



2013 Annual Report

Momentum:
The Institute for
Molecular Engineering
Surges Ahead



THE UNIVERSITY OF
CHICAGO



Institute for
Molecular
Engineering



“Traditional engineering schools divide engineering subject matter into different departments and disciplines; IME combines disciplines into a new approach to engineering research and education.”

Matthew Tirrell
Pritzker Director
Institute for Molecular Engineering

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Matthew TirrellPritzker Director
Institute for Molecular Engineering

Transforming, Solving, Inspiring IME's vision of the future

Since our inaugural report a year ago, the faculty of the Institute for Molecular Engineering has doubled in size from four to eight members, strengthening our group in quantum materials and computational engineering, and broadening our expertise in bioengineering and water. Having built this foundation, we find ourselves at the edges of two transitions.

First of all, with eight faculty members, we can expand from a near-exclusive focus on growth to beginning to deliver, and we are delivering on numerous fronts. We had established about \$2.5 million of new, funded research at the University of Chicago as of the end of fiscal 2013 in July, and that grew to more than \$4 million by the end of the calendar year. In May, we received approval from the University's Council of the Academic Senate to establish a PhD degree in Molecular Engineering. As of this writing, IME faculty are deeply immersed in reviewing applications and beginning to recruit the very top candidates that we identify. In December, the Curriculum Committee of the College approved the establishment of an undergraduate minor in Molecular Engineering, setting the stage for the implementation of a full undergraduate degree program by the time the class that matriculates next fall graduates in 2018. The first IME course, "Introduction to Emerging Technologies," will also be delivered in the autumn.

A second major transition is moving from hiring established faculty members to hiring entry-level assistant professors. The process is different when hiring junior faculty, in that more candidates must be interviewed to determine the optimum talents and fits. New faculty members, fresh from doctoral and postdoctoral work, bring new energy, ideas, techniques, and styles, and they also require mentorship, collaboration, and guidance in shaping their academic careers. These new members, who will begin to join us in the next year, will be the long-term keepers of the distinctive culture and approaches to molecular engineering research and education that we are creating at the University of Chicago.

One of the principal things I have learned, in my 30 months at the Institute for Molecular Engineering, is that the nature of my job, as well as those of all the faculty and staff, changes continually as we grow. We are no longer in our infancy, but we're still growing rapidly. We're endeavoring never to miss the special opportunity that doing something for the first time embodies. That is a unique promise and possibility of IME.

As we embark on the year 2014, we have begun the process of articulating our vision and mission in a clear and compelling fashion:

- **VISION:** The Institute for Molecular Engineering is transforming research and education to become a world leader in solving major technological problems of global significance, and continually inspiring creative applications of molecular-level science.
- **MISSION:** Our mission is to translate discoveries in physics, chemistry, biology, and medicine into solutions to important societal problems, and to create a research and teaching environment to enhance and transmit these capabilities to future generations.

Let us know what you think; email us at ime@uchicago.edu.

A handwritten signature in blue ink that reads "Matt Tirrell".

Matthew TirrellPritzker Director
Institute for Molecular Engineering

"In the year ahead, IME's scientists and engineers will combine the exceptional resources of the University of Chicago and Argonne to carry out research on the most important challenges of our time in energy, water, medicine, and molecular-level sciences."

— Eric D. Isaacs, Provost Designate, Director of Argonne National Laboratory, Professor in Physics, James Franck Institute, and the College

Institute for Molecular Engineering By the Numbers

New stats for 2013 show growth at the Institute for Molecular Engineering. Our faculty doubled, we appointed 20 fellows from around the University and Argonne National Laboratory, and we continued to rack up publications and grants. Our strong start shouldn't be a surprise; we're young, ambitious, and healthy—perfect conditions for thriving.

8

Engineering
faculty members

20

IME fellows

26

Postdoctoral
researchers

26

Graduate
students

14

Undergraduate
researchers

19

Grants totaling
\$2.5 million awarded
in FY '13 to IME
researchers

35

Publications with IME affiliations



Graduate students pursue discovery at IME

Doubling Down

Founding faculty doubles in size

Expansion marked the year 2013 at the Institute for Molecular Engineering, with four prominent senior scholars joining the faculty. Their specialties range from cancer bioengineering and water research to quantum computing and regenerative medicine.

The new faculty members will join a preeminent group that includes pioneers in the molecular design of materials and new kinds of electronic circuitry. Three of the new faculty members also will hold joint appointments at IME's partner institution, Argonne National Laboratory, a global leader in computing and materials research and a partner of the Institute for Molecular Engineering.

“In the quantum world, it’s Godzilla.”

Andrew Cleland to arrive in summer 2014



“Experimental physicist Andrew Cleland may have become the first man to catch a glimpse of the parallel universe,” says actor Morgan Freeman in a Discovery Channel feature on Cleland. Cleland, who will join the IME faculty

from the University of California, Santa Barbara, in the summer of 2014, led the research team that built the first quantum machine, demonstrating that “big” objects also obey the rules of quantum mechanics. *Science* magazine named the accomplishment the “Breakthrough of the Year” in 2010.

“Everyone thinks quantum mechanics is associated only with very, very small things,” said Cleland. “But if quantum mechanics is the fundamental description, then it should apply to everything, not just to electrons and atoms but also to tennis balls and cars and people.”

Of course, “big” is relative. The quantum machine was built inside a small square of silicone, where Cleland and his team had etched a barely visible metal paddle (about the width of a human hair) made up of over a trillion atoms. Before, the biggest experiment to demonstrate the quantum effect only had about 100 atoms. As Freeman described the machine, “In the quantum world, it’s Godzilla.”

At IME, Cleland’s group will continue its efforts to build superconducting quantum

Investigation

Doubling Down

Founding faculty doubles in size

Andrew Cleland (continued)

information systems that aim to read and decode encrypted messages millions of times faster than current state-of-the-art methods. This could be used, for example, to measure virus loads in biological solutions and has potential applications in medicine, pharmaceuticals, and food additives.

“Fifteen years ago no one was talking about practical applications for using quantum states,” said Cleland. “But today we understand the physics of how this can be done and have taken a big first step by showing that such devices can be built. Now it’s mostly an engineering problem and a matter of how much money and resources will be available to solve it.”

“Matt’s putting together an amazing collection of people working together to solve big problems.”

—Andrew Cleland

Intersecting Ideas

Computation pioneer Giulia Galli joined IME in November

When Matthew Tirrell told Giulia Galli that molecular science would intersect with engineering and technology in the Institute for Molecular Engineering, Galli knew she had found a new home. After immigrating from Italy, living in Switzerland, and moving to California, Galli settled in Chicago last fall to join IME’s founding faculty as the Liew Family Professor in Electronic Structure Theory and Simulation.

“It sounded too perfect to be true,” said Galli.

“The interdisciplinary approach at IME was exactly how my own research has been evolving. Finally someone was putting together all the aspects of research in an interdisciplinary but focused way to find solutions to some of the most exciting science and technology problems.”

Galli has worked at the Swiss Federal Institute of Technology in Lausanne, Switzerland, and at Lawrence Livermore National Laboratory, where she led the Quantum Simulations Group. Before



Giulia Galli

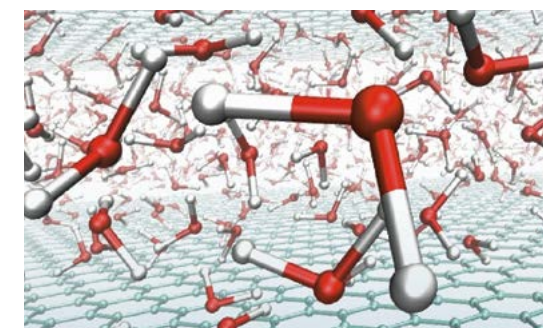
joining IME, she was Professor of Chemistry and Physics at the University of California, Davis.

Galli’s research involves the development of theories and computational methods to predict the properties of complex materials, encompassing solids, liquids, and nanostructures. She works closely with experimentalists to discover or modify materials’ properties so that they can function in a specific, desired manner. For example, her team is looking at how they might optimize abundant materials to more efficiently convert solar energy or store energy in chemical bonds.

Giulia Galli (continued)

Galli’s other work includes 15 years of studying the properties of water at ambient conditions and under pressure. At UChicago, she will work with scientists from around the University in the newly established Water Research Initiative. Galli will also continue her work with the Argonne Leadership Computing Facility, one of her many research sponsors. It not only has one of the biggest computers in the world, but its team of computational scientists can help Galli generate and test her computational methods and codes.

“Innovations do not happen in isolation,” said Galli. “The wide array of scientific activities within the University of Chicago is just phenomenal. I couldn’t think of a better opportunity.”



Galli’s work studies the properties of water in materials

From Laboratory to Real Life

Jeff Hubbell to begin at IME in 2014

With 84 patents, 324 publications, and start-up companies such as Focal Inc. and Biosurgery under his belt, Jeff Hubbell will join the Institute for Molecular Engineering next summer, poised to embody IME as an incubator for technology transfer. He has worked for the past 16 years using ideas developed in a lab to form companies or add to product portfolios, and has become an international leader in innovation spawned by research at the interface of disciplines.

Working as the Merck-Serono Chair in Drug Delivery and interim Dean of the School of Life Sciences at Ecole Polytechnique Federale de Lausanne, Switzerland, Hubbell has specialized in both life science and engineering fields.

“IME’s integrated thinking is 100 percent of who we are here,” he said. “The philosophy is rooted in deep science, yet driven with research principles, to understand, apply, and grow that science.”

At IME, Hubbell plans to continue his lab’s research in bioengineering, materials science, and chemical engineering for regenerative medicine and drug delivery; for the immune system’s fight of infection and malignancy; and for aspects that address autoimmune diseases such as type-1 diabetes.

“We have the opportunity to apply our knowledge of materials chemistry in diverse areas such as vaccines and thin films, and of protein engineering in regenerative medicine and immunological tolerance. IME offers us an excellent environment for such integrative work.”

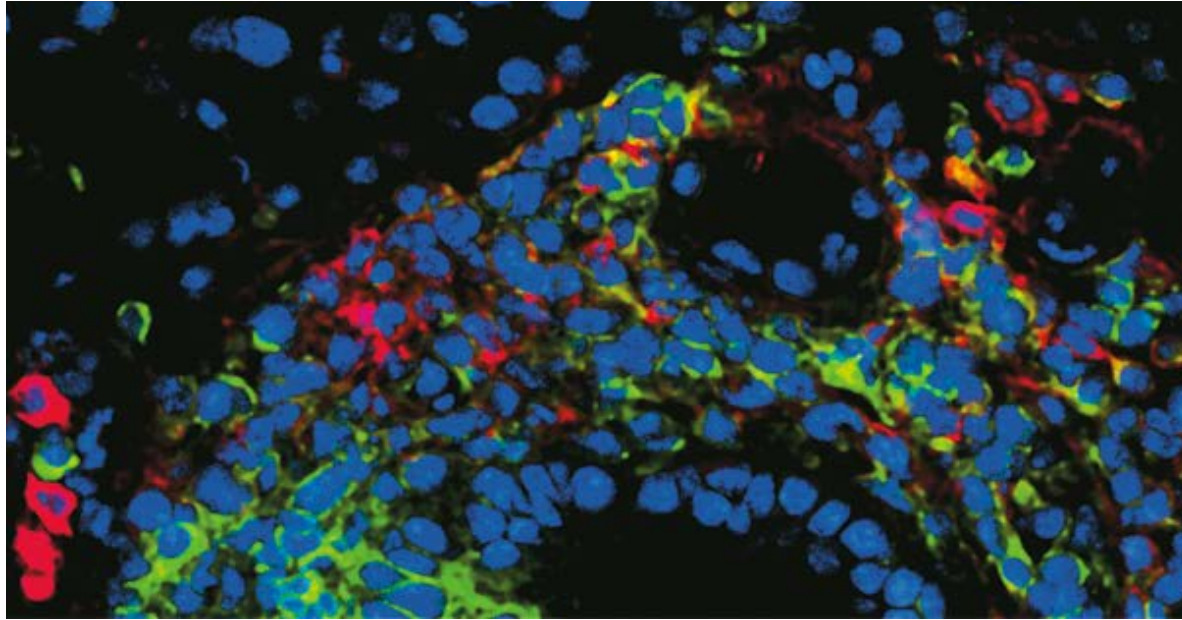
From Hubbell’s IME colleagues to the close collaboration with Argonne National Laboratory,



Jeff Hubbell

Doubling Down

Founding faculty doubles in size



Hubbell's work aims to modulate the immune system

“This is the chance to blend some of the greatest molecular engineering minds, while at the same time to rethink engineering education and to redefine the engineer of the future.”

—Jeff Hubbell

Jeff Hubbell (continued)

his lab can also benefit from work in other laboratories on energy. “In my biomaterials lab we conduct materials design, synthesis, and evaluation of polymer materials. The Argonne connection is especially intriguing because there are several applications of related materials in energy.”

Hubbell will also teach a course in the College on how to take an idea to market by working through innovation challenges, intellectual property issues, regulatory situations, marketplace demands, commercialization needs, and related economics.

“Science is a progression,” he said. “This is the chance to blend some of the greatest molecular engineering minds, while at the same time to rethink engineering education and to redefine the engineer of the future.”

Re-engineering Cancer Bioengineer Melody Swartz will join IME in July 2014

To Melody Swartz's mind, the Institute for Molecular Engineering has “a magnificent arrangement.” Her research in understanding the role of the lymphatic system in immunology and in cancer using an engineering approach is founded on a close dialogue between the physical and biological sciences. “With the developing environment in IME, we can carry out our integrative work with other immunologists and cancer biologists at the University of Chicago.” Swartz will join the faculty of IME in July.

She has spent the past 10 years at the Ecole Polytechnique Fédérale de Lausanne in Switzerland, most recently as Director of the Institute of Bioengineering. Trained as a chemical engineer, Swartz is a former professor at Northwestern University.

“We are discovering that the lymphatics help trick the immune system into treating the tumor as a normal tissue, enabling the tumor to avoid immune destruction. Our results suggest ways to reverse this response, to help re-educate the immune system to attack tumor cells instead of ignore them.”

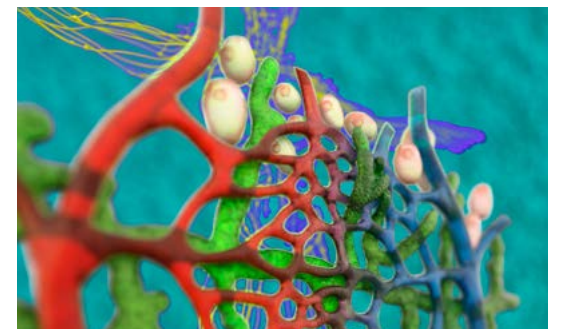
“The developing environment in IME is a magnificent arrangement, with a close dialogue between the physical and biological sciences.”

—Melody Swartz



Melody Swartz

Finding a new therapeutic strategy that targets lymphatic vessels to fight against cancer or autoimmunity is a long-term goal for Swartz. “Not many people are thinking about the lymphatic system as a target for therapy in this balance right now, so there is not much clinical research in this area,” she said. “It could be incredibly important.”



Swartz studies the tumor microenvironment

Another goal of Swartz's is to, “help students brand themselves without constricting buzz words,” she said. “Our belief is that real scientists need to constantly change. Our students are being trained to think big and to ask questions about the next cutting-edge thing. We want them to fluidly move into the next big thing, to zoom back out, and, finally, to identify how all of the moving parts fit together.”

Swartz was a 2012 MacArthur Foundation Fellow and the recipient of the largest Swiss award for cancer research, the Robert Wenner Award from the Swiss Cancer League.

Twenty Fellows Join IME

Pritzker Director of the Institute for Molecular Engineering Matthew Tirrell announced the appointment of 20 fellows to the Institute for Molecular Engineering in the fall of 2013. Recognized thought-leaders and esteemed research pioneers across the disciplines of physics, chemistry, biological sciences, and medicine, the fellows participate in IME's strategic planning and initiatives, including faculty recruiting, collaboration on research and education programs, joint efforts to secure research funding, and co-advising graduate students. They will serve for a term of three years renewable by mutual agreement.



John Alverdy

Sarah and Harold Lincoln Thompson Professor and Executive Vice Chair, Department of Surgery, and Director, Minimally Invasive Surgery

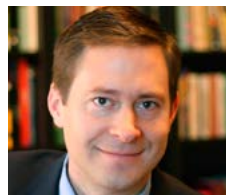
- Computational modeling, polymer therapies, anastomosis, necrotizing enterocolitis



Igor S. Aronson

Theory Group Leader, Senior Scientist, Materials Science Division, Argonne National Laboratory, and Fellow, Computation Institute

- Bacterial dynamics, self-assembled biomaterials, soft condensed matter physics, multi-scale modeling



Joel Collier

Associate Professor, Department of Surgery, Committee on Molecular Medicine, Committee on Immunology, the Graduate Program in Biophysical Sciences

- Self-assembling biomaterials systems, 3D cell culture, tissue repair



Seth B. Darling

Scientist, Center for Nanoscale Materials, Argonne National Laboratory

- Polymer molecular engineering, photovoltaics, nanopatterning/nanolithography, energy, solar energy, self-assembly, morphology characterization in soft matter systems



Greg Engel

Associate Professor, Department of Chemistry, James Franck Institute, and the Institute of Biophysical Dynamics

- Photosynthetic energy transfer, theoretical modeling, quantum materials, laser spectroscopy, photocatalysis and photochemistry



Nicola Ferrier

Principal Automation Engineer, Mathematics and Computer Science Division, Argonne National Laboratory, and Senior Fellow, Computation Institute

- Computer vision



Margaret Gardel

Associate Professor, Department of Physics, James Franck Institute, and the Institute for Biophysical Dynamics

- Force transmission at cell adhesions; cellular force transmission; self-assembly and biophysical properties of actin networks and bundles; jamming in colloidal suspension



Maryellen Giger

Professor of Radiology, the Committee on Medical Physics, and the College, and Vice Chair for Basic Science Research, Department of Radiology

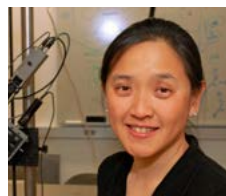
- Radiology, digital medical imaging, computer-aided diagnosis, quantitative image analysis, data-mining in breast imaging, chest/CT imaging, cardiac imaging, and bone radiography



Heinrich Jaeger

William J. Friedman and Alicia Townsend Professor of Physics, James Franck Institute, and the College

- Granular dynamics, soft robotics, dense suspensions, nanoparticle sheets, granular matter by design, necks and splats



Ka Yee C. Lee

Professor, Department of Chemistry, James Franck Institute, Institute for Biophysical Dynamics, and the Director of the Chicago Materials Research Center

- Protein-lipid interactions, biomembranes, monolayer and bilayer model systems for interfaces, microscopy and scattering techniques, biophysical aspects of diseases



Sidney Nagel

Stein-Freiler Distinguished Service Professor in the Department of Physics, James Franck Institute, and the College

- Granular materials, glass transition, jamming, singularities in free-surface flows, encapsulation of biological cells for transplantation, crumpling



Tobin Sosnick

Chair, Department of Biochemistry and Molecular Biology

- Synergistic studies of protein and RNA folding



Kevin White

Professor, Department of Human Genetics, Director, Institute for Genomics and Systems Biology

- Systems biology, gene regulatory networks, computational biology, cancer biomarkers and therapeutics



Stefan Vajda

Senior Scientist, Materials Science Division and Nanoscience and Technology Division, Argonne National Laboratory

- Physical and chemical properties of supported metal clusters and cluster-based nanomaterials, optical properties of clusters and nanostructures; nanocatalysis: study of the size/shape/composition and function relationship at the sub-nanometer and nanometer scale, support effects in catalysis; combined synchrotron X-ray scattering, X-ray absorption and mass-spectroscopy studies of nanocatalysts under realistic reaction conditions



Thomas Witten

Professor Emeritus in Physics, James Franck Institute, and the College

- Crumpling, evaporative deposition, granular packing, theoretical physics



Luping Yu

Professor of Chemistry

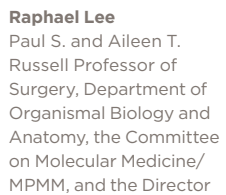
- Polymer chemistry, functional polymers, molecular electronics



Steven J. Sibener

Carl William Eisendrath Distinguished Service Professor, Department of Chemistry and James Franck Institute, and Director of the IME Water Research Initiative

- Chemical physics, physical chemistry of surfaces, nanoscience, polymer interfaces



Raphael Lee

Paul S. and Aileen T. Russell Professor of Surgery, Department of Organismal Biology and Anatomy, the Committee on Molecular Medicine/MPMM, and the Director of the Laboratory for Molecular Regeneration

- Electromagnetic (including ionizing) fields on tissue growth, repair, and morphogenesis



Steven J. Sibener

Carl William Eisendrath Distinguished Service Professor, Department of Chemistry and James Franck Institute, and Director of the IME Water Research Initiative

- Chemical physics, physical chemistry of surfaces, nanoscience, polymer interfaces



Julian Solway

Walter L. Palmer Distinguished Service Professor for Medicine and Pediatrics, Director of the Institute for Translational Medicine, Biological Sciences Division Associate Dean for Translational Medicine, Vice Chair for Research, Department of Medicine, and Chair, Committee on Molecular Medicine

- Asthma genetics, respiratory mechanics, computational modeling, cell and molecular physiology



Peter Littlewood

Professor of Physics and James Franck Institute, Associate Laboratory Director for Physical Sciences and Engineering, Argonne National Laboratory

- Dynamics of collective transport; phenomenology and microscopic theory of superconductors, transition metal oxides, and other correlated electronic systems; quantum optics in semiconductors; theoretical engineering



Diving In

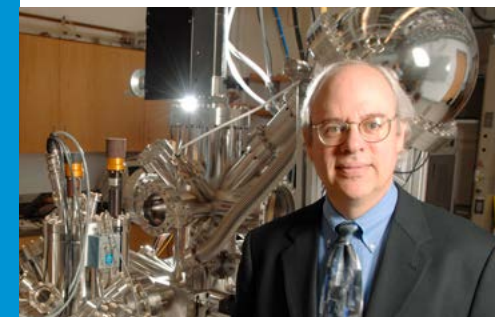
The Water Research Initiative establishes global partnership to advance solutions to water access, utility, quality, and preservation

“We feel it is critical to bring outstanding scientists together to address water-resource challenges that are being felt around the world, and will only become more acute over time.”

— UChicago President Robert J. Zimmer

While many may know that more than 783 million people do not have access to clean water, and almost 2.5 billion do not have access to adequate sanitation, the University of Chicago is doing something about it.

In a new partnership between the University’s Institute for Molecular Engineering and the departments of Chemistry, Ecology & Evolution, and Physics, as well as Israel’s Ben-Gurion University of the Negev, and Argonne National Laboratory, researchers are working to create new materials and processes for making clean, fresh drinking water more plentiful and less expensive by 2020. They also are developing technologies for using water more effectively in industry and agriculture.



Steven Sibener

“The expertise in basic science at the University of Chicago and Argonne National Laboratory combined with Ben-Gurion researchers’ decades of experience with applied science and desalination technology gives us a broad knowledge base to address one of the world’s most critical problems,” said Steven Sibener, Carl William Eisendrath Distinguished Service Professor in Chemistry and the Director of the Water Research Initiative.

“Our combined experience is a tremendous asset in turning early-stage science and technologies into innovative solutions that ultimately will have many applications.”

Working in multi-institutional collaborative teams, scientists are addressing an array of challenges in water management. One project involves multi-functional and anti-fouling membranes for water purification. Another focuses on ground water flow and replenishment in aquifers. This is particularly relevant to the joint US-Israel

LEFT: Water forms

Innovation

Diving In (continued)

research team studying two aquifer systems that are important sources of groundwater exploitation in Israel.

IME will bring tens of millions of dollars to the study of water and molecular engineering over the next decade through faculty hiring and research grants. Sibener also expects the Water Research Initiative to establish more industrial partnerships, which will lead to increase educational opportunities and technological advances.

“One of our goals is to develop scholars with a broad-based understanding of water utilization, science, and policy who will become leaders in the field,” said Sibener. “We expect that some of them will use their innovative ideas to develop viable new technologies that will ultimately lead to the creation of new companies to the benefit of us all.”

In addition to the commitment in water research at IME, UChicago also enjoys a campus-wide innovation network that includes researchers and scholars in a wide range of fields, including public policy at the Energy Policy Institute at Chicago (EPIC), microbiology researchers at the Marine Biology Laboratory, and University economists, social behavior scientists, and urban designers. This unique ecosystem enables the Water Research Initiative to tackle the water sustainability issues in a holistic approach that builds on itself.

Inaugural Water Research Grants Announced

Five seed grants have been awarded to researchers working in the Institute for Molecular Engineering’s Water Research Initiative at the University of Chicago. Collaborative teams of scientists from UChicago’s departments of Chemistry, Ecology & Evolution, IME and Physics, along with Ben-Gurion University of the Negev and Argonne National Laboratory have received funding to develop research projects with strong potential for providing technological solutions to the pressing challenges society is facing in water production, transportation and reuse.

“The five grants that were chosen were the lead programs, in part because they truly benefit from leveraging the strengths at the three institutions,” said Steven Sibener, Carl William Eisendrath Distinguished Service Professor in Chemistry and the James Franck Institute and Director of the Water Research Initiative. “They all require a true partnership in something that no one has done or could do alone.”

Sibener said another strength of the selected projects was their immediate relevance. “The winning proposals cover a range of topics that address critical issues concerning water resources,” he said. “They will use basic science, applied science, and engineering to take discoveries to a new level of innovation.”

Ben-Gurion, UChicago, and Argonne jointly committed more than \$1 million over the next two years to support the inaugural projects.

The agreement between Ben-Gurion University and the University of Chicago was signed last June in Israel. (clockwise from bottom left) UChicago President Robert J. Zimmer, Chicago Mayor Rahm Emanuel, Israeli President Shimon Peres and Ben-Gurion President Rivka Carmi



Water Research Initiative at home in the Chicago Innovation Exchange

While IME’s science labs will be located on UChicago’s main campus, the institute’s “fab lab” will be housed in the University’s new Chicago Innovation Exchange (CIE) on 53rd Street in Hyde Park. Located alongside new, permanent office spaces for the Water Research Initiative and Argonne National Laboratory in a building on the corner of Harper Avenue and 53rd Street, the “fabrication laboratory” will be a shared resource for researchers modeling new inventions both within IME and beyond.



Rendering of CIE interior space

It is one component of a 34,000-square-foot CIE campus set to open in the Autumn Quarter of 2014. Spread throughout three buildings on 53rd and Harper Avenue, CIE is dedicated to nurturing new businesses and product development, such as those coming out of the labs of IME and Argonne, the Chicago Booth School of Business, and the Polsky Center for Entrepreneurship, as well as through global partnerships. “There’s a groundswell of desire from faculty and students around the University to invent and commercialize new technologies and products,” said John Flavin, Executive Director of the Chicago Innovation Exchange.

IME and Argonne will be the only permanent groups on the CIE campus, ensuring there will be space for teams from across campus working on various projects to come in and out. “The exchange is meant to be a co-working space for new ventures,” Flavin said, “a place where resources can be shared and used by entrepreneurs, where people can come to be near other people who can help them. Corporate partners love it because they can access innovation. Global partners love it because it broadens their reach.”

Flavin plans a robust schedule of speakers and opportunities for co-mingling of new ventures with the city of Chicago, corporate partners, venture capitalists, mentors, and service providers. “We’re attracting incubating companies that are hard to get off the ground,” he said. “CIE is a gateway, a convening place for the beginning of technologies. It’s the University-wide enabling of commercialization.”

But Flavin said CIE isn’t just reserved for new products. “There’s a sweet spot for ventures that address urban problems, like the Urban Education Initiative,” he said. “That’s not necessarily tech, but it is innovation. We see a demand for strategic, global impact initiatives, such as the Water Research Initiative.”



John Flavin



“The lobby of the William Eckhardt Research Center will reflect the diversity and aspirations of each of the research programs that will call the Eckhardt Center home.”

—Kurt Haunfelner, Vice President for Exhibits and Collections at the Museum of Science and Industry



Upscaling A report on IME’s expanding facilities

Over the course of the past year, progress has continued on both long-term and interim facilities for IME researchers. The construction reaches from Ellis Avenue to 53rd Street in Hyde Park, and all the way to Argonne National Laboratory, where a new science building—the Energy Sciences Building—just opened its doors.

State-of-the-art and custom-designed with flexibility and lots of collaborative space, the new facilities reflect the institute’s vision for innovation, creativity, and technology. Much of it takes years to build; some spaces are up and running, while others will open in 2014 and 2015.

The William Eckhardt Research Center

The foundation has been laid and the structure of the William Eckhardt Research Center has risen on Ellis Avenue. Details for the interior are also progressing, with city partnerships helping inform the space.

For example, Chicago’s Museum of Science and Industry will partner with the Institute for Molecular Engineering and the Physical Sciences Division to design a visual and graphic identity for Eckhardt. “We’re thrilled to have been asked to collaborate with the University on the design of the lobby,” said Kurt Haunfelner, Vice President for Exhibits and Collections at MSI. “Our goal is to define a



Construction is underway on the Eckhardt Center

visual style that reflects the spirit of the Eckhardt Center, and the energy and promise of IME’s groundbreaking work.”



Renderings of the Eckhardt Center exterior, north lobby, and auditorium

Upscaling (continued)

The Awschalom Group Laboratories

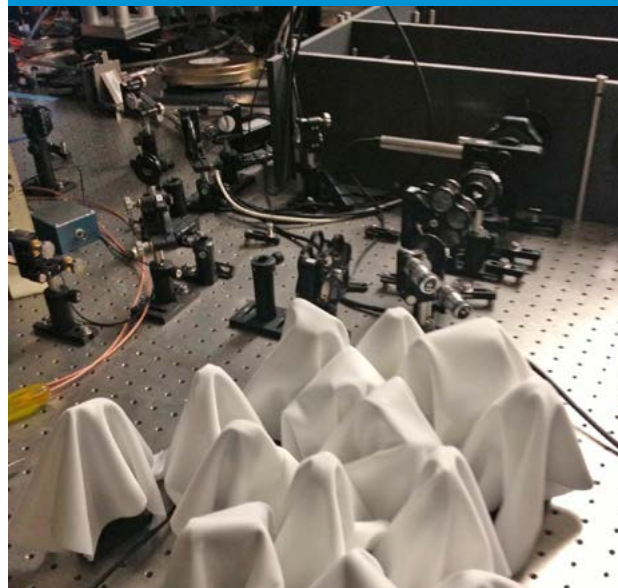
Even though it took four moving vans, three delivery dates, and months of disassembly and assembly, it was worth the effort to move the contents of David Awschalom's laboratory from California to Chicago. Awschalom is the Liew Family Professor in Spintronics and Quantum Information. His group studies condensed matter physics, specifically semiconductor spintronics and quantum information.

They use sensitive optical equipment and high-speed electronics to probe individual electron and nuclear spin dynamics in semiconductors and nanostructures. Their experimental setups consist of femtosecond pulsed lasers and other optical components secured to large one-ton tables with pegboard-like surfaces. The tables have the capacity to float on a bed of air to isolate the sensitive measurements from vibrations. The laboratories are also carefully temperature- and humidity-controlled to minimize optical and mechanical drifts during the measurements.

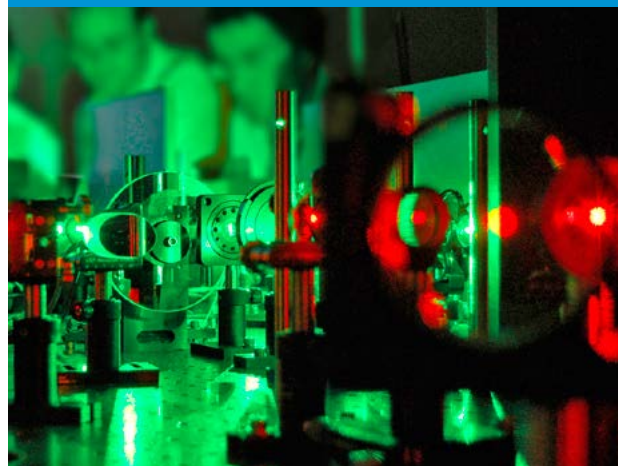
In Chicago, seven spacious laboratories spread over 3,000 square feet in the lower level of Jones Laboratory have been specifically constructed for the Awschalom group. Advantages of the new space include its below-grade location (less vibration), a tailored infrastructure providing required ambient conditions, digital displays to monitor experiments and an in-lab meeting room. "These labs were designed and constructed from scratch to meet our specific experimental needs," said Joe Heremans, a postdoctoral researcher in Awschalom's group who moved to Chicago to continue his work. Awschalom's lab will reside in Jones until the new William Eckhardt Research Center is completed in 2015.



DISASSEMBLE, PACK, TRANSPORT



UNPACK, SET UP, TEST



CALIBRATE, ADJUST, EXPERIMENT

The Energy Sciences Building at Argonne National Laboratory

With an investment of \$95 million, the US Department of Energy's Office of Science has established the Energy Sciences Building at Argonne National Laboratory. The facility's 145,000 gross square feet of floor space provides the 21st-century scientific infrastructure needed to accelerate the pace of discovery.

Dedicated to realizing solutions to the world's most critical energy challenges, the building provides a state-of-the-art research environment. Approximately 200 research personnel have begun to conduct leading research in energy conversion and storage, modeling and simulation,



Researchers work in a flexible space that can adjust to a changing science agenda

and alternative transportation sources. IME researchers will work in this building side-by-side with Argonne researchers in developing new technologies to meet the energy needs of the future.



The new building will help world-class scientists continue to play a leading role in nanoscience, materials, structural biology, energy systems, transportation science and technology, accelerator science, and nuclear and particle physics

Seeing Results

People around the world already feel the reach of IME research

“IME has built the foundation of a world-leading faculty and is beginning to deliver on the investments we have made and on the promise of the vision of a distinctive institute for engineering research and education.”

— Walter E. Massey, Trustee Emeritus, The University of Chicago President, School of the Art Institute of Chicago



Though the Institute for Molecular Engineering is located within a major academic research institution, its faculty members share a penchant for entrepreneurship that leads to commercial success. It's no coincidence that some IME offices sit inside the Chicago Innovation Exchange, which was established at the University in 2013 to spawn new businesses. (see sidebar on p. 17)

After all, one significant component of IME's mission is to serve as an incubator for technology transfer. Its researchers are largely dedicated to shepherding ideas from the laboratory into practical application. “We're building a faculty that will impact many sectors of society,” said IME Pritzker Director Matthew Tirrell.

Toward that end, the Barry L. MacLean and the John A. MacLean Sr. Endowed Professorships in Molecular Engineering, Innovation, and Enterprise were established in 2013. This support will enable researchers to focus on innovation with social impact.

And Jeff Hubbell, who will join IME's faculty in the summer of 2014, is not only an expert in materials chemistry, he's an experienced entrepreneur with three start-ups under his belt so far. The latest, which was co-founded with Melody Swartz, who is also now on the IME faculty, is Anokion, which develops solutions to antigen-specific immune tolerance.

This entrepreneurial spirit is a natural extension of the University of Chicago's pursuit of independent and original ideas. The Institute for Molecular Engineering exemplifies this spirit, and perpetuates the University's tradition of academic excellence.

LEFT: de Pablo's Glass

Impact

Seeing Results

While one of the core characteristics of the Institute for Molecular Engineering is its support of partnerships among scholars, IME is also committed to its partners outside academia.

From its earliest days, the Institute began establishing key relationships with corporations, government agencies, foundations, and philanthropists. These partnerships provide critical support for the IME enterprise—financially and, most importantly, intellectually.

A Wise Investment Bill Florida values IME

You might not expect William Florida, AB'87, AM'87, to be excited about molecular engineering—he earned degrees in public policy and social sciences as an undergraduate and graduate student at UChicago, and added a second master's degree from Harvard's Kennedy School of Government. After crisscrossing continents for his career, today he is an equity analyst, value investing for US and Japanese markets.

As an investor in public companies, he's also value investing in the Institute for Molecular Engineering. Florida has years of experience working with companies, from his days at Novartis, Roche Pharmaceuticals, and GlaxoSmithKline to his current work as an analyst. He's well positioned to help IME's Pritzker Director Matthew Tirrell collaborate with corporate America. "As an alumnus of UChicago," Florida said, "I am excited to offer insights and to help foster connections."

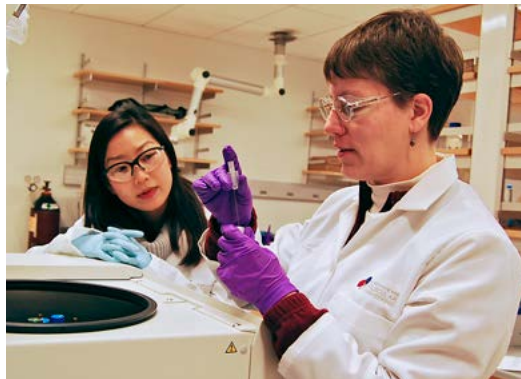


William Florida

He noted that few companies today have an annual budget for pure research. "The majority of basic, early stage research is shifting to university partnerships," Florida said. "Most corporations choose to focus on proven technologies that quickly evolve into products for commercialization. But when a relevant technology emerges from IME labs, companies will want to be at the table."

In the past two years, Florida has coordinated and hosted various luncheons and gatherings around the city to introduce IME and its faculty members to the corporate community.

In addition to his role with IME, Florida is on the Visiting Committee of the College and a past member of the Alumni Board of Governors at the University of Chicago.



Work underway in the Tirrell Lab will advance both academic and corporate innovation

Mutually Inclusive IME and Agilent push the boundaries on measurement

"Our academic collaborations bridge fundamental learning and practical applications," Jack Wenstrand said when asked why his company is working with the Institute for Molecular Engineering. Wenstrand is the director of university relations and external research at Agilent Technologies, Inc., a leading company in measurement solutions.

"Agilent's products and expertise enable measurements that lead to scientific discovery," Wenstrand said. "At the same time, advanced research poses new measurement challenges and creates novel measurement technologies that are critical to our future."

**"The University and
Matt Tirrell are looking
a century ahead."**

—Jack Wenstrand
Agilent Technologies, Inc

As a team, Agilent and IME can push the boundaries of innovation together. "When Agilent connects with university faculty members we ask, 'What is special, unique, and important at this university that is not being accomplished anywhere else in the world?'" Wenstrand said. "The University of Chicago and IME Pritzker Director Matt Tirrell are looking a century ahead. It's not often that something of this stature and magnitude happens. They are taking concepts and turning them into technologies with the potential to alter the future of measurement."

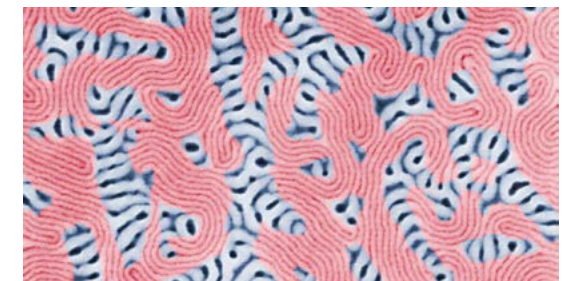
Forging the Future Corning supports science and scientists

Of all the discoveries made at Corning Incorporated over its 162-year history, two stand out in the mind of Dan Vaughn, Corning's external technology collaborations manager. First: innovation occurs best when research, manufacturing possibilities, and customer needs align.

Working with the Institute for Molecular Engineering provides Corning this integrated environment. "Our relationship with IME will help us discover what is possible," Vaughn said. "We're excited to collaborate with the leading academic scientists at IME to help develop new technologies."

Vaughn said a second discovery Corning made a long time ago is that emerging scientists are important. "It takes a long time to train scientists for industry," he explained. "A measure of success to Corning is the knowledge we gain from the relationship coupled with the next-generation scientist who can help us continue to solve tough problems."

Vaughn said the relationship between Corning and IME is a successful collaboration between industry and universities. "Director Matt Tirrell has a world-class team," he said. "They're taking a strategic and deliberate approach to solving meaningful problems."



Corning will be working with Paul Nealey, whose lab explores nanopatterning

Seeing Results

Firsts at UChicago

The University to begin offering a PhD in engineering

For the first time in its history, the University of Chicago will offer a PhD in engineering. The degree will emphasize the development of innovative solutions to technological problems of society based on molecular-level science.

The hallmark of IME's PhD program is a highly customized curriculum tailored to each individual student's needs and inspirations. There will be a wide variety of opportunities for students to engage in teaching and research, and a broad set of electives will help students acquire skills in leadership, communication, innovation, technology development, and product design.

"Our educational objective is to provide our graduate students with interdisciplinary expertise and skill sets that will enable them to tackle big, technological challenges facing society in areas such as health care, energy, and water resource management and information technology," said Matthew Tirrell, the Pritzker Director of the Institute for Molecular Engineering. "We will recruit doctoral students from all science and engineering fields. We're looking for creative and passionate people who are excited about developing technological solutions with high societal impacts."

The institute began accepting applications in autumn 2013, and the first directly admitted class will enroll in the 2014 Autumn Quarter.



TRAINING FUTURE INNOVATORS



Undergraduate minor in molecular engineering is established

The first undergraduate course in the Institute for Molecular Engineering will be offered in the 2014 Autumn Quarter as part of a newly established minor program in molecular engineering. Going forward, the institute will develop new courses, with a plan to propose a full bachelor's degree program in the 2014-15 academic year.

"We are launching a new minor as the latest component of our growing educational program in molecular engineering," said Matthew Tirrell, the institute's Pritzker Director. "We hope to transcend traditional engineering disciplines."

John W. Boyer, Dean of the College, said, "The new undergraduate course offerings in molecular engineering mark a pivotal moment in the University's undergraduate curriculum. This is the first time undergraduates will have the opportunity to build on the skills they gain through the Core with training in innovative molecular engineering."

Course offerings for the minor in molecular engineering will include: Introduction to Emerging Technologies; Nanomaterials: Synthesis, Fabrication, and Self-Assembly; Mathematical Foundations of Molecular Engineering; Selected Topics in Molecular Engineering; Product Design; and Research Practice. Students will be required to complete at least one quarter of research experience to earn the minor.

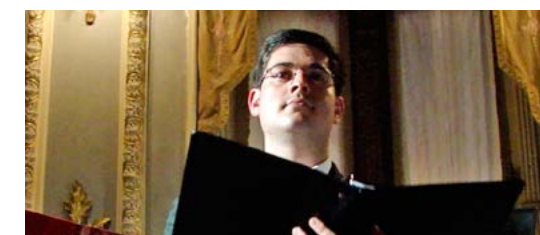
LAYING A FOUNDATION FOR MOLECULAR ENGINEERING

IME offers life-changing opportunity

With his Costa Rican accent and internationally recognized baritone voice, Johnny Alfaro Perez stands out among his 25 student peers conducting research at IME. Alfaro is working with Juan de Pablo to understand molecular motion and to probe the microscopic structure of fluids and solids.

"I am proud to be a first generation graduate student admitted to IME," said Alfaro, who also sang in his country's National Theater and graduated top of his class at Universidad de Costa Rica. "Our PhD program is unlike any in the US. It's exciting to be on a team researching and making discoveries with faculty who are leaders in their fields. My IME experience is already life changing."

Life changing to Alfaro begins with creating simulations for a better understanding of scientific experiments and models. "If we can manipulate molecules for new processes, then we can promote better lifestyles and find cures for conditions such as Alzheimer's and diabetes."



Alfaro balances science and singing

As a double major in chemical engineering and music, Alfaro claimed a spot as a soloist in Costa Rica's Chamber Renaissance and Baroque music groups. "Sensitivity comes from music that helps with life balance. My interests provide two viewpoints and always help me find a center."

2013 Highlights

Events and activities of the year



David Awschalom, Liew Family Professor in Spintronics and Quantum Information, has been elected to the European Academy of Sciences. The academy, which elects relatively few non-European scientists, bases its selections on pioneering new research fields that have substantial scientific impact.

Awschalom was also invited to chair the 7th International School and Conference on Spintronics and Quantum Information Technology; to serve as Keynote Speaker for the Swiss Nanoscience Convention; to present the Slichter Lecture at University of Illinois in Urbana-Champaign; to deliver the annual Gothenburg Mesoscopic Science Lecture sponsored by the Nobel Institutes of Physics; and to participate in this year's Nobel Week Dialogue. He was appointed to the Board of Reviewing Editors for *Science* by the American Association for the Advancement of Science.



Juan de Pablo, Liew Family Professor in Theory and Simulations, was named to the Mexican Academy of Sciences. The Academy invites distinguished researchers from all areas of science to promote and disseminate scientific research in Mexico, while fostering communication and exchange with scientists from other countries.

In addition, de Pablo was named co-director of the new Center for Hierarchical Materials Design. A collaboration among UChicago, Northwestern University, and Argonne National Laboratory, the center will develop the next generation of computational tools, databases, and experimental techniques for designing novel materials.

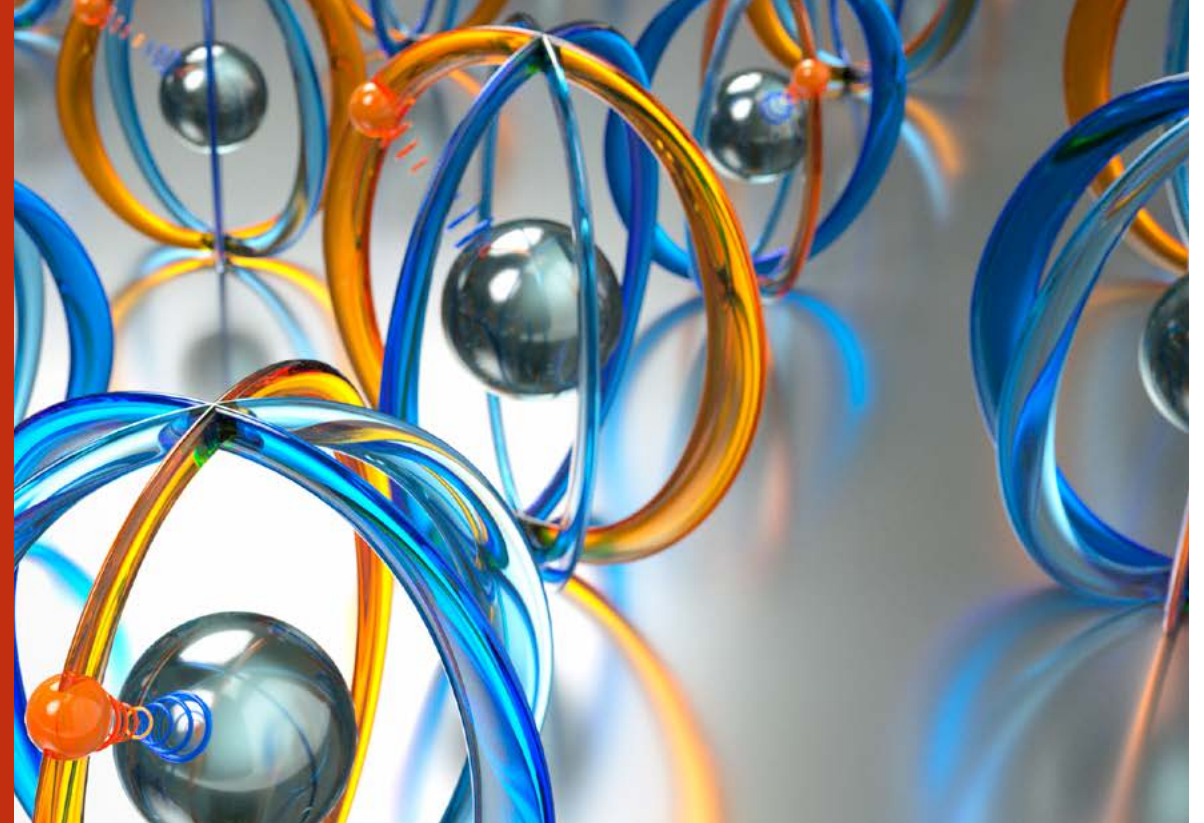


Giulia Galli, Liew Family Professor in Electronic Structure Theory and Simulation, was elected Fellow of the American Association for the Advancement of Science (AAAS) in the Section on Physics. Galli was one of 388 newly elected AAAS Fellows who were recognized by their peers for their efforts to advance science or its applications. Five other University of Chicago faculty members were elected as AAAS fellows in their areas.

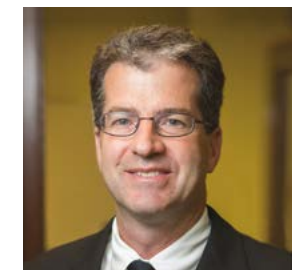


Awschalom spintronics

IME faculty are working with global partners on innovative technologies and gaining international recognition for their accomplishments.



Paul Nealey, Brady W. Dougan Professor in Molecular Engineering, won a \$1.5 million grant from the National Science Foundation to fund nanomanufacturing of block copolymers that self-assemble. The grant provides funding to address fundamental and technological issues essential for the widespread implementation of directed self-assembly (DSA) in nanomanufacturing of device structures.



Nealey also gave the Keynote Lecture at the International Conference of Photopolymer Science and Technology in Chiba, Japan, and was Keynote Speaker at the APS/CNM/EMC Users Meeting in Chicago.

2013 Highlights

Events and activities of the year (continued)



Matthew Tirrell giving a lecture to students at the Francis Parker School in Chicago

Matthew Tirrell, Professor and Pritzker Director of the Institute for Molecular Engineering, was an invited guest lecturer during Changwon National University's 2013 Summer School on Soft Matter in South Korea. He taught a class about complex coacervation and self-assembly.

In Chicago, Tirrell was also named Robert A. Pritzker Visiting Scientist-Inventor-Engineer in Residence at the Francis W. Parker School for the 2013-14 school year. He presented a public lecture in the fall of 2013, and he will continue to have a presence in Parker's science departments throughout the academic year. Located in Chicago's Lincoln Park neighborhood, the independent school for junior kindergarten through grade 12, is based on the progressive educational philosophies of John Dewey and Col. Francis Wayland Parker, emphasizing community and citizenship.

ON THE INTERNATIONAL STAGE

IME faculty members participate in Nobel Prize celebrations in Sweden

There's no doubt the Nobel Prize ceremony in Sweden this year was a big event for the University of Chicago: two of the University's economists received medals for the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel.

But also joining in the celebration were two of the University's faculty members in the Institute for Molecular Engineering: David Awschalom, the Liew Family Professor in Spintronics and Quantum Information, and Nancy Kawalek, Distinguished Fellow in the Arts, Sciences, and Technology and Professor in IME.

Awschalom, a pioneer in spintronics and quantum information science, participated in the Nobel



David Awschalom (right) participated on a Nobel Week panel

Week Dialogue, an open, cross-disciplinary forum on "Exploring the Future of Energy." He joined other world-leading scientists, policymakers, thought leaders, and six Nobel laureates in a discussion aimed at deepening the dialogue between the scientific community and the rest of society. Nancy Kawalek, a visionary in theater that combines science, technology and art, sat on a Nobel Week Dialogue panel discussing "New Formats for Communicating Science."

Nancy Kawalek, Distinguished Fellow in the Arts, Sciences, and Technology and Professor in IME, and the founder of a theater-science laboratory called *STAGE* (Scientists, Technologists and Artists Generating Exploration), organized and directed the inaugural event of the 2013 Nobel Week Festivities in Gothenburg, Sweden: a staged reading of the play *Copenhagen*, starring David Gross, 2004 Nobel laureate in physics, and Alan Heeger, 2000 Nobel laureate in chemistry, along with acclaimed British actress Fiona Shaw. The drama depicts a real-life meeting in 1941 between two friends, Nobel laureates Niels Bohr and Werner Heisenberg, which forever changed the nature of their relationship.

Kawalek first realized the intrigue of having "real" scientists perform the roles of scientists in 2010, while she was on the faculty with colleagues Gross and Heeger at the University of California, Santa Barbara. She asked them to read the parts of Bohr and Heisenberg for a fundraising event.



Nancy Kawalek directs David Gross before the reading

It was a hit. From there the performance was restaged in 2011 in Brussels, Belgium, as the opening event for the 100th anniversary of the famous Solvay Conferences in Physics. This led to an invitation to reprise the reading as part of the 2013 Nobel Week celebrations.

Kawalek's work at UChicago with *STAGE* is devoted to creating and developing new theater work inspired by science and technology.



(left to right) David Gross in the role of Werner Heisenberg, Fiona Shaw in the role of Margrethe Bohr, and Alan Heeger playing Niels Bohr

2013 Highlights

Campus Connections

One of the benefits of working on a campus with a deep dedication to interdisciplinary collaborations is the inherent opportunity to partner with others on exciting projects and events. In 2013, IME embraced this culture as its own, contributing to a range of initiatives at the University.

Arts|Science Initiative

The UChicago Arts|Science Initiative was established with the support of the Institute for Molecular Engineering, the Divisions of the Biological and Physical Sciences and the Humanities, and the Office of the Vice President for Research and for National Laboratories, in partnership with the Office of the Provost. The initiative cultivates collaboration, active exchange, and sustained dialogue among those engaged in artistic and scientific inquiry within the University and beyond. It provides opportunities for scholars, students, and arts practitioners, in multiple domains, to pursue original investigations and explore new modes of artistic production and scientific inquiry.

Center for Synthetic Chaperones

IME Fellow Raphael Lee, Paul S. and Aileen T. Russell Professor of Surgery, has established the Center for Synthetic Chaperones. His research team is studying surfactants that were discovered to chaperone refolding of denatured proteins, which is of particular importance in skin diseases.

Hack Arts Lab

The Institute for Molecular Engineering has partnered with the UChicago Computation Institute to establish the Hack Arts Lab (HAL), a new open “makerspace” for students exploring digital fabrication. Housing 3D printers, laser etchers, and other new tools, the lab enables students to explore the intersection of computer science and art.



Students work in the Hack Arts Lab

iGEM

IME was a major sponsor of the UChicago team participating in the international iGEM summer bioengineering competition. The premiere undergraduate Synthetic Biology competition, iGEM, the International Genetically Engineered Machine competition invites students to design and build biological systems and operate them in living cells. The iGEM Foundation is dedicated to education and competition, advancement of synthetic biology, and the development of open community and collaboration.

Physics with a Bang!

In celebration of the 2013 holidays and physics all year, IME, along with the James Franck Institute, the Department of Physics, and the Materials Research Science and Engineering Center, sponsored Physics with a Bang!, a day-long open house celebrating science at the University of Chicago. Students, families, teachers, and neighbors gathered in laboratories inside the Gordon Center for Integrative Science to participate in hands-on demonstrations and learn about some of the exciting work taking place there. Later, IME fellows Heinrich Jaeger, William J. Friedman and Alicia Townsend Professor in Physics, and Sidney Nagel, Stein-Freiler Distinguished Service Professor in Physics, gave a lecture in a filled-to-capacity lecture room in the Kersten Physics Teaching Center, where they performed experiments designed to entertain and demonstrate the powerful forces of cause and effect.

Searle Clean Room Facility

As part of the \$49 million renovation of the Searle Chemistry Laboratory, a “Clean Room” has been established in the lower level of the building. Designed in part to accommodate the sensitive nanoscience experiments conducted by IME researchers, the space provides rigid control of airborne and other pollutants.

2013 Highlights

Global Network

UChicago Researchers Attend Collaborative Workshop on Water Use in Israel

Last April, a group of 10 research scientists and supporting staff from the University of Chicago, Argonne National Laboratory, and Northwestern University joined another 20 research scientists from Ben-Gurion University of Negev’s Zukerberg Institute for Water Research at Beer Sheva, Israel, for a two-day workshop to develop research ideas and explore collaborations around the theme of “Science and Technology for Water and Its Utilization.” The ideas generated and the collaboration network initiated at the workshop laid a foundation for the Water Research Initiative established between UChicago and Ben-Gurion. (see p. 15)



Researchers from UChicago, Argonne, Northwestern, and Ben-Gurion began germinating the seeds of partnership in April 2013

Illinois Delegation to Israel

Sharon Feng, Executive Director of the Institute for Molecular Engineering, was a member of a delegation to the largest water technology showcase in the world—WATEC, held in Tel Aviv, Israel. Organized by Illinois Gov. Pat Quinn in the fall of 2013, the delegation included water researchers from academia, start-up companies, large corporations active in this marketplace and officials from the Department of Commerce and Economic Opportunities. During the trip, Feng conducted discussions exploring opportunities for collaboration with venture capital groups and large and small companies doing innovation in water technologies as well as other potential academic partners, such as Technion and University of Tel Aviv.

IME Professors give Harper Lectures Around the World

Matthew Tirrell, Pritzker Director of the Institute for Molecular Engineering, gave six Harper Lectures in 2013, three in India, one in Shanghai, one in Hong Kong, and one in Houston, Texas. Juan de Pablo, Liew Family Professor in Theory and Simulations, gave a Harper Lecture in Miami, Fla.

The Harper Lecture series is offered to the worldwide UChicago community by the University of Chicago Alumni Association. Named for the University’s first president, William Rainey Harper, the series carries on his vision of broadly accessible and innovative education.

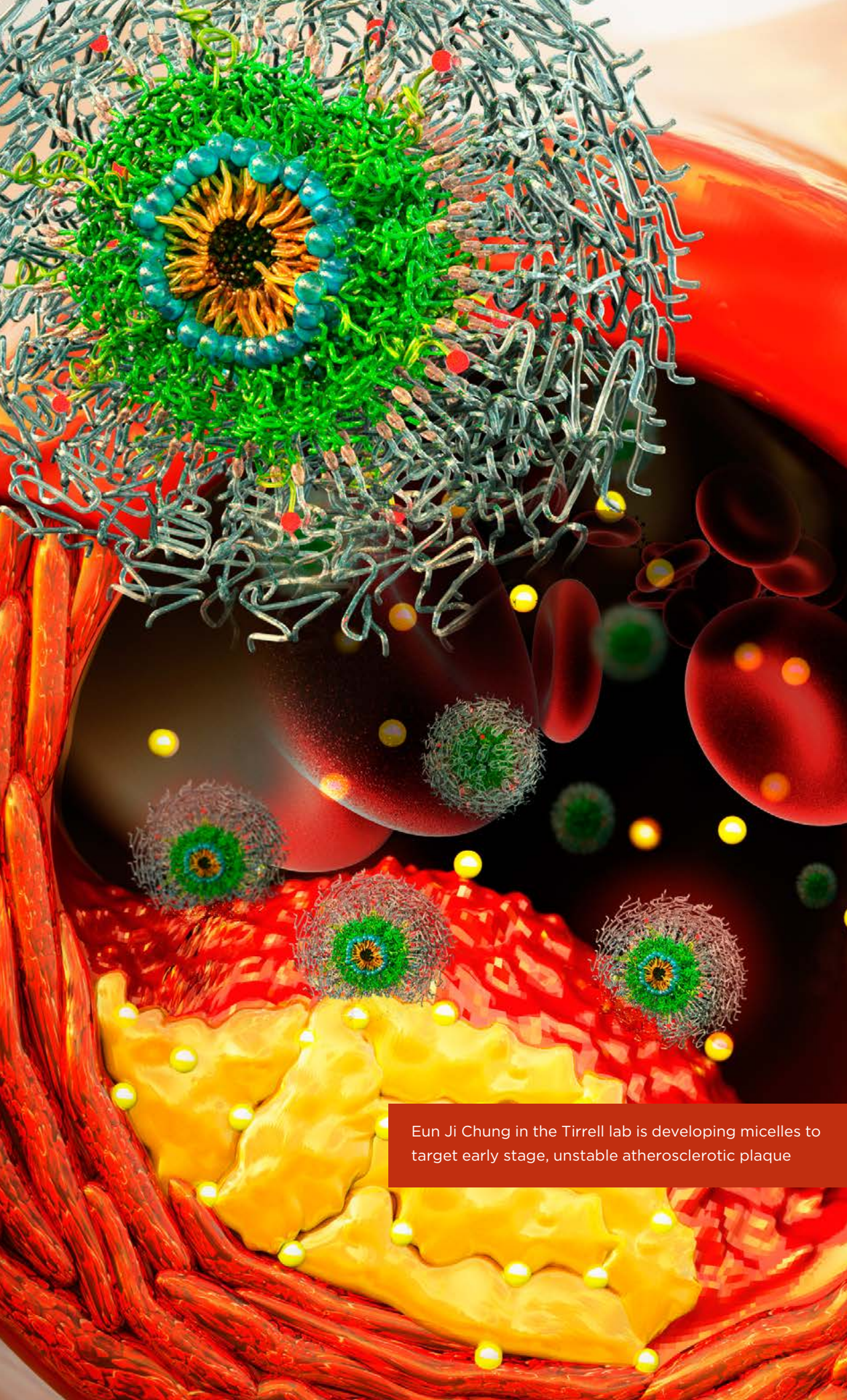
Expanding Horizons

IME researchers joined the Expanding Your Horizon (EYH) outreach program last year by conducting hands-on workshops for more than 30 middle school girls and showing them a short introduction to engineering science.

Through role models and hands-on activities for middle and high school girls, Expanding Your Horizon helps them recognize their potential and pursue opportunities in science, technology, engineering, and mathematics.



(left to right) IME researchers Eun Ji Chung, Emily Wonder, Lorraine Leon, and Sarah Perry worked with the Expanding Your Horizon (EYH) outreach program, conducting hands-on workshops in engineering science for more than 30 middle school girls



Eun Ji Chung in the Tirrell lab is developing micelles to target early stage, unstable atherosclerotic plaque

The Institute for Molecular Engineering

George Herbert Jones Laboratory
5747 S. Ellis Ave., Second Floor
Chicago, Illinois 60637

Matthew Tirrell

Pritzker Director

Sharon Feng

Executive Director

All illustrations in this book were created by Peter Allen, with the exception of the image on page 4, which was created by C. Zhang, Princeton University

Snapshots from 2013



(l to r) Paul Nealey and Juan de Pablo at IME's reception at the AICHE 2013 Annual Meeting in San Francisco



Matthew Tirrell lectures during the summer session at Changwon National University in South Korea



Members of the Awschalom Group in new labs at UChicago



Lorraine Leon and Bret Ulery display the IME silly band overlooking the Swiss Alps. In spring 2013, Tirrell lab researchers attended the Gordon Research Conference sponsored by IME in Les Diablerets, Switzerland



Matthew Tirrell discusses advances at IME on FOX 32 TV in December



Tirrell Lab undergraduate researcher Emma Patchak loads a sample into the neutron beam of the High Flux Isotope Reactor at Oak Ridge National Laboratory



Nancy Kawalek directing a staged reading of the play *Copenhagen* during the 2013 Nobel Prize Week festivities



IME picnics and plays baseball during the summer



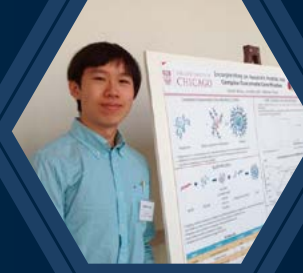
Jeff Hubbell (left) and Matt Tirrell share a glass of wine with bioengineering pioneer Allan Hoffman (center)



IME postdoctoral researchers with other attendees at Georgia Tech for a Future Faculty Workshop



David Awschalom (right) and other attendees at the IME annual holiday party—an occasion to thank everyone and welcome new faculty, staff, and students



UChicago College students contribute posters and oral presentations at the Midstates Consortium for Math and Science Undergraduate Symposium





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