry.

"I am thrilled by Professor Gleason's willingness to serve in this capacity," he wrote. ◊

MIT introduces edX course 10.03x

The MIT Center for Biomedical Innovation (CBI) announces a collaboration with the Amgen Foundation to develop the Amgen-MIT Biomanufacturing Educational Initiative, focused on biologics manufacturing. The new course will be part of edX, a massive open online course (MOOC) platform founded by MIT and Harvard University in May, 2012. The platform hosts online university-level courses in a wide range of disciplines to a worldwide audience at no charge and allows for research into learning.

The characteristics of biologic medicines are closely related to manufacturing processes and environmental conditions. This initiative aims to highlight the complexity and importance of biologics manufacturing; increase global undergraduate exposure to the field; and encourage students around the world to consider careers in the pursuit of manufacturing life-saving biologic medications.

The course, Making Biologic Medicines for Patients: The Principles of Biopharmaceutical Manufacturing (10.03x), will teach undergraduate students about the manufacturing of large, complex biologic medicines like monoclonal antibodies for the treatment of diseases such as rheumatoid arthritis and cancer. This new course is one of a number of new online courses being developed at MIT for the edX platform. Due to the open and global nature of edX, the class aims to attract students from around the globe, including underrepresented minorities and students from developing regions.

"In 10.03x, we will teach fundamental principles of bioprocessing and leverage the online environment to connect the principles to application," said Dr. Stacy Springs, director of the MIT CBI Biomanufacturing Research and Educational Program, also known as BioMAN.

"Our goal is to inspire undergraduate students to pursue engineering studies in this field and encourage both new leaders and operators who will support the quality manufacturing of biomedicines for our future," said professor Love, who is also co-principal investigator on the Amgen Foundation grant. ◊

Two Course X professors recognized for excellence in undergraduate education

Will Tisdale Receives Baker Award for Undergraduate Teaching

On May 8, William A. Tisdale, the Charles and Hilda Roddey Career Development Assistant Professor in Chemical Engineering, received the Everett Moore Baker Memorial Award for Excellence in Undergraduate Teaching. This Institute-wide award is given annually to an MIT faculty member in recognition of his or her "exceptional interest and ability in the instruction of undergraduates." It is the only teaching award in which the nomination and selection of recipients is done entirely by students.

"This is a truly unexpected and deeply meaningful honor — especially knowing that it came from the students," Tisdale says. "It is quite humbling to have my name included among the past award recipients. I'm convinced that the recognition is due in no small part to the inspiring example and mentorship that Alan [Hatton] has provided me as my senior faculty co-instructor in 10.302. I am also amazed at the dedication and respect the MIT undergraduate students show toward their own learning; it is a privilege to teach such capable and willing minds."

T. Alan Hatton, the Ralph Landau Professor of Chemical Engineering Practice, won the Baker Award in 1983. He and Tisdale co-taught 10.302 (Transport Processes), a chemical engineering course that focuses on "the ability to solve real heat- and mass-transfer problems of engineering significance."

According to one of the student nominators, "It was a privilege to be a student in 10.302."

Tisdale's lectures were noted for being well-organized; students said they also "creatively spark discussion and interest in the class. … His priority is that students learn. Questions that take the lecture off-track are always welcomed and, in the end, never hinder the flow of the class. His responses enhance the growth of understanding of the material."

Other student nominators agreed, saying:

"Professor Tisdale has a terrific humor that builds the teacher-class relationship. His connection with students is evident and strong."

"Great teachers have an innate sense of when students need help and provide support to those individuals. Professor Tisdale brings out the best in individuals and inspires them to want to learn and gain understanding." ◊

Kristala Prather Named 2014 MIT MacVicar Fellow

Every year, MIT's MacVicar Faculty Fellows Program recognizes a handful of professors who are exceptional undergraduate teachers, educational innovators, and mentors. Professor Kristala Prather has been named one of five 2014 MacVicar Fellows.

Founded in 1992, the MacVicar Faculty Fellows Program was created to honor the legacy of Margaret MacVicar, an MIT alumna and professor of physical science who served as the Institute's first dean for undergraduate education, from 1985 to 1990.

Prather earned her SB in chemical engineering at MIT in 1994 and her PhD in the same field at the University of California at Berkeley in 1999. In 2004, she joined MIT's chemical engineering faculty as an assistant professor, and in 2011 she was named the Theodore T. Miller Associate Professor of Chemical Engineering.

"I know quite well how transformative the MIT experience can be," Prather says. Now, as a professor, she strives to "return some of the inspiration that I received — to students in the classroom, UROPs in my research lab, my advisees (formal and informal!), and those who don't fit neatly into any of the above categories. I want these students to know that I have been further inspired by each of them. I look forward to many more years of teaching and learning from them."

Students call Prather a "natural" in the classroom who "deeply influences" many students. They value her "open and interactive environment," her ability to explain complex concepts clearly, and her knack for using humor in her lectures, "making them engaging, interesting, lively, and fun." A UROP student who worked with Prather for several semesters wrote, "I can attest to her incredible mentorship capabilities, her effectiveness as a reachable and helpful principal investigator, and a fantastic role model."

One colleague noted that students respond to Prather's personalized attention "in ways that continue to astound and impress me." Another characterized her as "smart, energetic, enthusiastic, productive, and articulate. She cares deeply about research and teaching, takes mentorship responsibilities very seriously, contributes time and energy to the community, and is a terrific colleague." ◊

Faculty News

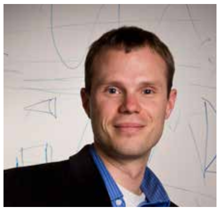
Bob Langer wins Kyoto Prize

Robert Langer, the David H. Koch Institute Professor at MIT, is one of three individuals who have been awarded this year's Kyoto Prize, Japan's highest private award for global achievement, created by Japanese philanthropist Kazuo Inamori. As part of the prize, Langer will receive a diploma, a gold Kyoto Prize medal, and a cash gift of 50 million yen (approximately $500,000).

Langer, who holds appointments in the departments of chemical engineering and biological engineering, was cited as "a founder of the field of tissue engineering and creator of revolutionary drug delivery system (DDS) technologies." His citation notes that "tissue engineering is indispensable for the implementation of regenerative medicine. Langer's technique applies biodegradable polymer technologies to construct 'scaffolds' for cell growth, contributing to the regeneration of tissues and organs. He has also developed DDS technologies for the controlled release of proteins, nucleic acids, and other macromolecular drugs. He holds more than 800 patents and is actively involved in promoting the practical application of his discoveries as a leader in the interdisciplinary advancement of medicine and engineering."

The awards will be presented on Nov. 10 in Kyoto, Japan.

Brad Olsen selected as Sloan Research Fellow



Professor Bradley Olsen is one of 126 American and Canadian researchers awarded 2014 Sloan Research Fellowships, the Alfred P. Sloan Foundation.

Awarded annually since 1955, Sloan Research Fellowships are given to early-career scientists and scholars whose achievements and potential identify them as rising stars among the next generation of scientific leaders. This year's recipients are drawn from 61 colleges and universities across the United States and Canada.

"For more than half a century, the Sloan Foundation has been proud to honor the best young scientific minds and support them during a crucial phase of their careers when early funding and recognition can really make a difference," Paul L. Joskow, president of the Alfred P. Sloan Foundation, said in a statement. "These researchers are pushing the boundaries of scientific knowledge in unprecedented ways."

Administered and funded by the foundation, the fellowships are awarded in eight scientific fields: chemistry, computer science, economics, mathematics, evolutionary and computational molecular biology, neuroscience, ocean sciences, and physics. To qualify, candidates must first be nominated by fellow scientists and subsequently selected by an independent panel of senior scholars. Fellows receive $50,000 to be used to further their research.

Kwanghun Chung named Searle Scholar

Assistant Professor Kwanghun Chung is one of fifteen 2014 Searle Scholars. The Searle Scholars Program supports research of outstanding individuals who have recently begun their appointment at the assistant professor level, and whose appointment is their first tenure-track position at a participating academic or research institution. Today, 153 institutions are invited to participate in the Program.

Chung's research area is "Whole Brain Single Cell-Omics for Understanding Brain Function and Dysfunction."

"A mammalian brain is staggeringly complex. It consists of billions of neurons forming thousands of specific connections with other neurons. Each individual neuron belongs to one of thousands of genetically distinct populations," he explains, "In studying how genes and environmental factors affect function and dysfunction of such a complex system, technologies that enable rapid extraction of brain-wide anatomical connectivity as well as molecular details from the same brain at single cell resolution, would have the potential to radically accelerate the rate of discovery. We develop and apply such transformative techniques to identify neuronal circuits, subcellular structures, genes and molecules that are abnormal in the diseased brain."

The Program was established at The Chicago Community Trust in 1980 and has been administered by Kinship Foundation since 1996. The Program is funded from the estates of Mr. and Mrs. John G. Searle. Mr. Searle was the grandson of the founder of the world-wide pharmaceutical company, G.D. Searle & Company. It was Mr. Searle's wish that certain funds be used to support "...research in medicine, chemistry, and the biological sciences."

Each year 15 new individuals are named Searle Scholars. Awards are currently set at $100,000 per year for three years. Since its inception, 542 Scholars have been named and over $115 million has been awarded.

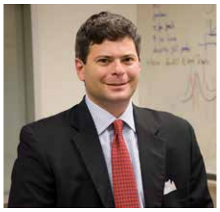
Two Professors earn tenure

The Department is proud to announce two newly tenured professors: Daniel Anderson and J. Christopher Love.

Daniel Anderson, the Samuel A. Goldblith Associate Professor of Applied Biology in the Department of Chemical Engineering, the Institute for Medical Engineering and Science, and the David H. Koch Institute for Integrative Cancer Research, centers his research on the combinatorial development of biomaterials and nanoparticles for medicine, including the delivery of drugs and macromolecules inside specific cell targets, in vivo.

J. Christopher Love, an associate professor in the Department of Chemical Engineering, improves the design and implementation of quantitative bioanalytical processes in order to gain a deeper knowledge of the heterogeneities and dynamics of individual cells within a complex population.

The Novartis-MIT Center for Continuous Manufacturing wins collaboration award



The Novartis-MIT Center for Continuous Manufacturing, a 10-year research collaboration aimed at transforming pharmaceutical production, has earned the Council for Chemical Research (CCR)'s 2014 Research Collaboration Award. The Center's director is Professor Bernhardt Trout.

Combining the industrial expertise of Novartis with MIT's scientific and technological leadership, the Center develops new technologies to replace the pharmaceutical industry's conventional batch-based system with a continuous manufacturing process.

Initial research is conducted primarily through PhD programs at MIT laboratories and involves MIT faculty members, students, postdoctoral fellows, and staff scientists. Novartis then applies the research to industrial-scale projects and pilots new manufacturing processes using its own pharmaceutical products. Novartis has committed its manufacturing and R&D resources and $65 million to the Center over the next 10 years.

Citing the programs collaborators - MIT, Novartis, and the FDA - this award honors a team of professionals in the field whose combined efforts have made an outstanding contribution to the advancement of chemistry-related science or engineering.

The award description explains that articulation of successful collaborations between university, industry and government laboratories in development and commercializing new technologies is important. CCR's Action Network for Research Collaboration maintains a collection of "success stories," which will now include the MIT-Novartis Center, to serve as examples of collaboration success that is beneficial to the country. ◊

2014 Hottel Lecture in Chemical Engineering Friday, November 21, 2014

Energy and the Industrial Revolution: Past, Present, and Future

Arun Majumdar
Jay Precourt Professor, Stanford University
Former VP of Energy, Google.org

Arun Majumdar is the Jay Precourt Professor at Stanford University, where he serves on the faculty of the Department of Mechanical Engineering and is a Senior Fellow of the Precourt Institute for Energy.

Prior to joining Stanford, he was the Vice President for Energy at Google, where he created several energy technology initiatives and advised the company on its broader energy strategy. He continues to be a consultant to Google on energy.

In October 2009, Dr. Arun Majumdar was nominated by President Obama and confirmed by the Senate to become the Founding Director of the Advanced Research Projects Agency - Energy (ARPA-E), where he served till June 2012. Between March 2011 and June 2012, Dr. Majumdar also served as the Acting Under Secretary of Energy, and a Senior Advisor to the Secretary of Energy.

For more information on the Hottel lecture, go to *http://web.mit.edu/cheme/news/hottel.html*

Faculty News

Professor Charlie Cooney retires

Professor Emeritus Charles L. Cooney, the former Robert T. Haslam (1911) Professor of Chemical and Biochemical Engineering and Faculty Director of the Deshpande Center for Technological Innovation, has retired after 34 years as a professor at MIT.

Cooney has been integral part of the field of biochemical engineering since its infancy. With the advent of recombinant DNA techniques in the 1970s, Cooney quickly joined the effort to translate biotechnology discoveries into new manufacturing processes and products working primarily in the pharmaceutical industry.

In the Department of Chemical Engineering, Cooney will continue to teach courses in biochemical engineering with a focus on separation processes and drug development. He has taught in Professional Education courses since 1970, originally in Institute Prof. Daniel Wang's course on Fermentation Technology. He has followed it with related course, Downstream Processing, which continues to be a rapidly evolving field.

Over the years, Cooney has worked on problems involving biofuels, single-cell protein, recombinant proteins, and small molecule drugs. The Cooney Lab has addressed a range of questions about scaling up cultures to industry scale. Lab results include software that precisely controls biochemical processes and a real-time, non-invasive technique to monitor power-mixing.

Cooney's research and teaching interests span a range of topics in biochemical engineering and pharmaceutical manufacturing. He has published over 300 research papers, over 30 patents and co-authored or edited 5 books including *Development of Sustainable Bioprocesses: Modeling and Assessment*, Wiley Press 2006. He research interest include manufacturing in the pharmaceutical, biotech and biofuels industries, as well as bioprocess design, operation and control, and processing of pharmaceutical powders and technological innovation strategy. His teaching has focused on bioprocessing, drug development and technological innovation. As founding faculty director of the Deshpande Center he is interested in the process of stimulating technological innovation and translating innovation into new company creation.

Cooney received his Bachelor's degree in Chemical Engineering from the University of Pennsylvania (1966), Master's (1967) and Ph.D. (1970) degrees in Biochemical Engineering from MIT. After a short post-doctoral time at the Squibb Institute for Medical Research in 1970, he joined the MIT faculty as an Assistant Professor in 1970 and became a full Professor in 1982. He received the 1989 Gold Medal of the Institute of Biotechnological Studies (London), the Food, Pharmaceutical and Bioengineering Award from the American Institute of Chemical Engineers and the James Van Lanen Distinguished Service Award from the American Chemical Society's Division of Microbial and Biochemical Technology, was elected to the American Institute of Medical and Biochemical Engineers and in 2009 elected to the first class of American Chemical Society Fellows. In July 2012 he was awarded Honoris Causa by Ramon Llull University in Barcelona. He serves as a consultant to a number of biotech and pharmaceutical companies, is on multiple editorial boards of professional journals, sits on the Boards of Directors of Polypore International, Inc., LS9, Inc., Mitra (India), GreenLight Bioscience, Essentient, Inc. and Biocon, Ltd (India) and was previously on the Boards of Genzyme, Cuno, Inc., Pall Corp. and Astra. He chaired the FDA Advisory Committee for Pharmaceutical Science from 2004-2006.

In addition to his professional interests, Prof. Cooney is a Trustee Emeritus of Boston Ballet, an Overseer of the Boston Symphony Orchestra, and a board member of MIT's Community Service Fund. Other interests include rock climbing, skiing, high altitude mountaineering (with assents of Denali, Ama Dablam, Mont Blanc, Kilimanjaro, Huascaran), scuba diving and antique map collecting. ◊

Representing three academic generations, Charlie Cooney, Art Humphrey and Danny Wang celebrate the 50th anniversary of Wang's Fermentation Technology short course during the summer of 2014.

Two honors for Danny Wang

Fermentation Technology Short Course celebrates its 50th anniversary

Started in 1970 by Danny Wang and Charlie Cooney, "Fermentation Technology" is the longest-run course in the MIT Professional Education catalog. This course emphasizes the application of biological and engineering principles to problems involving microbial, mammalian, and biological/biochemical systems. The aims of the course are to review fundamentals and provide an up-to-date account of current knowledge in biological and biochemical technology. The lectures will emphasize and place perspectives on biological systems with industrial practices. The course is a perennial favorite, with attendees from all areas of industry.

This summer marked the 50th offering of the course, with Wang continuing as director, along with his present co-director, Professor Kristala Prather.

To mark the occasion, The course held a special lobster bake (to help the attendees experience as much New England culture as possible) and the students and Wang were presented with engraved bottles of wine commemorating the milestone.

Wang has no plans to step down any time soon.

For more information on this and other professional education short courses, go to *web.mit.edu/professional/*.

Danny Wang and Kristala Prather at the 2014 Fermentation Short Course celebration.

"Danny Wang started biotechnology before there was biotechnology."

- Frances Arnold, inaugural Daniel I.C. Wang Lecturer

The Daniel I.C. Wang Lecture on the Frontiers of Biotechnology established

The Daniel I. C. Wang Lecture, previously the Frontiers of Biotechnology Lectureship, was established in 1999 through a generous donation from Dr. Noubar Afeyan to acknowledge the enabling technologies and developments that have sustained the growth of biotechnology and life sciences. Some of these include bioprocess engineering (upstream and downstream processes), bioanalytical developments, advanced and new instruments, novel delivery concepts, biomedical devices, rational drug design, computational methods, bioinformatics, and information technology. It is the intent of this Lectureship to recognize and honor achievements on the "frontiers of biotechnology" and the distinguished scientists and engineers responsible for them.

The lecture was renamed in 2014 to honor Institute Professor Daniel I.C. Wang, a poineer and leader in the field of biochemical and biological engineering.

The inaugural Wang Lecturer was Frances Arnold of the California Institute of Technology, who spoke on "Expanding the enzyme universe by evolution and design" on Friday, September 26, 2014.

For a video of the lecture, go to *web.mit.edu/cheme/news/wang/*.

Frances Arnold speaks to a full house during the first Daniel I.C. Wang Lecture.

Student News

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

Scaling up in Morocco

Course X students experience first-hand a new culture and a new perspective of their chemical engineering work

The ever-increasing global population, coupled with limited available arable lands, is exerting growing pressure on our global food supply. These nutrition demands can only be met through efficient, sustainable agricultural practices, which, in general, rely on the use of fertilizers. Phosphate, one of the three key nutrients in fertilizers, is a limited natural resource, and there are only finite currently known reserves of this important mineral; the world's largest reserves are located in the Khouribga basin in central Morocco.

OCP Group, a Moroccan state-owned corporation founded in 1920, is one of the world's leading exporters of phosphate rock and derivative products. OCP produces a wide range of products across the phosphate value chain, with operations that range from phosphate rock mining to chemical processing of phosphoric acid and fertilizers. In the past few years since they joined our Industrial Liaison Program (ILP), OCP has begun to develop strong ties with MIT; these ties cut across many different areas, including an Executive Management program with the Sloan School, and a co-development and research program with the Chemical Engineering department. Recognizing that optimizing the processing and use of phosphate could be both an important undertaking for the company and an opportunity for rich scholarly research, OCP and MIT have developed a joint R&D agreement. Professors T. Alan Hatton and Claude Lupis visited the OCP facilities in Morocco a number of times over the past three years, with reciprocal visits by OCP researchers to MIT, to develop a comprehensive OCP-MIT Program in Phosphate Processing. Co-Directors Hatton and Lupis were joined by Professors Allan Myerson, Richard Braatz, Daniel Blankschtein and James Swan as co-PIs to address selected issues in the mining, beneficiation and processing of this finite resource through the application of sound fundamental chemical and engineering principles. The joint R&D agreement was executed in December 2013.

Kathryn Maxwell poses in front Casablanca's Hassan II Mosque, home of the world's tallest minaret.

In January 2014, five MIT Chemical Engineering professors (T. Alan Hatton, Claude Lupis, Allan Myerson, Richard Braatz and Jim Swan) traveled to Morocco with a postdoc associate (Paul Brown) and six students (Ran Chen, Kathryn Maxwell, You Peng, Vishnu Sresht, Qing Xu and Zhilong Zhu) to visit the mining and chemical processing sites, and to give presentations to the OCP Group staff. The goal was for the students to get a better appreciation for what their projects are really about, and to make personal connections with their counterparts in the company.

"The field trip to OCP Morocco was a once-in-a-life-time experience. We were not only warmly welcomed by the project sponsors at OCP, but also were amazed by the gigantic mining facilities as well as the large scale production complex they own," said You Peng, a graduate student of Allan Myerson and Richard Braatz, "The sheer size of the mining sites, which produce ~30 million tons of phosphate rock per year, was far beyond my expectations and imagination. An important purpose of this well-organized site visit was to build connections with the corresponding project advisors and update them on the goals, plans, and current progress of the various collaborative projects. Overall, these discussions clarified the critical details of the processes of interest and provided us with the specific expectations of the company sponsors."

"A 100 ton dump truck, 100 ton mining shovel, Komatsu bulldozer, I had all these toys as a kid, but to see these colossal machines at work voraciously clawing at 19 million tons of phosphate rock was, to me, phenomenal," said Paul Brown, a postdoc in the Hatton Lab. He was impressed with how "the extracted 'white gold', along with disinterred fossils, rolls along kilometers of conveyor belt across the arid landscape to the beneficiation plant, and then is transported to be treated and turned into phosphoric acid and fertilizer near the coastal ports in order to ready them for shipment around the world for use as fertilizer and feeds and, more recently, for use in lithium ion batteries."

Blankschtein graduate student Vishnu Sresht offered his perspective:

"OCP produces nearly 5 million tons of phosphoric acid annually, accounting for about 40% of global phosphoric acid exports. However, knowing these numbers does nothing to prepare you for the shock of seeing OCP's gargantuan draglines. The first glimpse of these 10,000 ton, 2000 kW guzzling monsters, looming over a desolate, semi-desert landscape littered with 100 foot tall mounds of rock and dirt, strongly reminds you of seeing majestic Brachiosaurs for the first time in Jurassic Park. This feeling of immense scale is

"This was the first time I had been to a chemical plant and I was lucky that I had come to the biggest. I now realized how even the most modest of discoveries or advancements in the lab back at MIT would scale up to improve production, cut energy and water usage and mitigate potential environmental degradation."

- Paul Brown, postdoctoral associate in the Hatton Lab

The MIT students and postdoc pose in front of an OCP mining truck used to cart phosphate ore to a nearby washing and cleaning facility.

a constant companion on a tour of OCP's mining and extraction facilities, lending a sense of surrealism whenever you see draglines dump 100 tons of ore onto mining trucks whose wheels are twice as tall as a grown man, or stand on the banks of a 300-foot diameter sedimentation tank."

OCP is more resolute than ever before on expansion. As part of an ambitious multi-billion dollar investment strategy, Morocco's largest corporation plans to expand several phosphate mines in central Morocco at Khouribga, and construct the world's first solid-material conveying pipeline to transport the phosphate ore 116 miles to the Atlantic coast where its chemical plants and shipping facilities are located. A critical component of this investment strategy is this collaboration with the chemical engineering department at MIT, through which MIT and OCP engineers hope to develop new and improved methods for the flotation of phosphates from phosphate ore, the removal of wa¬ter from phosphate rock slurry via poly¬mer-based flocculation, the increase of phosphoric acid throughput via efficient crystallization, and even the extraction of uranium from process byproducts. This push to improve processes is a critical element in OCP's strategy to become a flexible, innovative cost-leader in the phosphate sector.

OCP's ambitions bode well for an over-pop¬ulated world where global food security is increasingly dependent on phosphate and phosphoric acid-based fertilizers. OCP's phosphate production targets are intend¬ed to enable an increase in global food production that would match the increase in the world population, which is projected to reach 9 billion by 2050 according to UN estimates.

Sresht continues, "As a graduate student working with Professor Blankschtein towards designing novel surfactant formulations to efficiently separate phosphate from the silicates and carbonates present in the phosphate ore, my visit to OCP's mining and processing facilities opened my eyes to the magnitude of the potential impact of any process improvements we come up with. The sheer volume of material being processed at the OCP facilities guarantees that even a 5% enhancement in process efficiencies can potentially have a major impact. But seeing these facilities also drives home the realization that most real-world industrial processes are much 'dirtier' than the idealized bench-scale set¬ups that researchers are used to working with—both in terms of the number and variety of contaminants present in a typical system, and, in this case, the volume of actual dirt present in the ores! Understanding how to apply results from computational models and bench-top experimental setups to these large-scale systems will be a challenging endeavor."

Kathryn Maxwell, a graduate student in both the Hatton and Blankschtein labs, explains, "Our trip to Morocco was my first international experience. It was enlightening to see both a new culture and the equip

continued on page 19

An OCP dragline moving dirt and rock to expose the phosphate ore underneath. Note for scale the people at the bottom center of the photo.

Tiny particles could help verify goods

Chemical engineers hope smartphone-readable microparticles could crack down on counterfeiting.

Article by Anne Trafton, courtesy of the MIT News Office.

Some 2 to 5 percent of all international trade involves counterfeit goods, according to a 2013 United Nations report. These illicit products — which include electronics, automotive and aircraft parts, pharmaceuticals, and food — can pose safety risks and cost governments and private companies hundreds of billions of dollars annually.

Many strategies have been developed to try to label legitimate products and prevent illegal trade — but these tags are often too easy to fake, are unreliable, or cost too much to implement, according to MIT researchers who have developed a new alternative.

Led by MIT chemical engineering professor Patrick Doyle and Lincoln Laboratory technical staff member Albert Swiston, the researchers have invented a new type of tiny, smartphone-readable particle that they believe could be deployed to help authenticate currency, electronic parts, and luxury goods, among other products. The particles, which are invisible to the naked eye, contain colored stripes of nanocrystals that glow brightly when lit up with near-infrared light.

These particles can easily be manufactured and integrated into a variety of materials, and can withstand extreme temperatures, sun exposure, and heavy wear, says Doyle, the senior author of a paper describing the particles in the April 13 issue of Nature Materials. They could also be equipped with sensors that can "record" their environments — noting, for example, if a refrigerated vaccine has ever been exposed to temperatures too high or low.

The paper's lead authors are MIT postdoc Jiseok Lee and graduate student Paul Bisso. MIT graduate students Rathi Srinivas and Jae Jung Kim contributed to the research.

'A massive encoding capacity'

The new particles are about 200 microns long and include several stripes of different colored nanocrystals, known as "rare earth upconverting nanocrystals." These crystals are doped with elements such as ytterbium, gadolinium, erbium, and thulium, which emit visible colors when exposed to near-infrared light. By altering the ratios of these elements, the researchers can tune the crystals to emit any color in the visible spectrum.

To manufacture the particles, the researchers used stop-flow lithography, a technique developed previously by Doyle. This approach allows shapes to be imprinted onto parallel flowing streams of liquid monomers — chemical building blocks that can form longer chains called polymers. Wherever pulses of ultraviolet light strike the streams, a reaction is set off that forms a solid polymeric particle.

In this case, each polymer stream contains nanocrystals that emit different colors, allowing the researchers to form striped particles. So far, the researchers have created nanocrystals in nine different colors, but it should be possible to create many more, Doyle says.

Using this procedure, the researchers can generate vast quantities of unique tags. With particles that contain six stripes, there are 1 million different possible color combinations; this capacity can be exponentially enhanced by tagging products with more than one particle. For example, if the researchers created a set of 1,000 unique particles and then tagged products with any 10 of those particles, there would be 1030 possible combinations — far more than enough to tag every grain of sand on Earth.

"It's really a massive encoding capacity," says Bisso, who started this project while on the technical staff at Lincoln Lab. "You can apply different combinations of 10 particles to products from now until long past our time and you'll never get the same combination."

"The use of these upconverting nanocrystals is quite clever and highly enabling," says Jennifer Lewis, a professor of biologically inspired engineering at Harvard University who was not involved in the research. "There are several striking features of this work, namely the exponentially scaling encoding capacities and the ultralow decoding false-alarm rate."

Versatile particles

The microparticles could be dispersed within electronic parts or drug packaging during the manufacturing process, incorporated directly into 3-D-printed objects, or printed onto currency, the researchers say. They could also be incorporated into ink that artists could use to authenticate their artwork.

the tag's material properties without impacting the coding strategy is really powerful," he says. "What separates our system from other anti-counterfeiting technologies is this ability to rapidly and inexpensively tailor material properties to meet the needs of very different and challenging requirements, without impacting smartphone readout or requiring a complete redesign of the system."

The research was funded by the U.S. Air Force, the Office of the Assistant Secretary of Defense for Research and Engineering, the Singapore-MIT Alliance, the National Science Foundation, the U.S. Army Research Office, and the National Institutes of Health. ◊

2014 Alumni TG

On the afternoon of Friday, April 11, Course X students, faculty and alumni celebrated the beginning of the weekend. A monthly tradition managed by the GSCX, TGs offer a respite from studies and research, and allow the ChemE Community to relax together. We plan to host another alumni-centric TG in the spring; be on the lookout for an invitation from our graduate students.







(Morocco article continued from page 17)

ment my project works with in full scale. The equipment was all much larger than I had pictured, especially the giant dragline that scooped up rocks and the mining pits themselves. The OCP representatives were very excited to welcome us and give us tours of their facilities, and served us authentic Moroccan tea and lunches. It was very helpful to discuss our projects with OCP in person and to get their feedback and expertise on the various projects."

Qing Xu, a member of the Hatton and Swan groups, concurred that the warm welcome by OCP ensured that the visit "was really a wonderful experience." He added, "I was extremely impressed by the huge dragline (like a skyscraper); humans are like ants when standing beside those giants!"

Ran Chen, who is working with Lupis and Hatton, noted that "the gigantic machine is operated by only one person and it took him tens of years to learn how to do that. Gaining such first-hand experience of industrial processing was really helpful for me in terms of understanding what was going on in real production and how our research can help to improve the efficiency of real industry."

Maxwell continued that "between instructive talks and site tours, our affable hosts provided plenty of traditional food and entertainment, whether on-site or at our hotel in Casablanca. Scientific discussion was varied and fun and it slowly dawned on me that improving the seemingly simple procedure of digging and washing rock was going to be quite challenging. We would suggest an approach only to be rebutted, offer a solution only to find its flaws. It was exciting to be involved in this kind of deliberation and to even-tually settle on directions we all thought might be fruitful allowing for fundamental chemistry and modelling to combine with process engineering to reach our goals."

Sresht embraces the program as well: "Addressing these challenges is not without its perks. The chance to co-develop innovations with OCP and have them implemented on OCP's shop floor brings with it the opportunity to explore the ethnic diversity of Morocco. The country's unique geographical position gives it a wealth of culture, architecture, and cuisine with discernable French, Spanish, Berber, and Arabic influences. Where else can you ponder fascinating chemical engineering problems while sampling spicy tagines?"

Zhilong Zhu, who works alongside Peng in in the Braatz and Myerson team, agrees: "Without any question, I think this was a truly worthwhile trip and I look forward to going to Morocco again for our yearly update meetings." ◊

Research Highlights

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

Bionic plants

Nanotechnology could turn shrubbery into supercharged energy producers or sensors for explosives.

Article by Anne Trafton, courtesy of the MIT News Office.

Plants have many valuable functions: They provide food and fuel, release the oxygen that we breathe, and add beauty to our surroundings. Now, a team of MIT researchers wants 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.

In a new Nature Materials paper, the researchers report 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."

Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering and leader of the MIT research team, and the paper's lead author, postdoc and plant biologist Juan Pablo Giraldo, envision turning plants into self-powered, photonic devices such as detectors for explosives or chemical weapons. The researchers are also working on incorporating electronic devices into plants. "The potential is really endless," Strano says.

Supercharged photosynthesis

The idea for nanobionic plants grew out of a project in Strano's lab to build self-repairing solar cells modeled on plant cells. As a next step, the researchers wanted to try enhancing the photosynthetic function of chloroplasts isolated from plants, for possible use in solar cells.

Chloroplasts host all of the machinery needed for photosynthesis, which occurs in two stages. During the first stage, pigments such as chlorophyll absorb light, which excites electrons that flow through the thylakoid membranes of the chloroplast. The plant captures this electrical energy and uses it to power the second stage of photosynthesis — building sugars.

Chloroplasts can still perform these reactions when removed from plants, but after a few hours, they start to break down because light and oxygen damage the photosynthetic proteins. Usually plants can completely repair this kind of damage, but extracted chloroplasts can't do it on their own.

To prolong the chloroplasts' productivity, the researchers embedded them with cerium oxide nanoparticles, also known as nanoceria. These particles are very strong antioxidants that scavenge oxygen radicals and other highly reactive molecules produced by light and oxygen, protecting the chloroplasts from damage.

The researchers delivered nanoceria into the chloroplasts using a new technique they developed called lipid exchange envelope penetration, or LEEP. Wrapping the particles in polyacrylic acid, a highly charged molecule, allows the particles to penetrate the fatty, hydrophobic membranes that surrounds chloroplasts. In these chloroplasts, levels of damaging molecules dropped dramatically.

Using the same delivery technique, the researchers also embedded semiconducting carbon nanotubes, coated in negatively charged DNA, into the chloroplasts. Plants typically make use of only about 10 percent of the sunlight available to them, but carbon nanotubes could act as artificial antennae that allow chloroplasts to capture wavelengths of light not in their normal range, such as ultraviolet, green, and near-infrared.

With carbon nanotubes appearing to act as a "prosthetic photoabsorber," photosynthetic activity — measured by the rate of electron flow through the thylakoid membranes — was 49 percent greater than that in isolated chloroplasts without embedded nanotubes. When nanoceria and carbon nanotubes were delivered to-

Researchers use a near-infrared microscope to read the output of carbon nanotube sensors embedded in an Arabidopsis thaliana plant.

Photo: Bryce Vickmark

"Plants are very attractive as a technology platform. They repair themselves, they're environmentally stable outside, they survive in harsh environments, and they provide their own power source and water distribution."

- Michael Strano

Carbon P. Dubbs Professor of Chemical Engineering

gether, the chloroplasts remained active for a few extra hours.

The researchers then turned to living plants and used a technique called vascular infusion to deliver nanoparticles into Arabidopsis thaliana, a small flowering plant. Using this method, the researchers applied a solution of nanoparticles to the underside of the leaf, where it penetrated tiny pores known as stomata, which normally allow carbon dioxide to flow in and oxygen to flow out. In these plants, the nanotubes moved into the chloroplast and boosted photosynthetic electron flow by about 30 percent.

Yet to be discovered is how that extra electron flow influences the plants' sugar production. "This is a question that we are still trying to answer in the lab: What is the impact of nanoparticles on the production of chemical fuels like glucose?" Giraldo says.

Lean green machines

The researchers also showed that they could turn Arabidopsis thaliana plants into chemical sensors by delivering carbon nanotubes that detect the gas nitric oxide, an environmental pollutant produced by combustion.

Strano's lab has previously developed carbon nanotube sensors for many different chemicals, including hydrogen peroxide, the explosive TNT, and the nerve gas sarin. When the target molecule binds to a polymer wrapped around the nanotube, it alters the tube's fluorescence.

"We could someday use these carbon nanotubes to make sensors that detect in real time, at the single-particle level, free radicals or signaling molecules that are at very low-concentration and difficult to detect," Giraldo says.

By adapting the sensors to different targets, the researchers hope to develop plants that could be used to monitor environmental pollution, pesticides, fungal infections, or exposure to bacterial toxins. They are also working on incorporating electronic nanomaterials, such as graphene, into plants.

"Right now, almost no one is working in this emerging field," Giraldo says. "It's an opportunity for people from plant biology and the chemical engineering nanotechnology community to work together in an area that has a large potential."

The research was funded primarily by the U.S. Department of Energy. ◊

Other Fall 2014 Course X Research News

- Daniel Anderson designs nanoparticles offering better gene silencing, could help treat liver disease
- Martin Bazant helps to introduce a novel bromine battery: small-scale demo, large-scale promise
- Paula Hammond's "one-two punch" nanoparticle cancer treatment works on tumors
- Kristala Prather and colleagues use biology to improve chemical synthesis
- Paul Barton, Martin Bazant, Bill Green, Heather Kulik, and Will Tisdale earn MITEI energy research seed grant awards
- Daniel Anderson and Bob Langer expand the power of RNA interference

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

Research Highlights

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

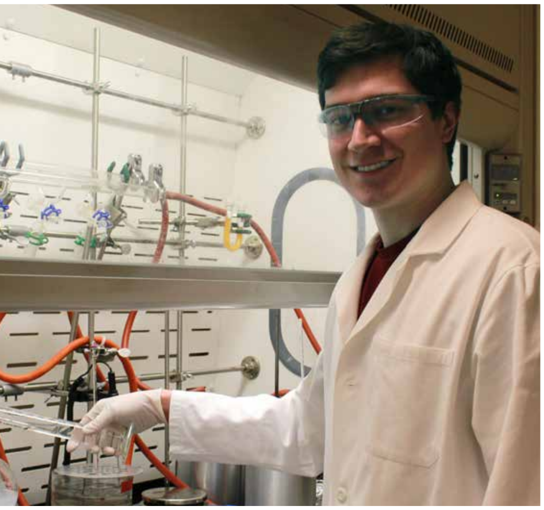
Engineering earth-abundant catalysts that mimic platinum in renewable energy technologies

MIT team develops a process to create inexpensive catalysts that can replace platinum catalysts in renewable energy technologies.

Article by Melanie Kaufman, courtesy of the MIT News Office.

When one considers nonrenewable resources, the first to come to mind are fossil fuels: petroleum, coal, and natural gas. The rapid depletion of these unsustainable resources has sparked global research on renewable-energy technologies, such as fuel cells, electrolyzers, and lithium-air batteries.

Unfortunately there is a common unsustainable thread that links these burgeoning technologies: a dependence on platinum-group metals (PGMs). These elements — platinum, palladium, rhodium, iridium, ruthenium, and osmium — are the six least-abundant in the Earth's lithosphere, yet are the most stable and active catalysts. Even with efficient recycling, numerous studies have indicated that the Earth simply does not contain enough PGMs to support a global renewable-energy economy. Thus, PGMs can be considered unsustainable resources that are currently needed to enable renewable energy technologies.



Graduate Student Sean Hunt, lead author on the paper.

MIT graduate student Sean Hunt, postdoc Tarit Nimmandwudipong, and Yuriy Román, an assistant professor of chemical engineering, have an idea for how to replace PGMs with metals that are more plentiful. In a paper published recently in the journal Angewandte Chemie, the team explained its process of synthesizing these alternative catalysts.

"Because the PGMs tend to be the most active and stable catalysts in virtually all relevant thermal and electrocatalytic processes, our research sought to answer an exciting question," Hunt explains. "Rather than finding new materials to replace PGMs in specific reactions, is it possible to modify the electron density of earth-abundant early transition metals [groups IV to VI on the periodic table] to catalytically mimic the PGMs?"

In the simplest sense, one can imagine that tungsten, with six valence electrons, can be electronically modified to mimic platinum, which has 10 valence electrons, by reacting it with carbon (four valence electrons) to give the ceramic material tungsten carbide (WC). Numerous studies have shown that WC is indeed platinum-like, and able to catalyze important thermo- and electrocatalytic reactions that tungsten metal cannot — such as biomass conversion, hydrogen evolution, oxygen reduction, and alcohol electrooxidation. Importantly, tungsten is more than three orders of magnitude more abundant than platinum in the Earth's crust, making it a viable material for a global renewable-energy economy.

However, both WC and platinum are heterogeneous catalysts, meaning that they require nanoparticle formulations to create high surface areas and invoke quantum confinement effects to maximize the rates of chemical reactions. While platinum nanoparticles are relatively easy to synthesize, until now, there have been no known methods to synthesize WC nanoparticles less than 5 nanometers and devoid of surface impurities. As Hunt explains, "Tungsten carbide forms at very high temperatures, typically over 800 degrees Celsius [1500 degrees Fahrenheit]. These high temperatures cause nanoparticles to sinter into large microparticles with low surface areas. Methods to date that alleviate this agglomeration instead result in nanoparticles that are covered with excess surface carbon. These surface impurities greatly reduce, or completely eliminate, the catalytic activity of WC."

To solve this problem, the MIT team developed a "removable ceramic coating method" by coating colloidally dispersed transition-metal oxide nanoparticles with microporous silica shells. At high temperatures, they show that reactant gases, such as hydrogen and methane, are able to diffuse through these silica shells and intercalate into the encapsulated metal oxide nanoparticles. This transforms the oxide nanoparticles into transition metal carbide (TMC) nanoparticles, while the silica shells prevent both sintering and excess carbon deposition. The silica shells can then be easily removed at room temperature, allowing the dispersal of nonsintered, metal-terminated TMC nanoparticles onto any high-surface-area catalyst support. This is the first method capable of this result.

The team has also been successful in synthesizing the first nonsintered, metal-terminated bimetallic TMC nanoparticles. Electrocatalytic studies have shown that these materials are able to perform hydrogen evolution and methanol electrooxidation at rates similar to commercial

Michelle Teplensky ’14

Alumna Highlight

Being a Course X senior makes one busy enough, but in her final year as an undergraduate, Michelle Teplensky was even busier than the average MIT student.

First, Michelle was selected for Capital One Academic All-America at-large honors, as announced by the College Sports Information Directors of America in June. She was voted to the third team for women’s field hockey. Teplensky tallied 17 goals, including three game-winners, and five assists for 39 points as a starter in the midfield. A NEWMAC All-Conference first-team selection, she ranked fifth in the league in goals and points. Teplensky secured a spot on the NFHCA New England East Region first team while collecting academic accolades from the NEWMAC and the NFHCA.

Teplensky has also won a Gates Cambridge Scholarship, a competitive full-cost scholarship allowing her to pursue a PhD in chemical engineering and biotechnology at the University of Cambridge, UK, in fall 2014.

At the University of Cambridge, Teplensky is focusing her PhD work on biotechnology and polymers, designing drug-targeting systems that can be commercialized. With the ultimate goal of becoming a CTO at a biotechnology company, she intends to focus her future research on targeted treatments. She is particularly interested not only in curing disease, but also making treatments less arduous. Teplensky explains, “I plan to work under Professor Nigel Slater to address the existent issue of treating debilitating diseases with a more effective and efficient drug delivery by combining novel technologies in chemical engineering, polymer science, and biopharmaceuticals. Professor Slater’s current research into targeted nanoparticles and biopolymers is a great fit for my passion and interests and I am incredibly excited and grateful to the Gates Cambridge Trust for such an incredible opportunity.”

A chemical-biological engineering major, Teplensky has done research in three MIT laboratories. In 2011, she worked in the Sikes Laboratory, which focuses on engineering biomolecular systems for the fields of medicine and energy. She then accepted a research position in the Prather Laboratory, which studies the production of unnatural organic compounds in the nascent field of synthetic biology.

Kristala Jones Prather, an associate professor of chemical engineering, says, “What sets Michelle apart from many of her peers is her leadership skills. She exudes a level of excitement and enthusiasm for science and engineering that is infectious and inspires others around her. I know that she will take this same energy and talent to new heights in the other Cambridge.” Teplensky also undertook research in the world-renowned Langer Laboratory, where she investigated the use of polymers for targeted therapies in the treatment of type-1 diabetes.

As a student, Teplensky was an active member of the MIT community, serving as a peer network engagement intern for MIT Hillel and advocate. She was president of MIT’s chapter of American Institute of Chemical Engineers, and developed a symposium that brought together company representatives to network with students. Through the MIT International Science and Technology Initiative (MISTI), she spent seven weeks in Germany, teaching math and science. ◊

PGM-based catalysts, while maintaining activity over thousands of cycles. The catalytic activities obtained were more than two orders of magnitude better than commercial WC powders and WC nanoparticles made by current state-of-the-art synthesis methods that do not prevent sintering or surface carbon deposition.

Next steps include the synthesis of other bimetallic TMCs, as well as transition metal nitride (TMN) nanoparticles. The team is investigating these materials for other electrocatalytic reactions as well as thermal catalytic reactions, such as hydrodeoxygenation for biomass reforming.

“This new method unlocks a broad range of monometallic and heterometallic transition metal carbide and nitride nanoparticles that researchers previously have been unable to synthesize or study,” Román says. “While our research focuses mainly on the sustainable replacement of PGMs in thermal and electrocatalytic applications, we also anticipate broader impacts of our new TMC and TMN technologies outside catalysis. Because of their unique chemical, mechanical, and electronic properites, carbides and nitrides have garnered much attention for use in applications as diverse as supercapacitors, medical implants, optoelectronics, coatings, and high-temperature materials for the aerospace and nuclear sectors.”

This research was supported by the Department of Energy’s Basic Energy Sciences Division. ◊

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***

Dynamet Technology, founded by **Stanley Abkowitz '48**, has been acquired by RTI International Metals. Dynamet is an industry innovator in titanium powder metallurgy and a supplier of near-net shape titanium and titanium alloy preforms and components to commercial aerospace, defense, biomedical and industrial customers. It will be included in RTI's Titanium Segment.

Abkowitz says, "We look forward to becoming part of the innovative team and culture at RTI. Our common view of the vast market opportunities and applications for the continued development and use of Dynamet Technology's advanced powder metal technology make joining with RTI the ideal path forward to accelerate progress and market acceptance."

Peter H. Spitz SM '48 has a blog called *chemengineeringposts.com*.

It includes weekly/biweekly posts covering the developments in the fields of industrial chemistry and energy.

Octavio Morelos Valdés '54 has written a book regarding the development of physics as a science. *La Física a Mi Alcance, Perspectiva Histórica* is not a textbook, but a history of the field. The book has two sections: the first is devoted to the general public, and the second contains pertinent suggestions for high school teachers to help make their courses more comprehensive and attractive.

Wolf Vieth '56, ScD '61 has been honored by Rutgers University's Department of Chemical and Biological Engineering for his work as its second chairman 1968-1978. The department writes, "A polymer scientist himself, Vieth worked on enzyme catalysis, a field which later evolved into biochemical engineering, microbioal engineering, fermentation and waste treatment technology. With Professor Alkis Constantinides, he helped establish the department's biochemical engineering research and educational programs. In 1970, the programs had become so prominent the department formally changed its name from the Department of Chemical Engineering to the Department of Chemical and Biochemical Engineering. Rutgers School of Engineering became the first university in the nation to sanction this name, giving the department the opportunity to have more visibility and relevance in New Jersey, which continued to grow as a chemical and pharmaceutical producer over the course of the decade. "

Michael Sefton ScD '74 has received the 2014 Engineers Canada Gold Medal Award, the highest engineering recognition in Canada. The citation states, "Mike Sefton of the University of Toronto is being honored for his groundbreaking work in tissue engineering. He was the first to recognize the importance of combining living cells with synthetic polymers to create 'artificial' organs and tissues. His current research into the creation of modular tissue components seeks to create cardiac muscle to treat heart failure and pancreatic tissue for diabetes, among other possibilities."

After nearly 5 years in senior engineering and contruction oversight roles on Chevron's Wheatstone LNG Project, **William Fraizer SM '80** recently transferred to a new position. He is now Technical Manager for the Gorgon Project's Commissioning & Start-up Team.

Gorgon is the largest of the two new greenfield LNG projects Chevron is building in Western Australia. The Gorgon Project scope includes subsea development wells, subsea gathering systems and pipelines, a 3 train LNG production & export system, and a Domestic Gas production system. First gas production is slated to begin in 2015.

Fraizer's new position will involve regular travel to the LNG plant site, located on Barrow Island, off the northwest coast of Australia, as well as work in their offices in Perth. He previously worked on Gorgon during earlier phases of its development, and is pleased to return to help bring the project into production.

Brian Anderson MSCEP '04, PhD '05 has had a busy 2014. In April 2014, he visited the White House as a 2012 Presidential Early Career Award for Scientists and Engineers recipient. On September 1st, West Virginia University launched its Energy Institute and he was named director.

Micah Green PhD '07 has been recognized by DuPont as a member of its 2014 Class of Young Professors. DuPont named 10 young faculty members from around the world to this group as part of its corporate efforts to recognize innovative research. Over the next three years, the company will provide these professors with $600,000 to support their work in advancing basic science to meet global challenges in food, energy and protection. ◊

Blast from the Past

In the Spring 2014 edition, fellow alumni and former staff found friends in the posted photos:

In the photo to the left, **Peter Moore PhD ’02** recognized himself in the photo to the left, as the left-most smiling graduate. **Carlos Rinaldi PhD ’02** is on the far right. Peter says, “That is the only time I wore that gown, which I had borrowed from Matthew Dyer. :-)”

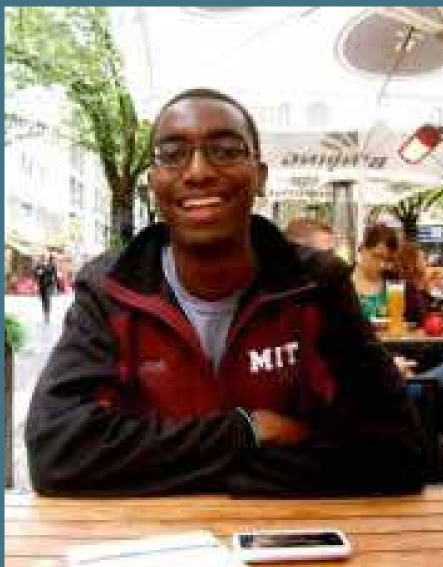
Since leaving MIT, Peter has been working for Evonik, a German specialty chemical company. He’s currently based in Singapore, in charge of building an extension to its Oil Additives plant.

This edition focuses on Holiday Party fun! Do you see yourself or others below?

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

In Memoriam

Paul Uche ’13



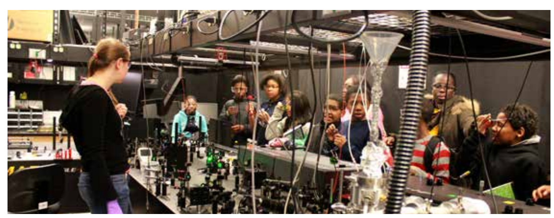
Paul U. “Looch” Uche ’13 died on June 19 in Toronto from causes related to leukemia. He was 23.

Uche, who received his SB in chemical engineering from MIT last June, was an active member of the MIT community, participating in the Bernard M. Gordon-MIT Engineering Leadership Program; the MIT International Science and Technology Initiatives (MISTI) program in France and Germany; the Public Service Center; and the Undergraduate Practice Opportunities Program. He was a cherished member of the Baker House and Westgate communities, as well as the Sigma Chi fraternity.

Diagnosed with acute myeloid leukemia in 2012, Uche’s search for a bone marrow donor inspired hundreds of classmates, professors, and friends to rally behind him, according to his family. A talented writer, musician, and engineer, Uche channeled much of his energies since being diagnosed into creative efforts, penning a blog, recording music, and raising awareness of leukemia to support the researchers and doctors who treated him in Boston and Toronto. ◊

Course X Hosts Future Chemical Engineers

In January, Professor William Tisdale and several Course X labs hosted teachers and middleschoolers from Boston’s Young Achievers Science and Math Pilot School. They spent the day learning about chemical engineering and conducting their own experiments.



Blast from the Past Bonus Update

We included in the Spring 2014 edition of XCurrents a photo from Gerry Lessells '50 from his time at the Practice School during the Spring of 1950. He thought it was at the Hercules Powder Company in Parlin, New Jersey.

A fellow subject of the image, Bill Nichols '50 wrote in to help fill in the blanks:

From left to right: (back row) Harry Foden, Ray Gilliam, Amiel Brinkley, Bill Nichols, unknown, and Gerry Lessells. (front row) Bhuvenish Mathur, P.T. Wu, Hugh Simpson, John Senese, and Fred Clemens.

Thank you to Gerry and Bill for sharing! ◊

A Special Lunch for the 2014 Fong Award Winner

The Wing S. Fong (1954) Memorial Prize was established in 2011 through the help of his wife Lourdes, daughter Genevieve, and family friend Dominick Sama SB '54 SM '55 ScD '60. Each year, it is awarded to a chemical engineering senior of Chinese descent with the highest cumulative GPA, in honor of the memory of Fong, his hard work, and his dedication to his adopted home, university, and country.

This year, the winner was Kevin Wu '14, and he had an opportunity to have a traditional Chinese lunch with Mrs. Fong while in the Bay Area this spring. They enjoyed a hearty Dim Sum with some of her friends. ◊

At left, Lourdes Fong (center left), Kevin Wu '14 (center right) and two friends. At right, some samples of the lunch, including traditional eggplant, chicken feet, chow faan with beef, and Chinese tamale.

Thank You for Your Support!

This honor roll is a special salute to those who have given over $100 to the MIT Chemical Engineering Department for the period of July 1, 2013, through June 30, 2014.

Thank you to everyone who has supported us throughout the year!

Every effort has been made to ensure the accuracy of this list.
Please direct corrections to: ***Melanie Kaufman, Editor,*** at melmils@mit.edu

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Massachusetts Institute of Technology
Chemical Engineering Department
77 Massachusetts Avenue, Room 66-369
Cambridge, MA 02139-4307 USA
web.mit.edu/cheme/

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Fall 2014 Chemical Engineering Dept. Seminar Schedule

All Seminars are Fridays at 3pm in 66-110, unless otherwise noted.

Friday, October 24
Biological Control Systems: Systems Biology of Diseases and the Design of Effective Treatments
Professor Babatunde Ogunnaike, University of Delaware

Friday, November 7
Predicting Physical and Chemical Properties of Complex Materials with First Principle Calculations
Professor Giulia Galli, Molecular Engineering, University of Chicago

Friday, November 14
An Engineering Approach to Identify Antivirulence Strategies
Professor Mark P. Brynildsen, Princeton University

Friday, November 21
***Hoyt C. Hottel Lecture*: Energy and the Industrial Revolution: Past, Present, and Future**
Arun Majumdar, Jay Precourt Professor, Stanford University; Former VP of Energy, Google.org

Friday, December 5
Protein Assembly and Disassembly to Create Therapeutic Materials
Professor Julie Champion, Georgia Institute of Technology

The MIT Chemical Engineering Department
cordially invites you to attend the

MIT CHEMICAL ENGINEERING RECEPTION
2014 Annual AIChE Meeting

Monday, November 17th, 2014
from 7:00 – 9:00 p.m.

Imperial Ballroom B
Atlanta Marriott Marquis
265 Peachtree Center Avenue NE
Atlanta, Georgia

to recognize the following award winners:

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