THE UNIVERSITY OF CHICAGO

Institute for Molecular Engineering
5747 South Ellis Avenue
Chicago, IL 60637

Institute for Molecular Engineering

Inaugural Report

JULY 2011–DECEMBER 2012

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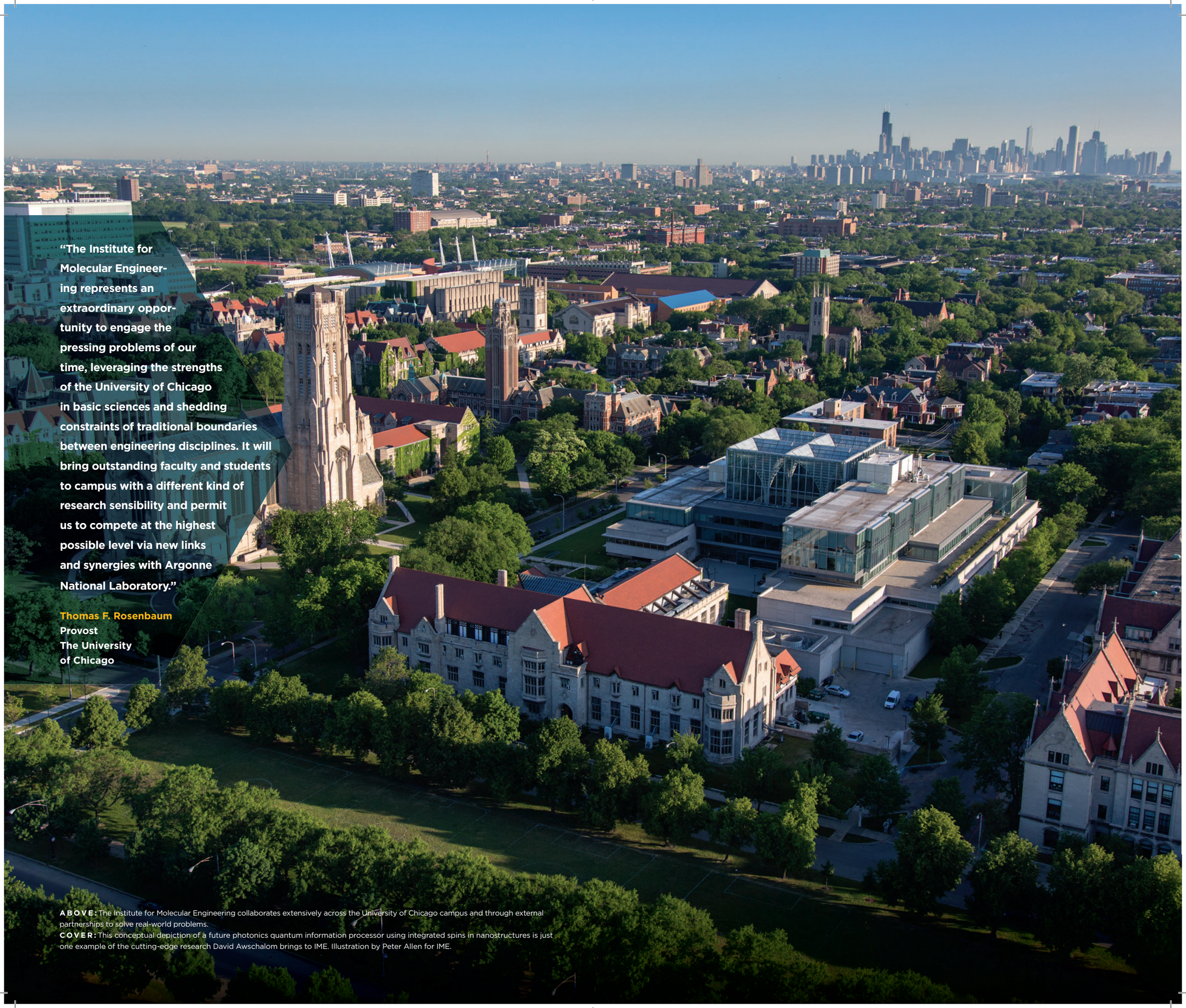
THE UNIVERSITY OF CHICAGO | Institute for Molecular Engineering

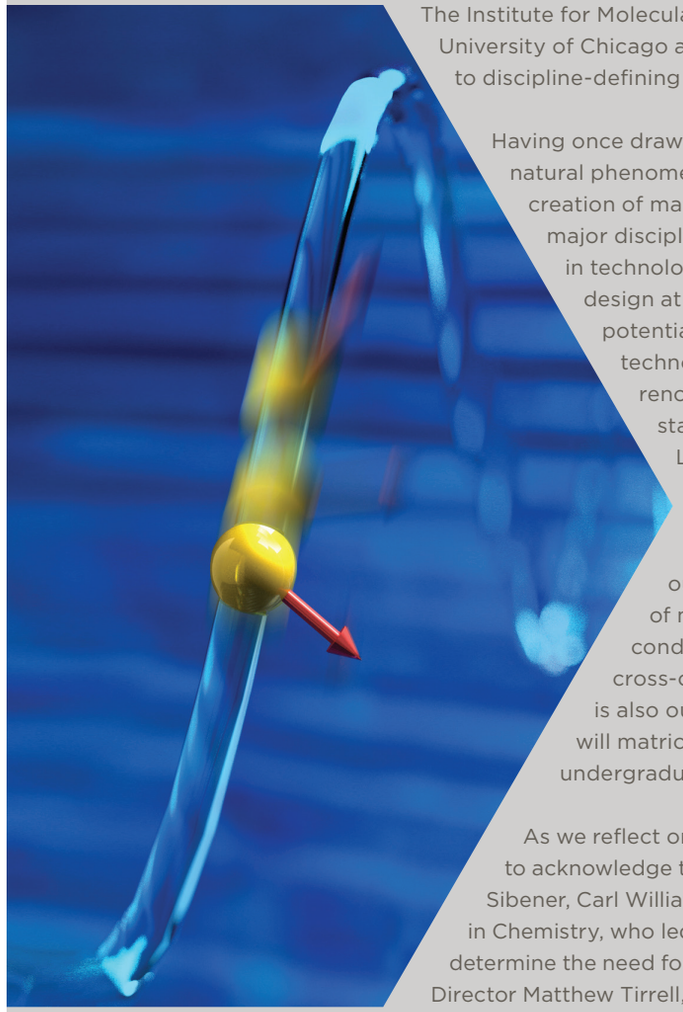


"The Institute for Molecular Engineering represents an extraordinary opportunity to engage the pressing problems of our time, leveraging the strengths of the University of Chicago in basic sciences and shedding constraints of traditional boundaries between engineering disciplines. It will bring outstanding faculty and students to campus with a different kind of research sensibility and permit us to compete at the highest possible level via new links and synergies with Argonne National Laboratory."

Thomas F. Rosenbaum
Provost
The University of Chicago

ABOVE: The Institute for Molecular Engineering collaborates extensively across the University of Chicago campus and through external partnerships to solve real-world problems.
COVER: This conceptual depiction of a future photonics quantum information processor using integrated spins in nanostructures is just one example of the cutting-edge research David Awschalom brings to IME. Illustration by Peter Allen for IME.

LETTER FROM THE PRESIDENT

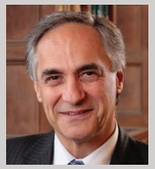


The Institute for Molecular Engineering is both a departure for the University of Chicago and a reflection of our enduring commitment to discipline-defining science of impact.

Having once drawn a line between science as a study of natural phenomena and engineering as the design and creation of man-made artifacts, we are now developing a major discipline at their intersection. Recent advances in technology have made it possible to manipulate and design at the molecular scale, opening up vast new potential for practical application. IME fuses these technological innovations with the University's renowned scientific research and our long-standing connection with Argonne National Laboratory to address society's most pressing concerns.

IME has assembled a pioneering team of outstanding faculty to create the future of molecular engineering. In addition to conducting research and building extensive cross-campus and corporate relationships, IME is also outlining its educational program, which will matriculate new graduate students in 2014, with undergraduates to follow.

As we reflect on the first 18 months of IME, I would like to acknowledge the initiative and determination of Steven Sibener, Carl William Eisendrath Distinguished Service Professor in Chemistry, who led two faculty committees to assess and determine the need for such an institute. And I thank IME Pritzker Director Matthew Tirrell, whose leadership and foresight help shape what IME means to science, engineering, and the University of Chicago. In closing, I would like to thank the Pritzker Family Foundation, Thomas and Margot Pritzker, Bill Eckhardt, John and Serena Liew, and Brady Dougan and Laura Niklason for their critical early and visionary support for IME, and to express my gratitude to all the University alumni, scholars, friends, and partners who have helped foster an ambitious idea into reality.



Robert J. Zimmer
President
The University of Chicago

ABOVE: An example of how the Institute for Molecular Engineering is deeply rooted in the physical and basic sciences, David Awschalom's research in spintronics manipulates single electrons to create an infinite number of states, which improves information storage capacities for technological devices. The illustration depicts the quantum properties of a single electron spin moving through space. Illustration by Peter Allen for IME.

LETTER FROM THE DIRECTOR

With a new and growing faculty, dozens of researchers, burgeoning internal and external partnerships, and upcoming academic degree programs, **the Institute for Molecular Engineering is more than an idea. It is a reality.**

IME is a revolutionary project for the University—a clear, bold statement that the University of Chicago wants to build on its commitment to basic science research by translating some of that scholarship into applications that can benefit society. Engineers and scientists use many of the same tools, speak the same language, and cooperate extremely well. Through our research, and by finding ways to apply the discoveries that are made here and among our partners, IME will strengthen the University's dedication to scientific inquiry while advancing its mission to enrich society.

Over the first 18 months of IME, I have been excited to watch research unfold and expand as we continue to forge our unique path. In the last six months we've begun building our senior faculty—first with Juan de Pablo and Paul Nealey, who both joined us from the University of Wisconsin, and soon with David Awschalom and Nancy Kawalek, both of the University of California, Santa Barbara, who will join us early this year. More than 50 graduate students and postdoctoral researchers have followed the faculty, and our new executive director, Sharon Feng, who joined us in September, rounds out the team with more than 20 years of corporate industry experience in high-tech materials.

This is an exciting time for IME. We are on track to hire an additional three to five faculty members each year, with the goal of having a full-time faculty of 25 within the next five to eight years. Our PhD program will start accepting applicants in fall 2013, with an undergraduate degree program to follow the next year. Both of these programs will demand the development of laboratory courses that provide design- and project-based learning opportunities, as well as product development and entrepreneurship training. As we grow, so too will our facilities—the William Eckhardt Research Center will open in 2015, with amenities to suit the most advanced molecular research.

IME continues to work closely with Argonne National Laboratory, where our faculty members hold dual appointments, to redefine how the University of Chicago can benefit from the research, facilities, and proximity of the national laboratory. On campus, we are forging interdisciplinary partnerships with the University of Chicago Booth School of Business, the Pritzker School of Medicine, and the Physical Sciences Division. Externally, there is interest from numerous major US corporations that will serve as vehicles for sponsorships and product development.

This inaugural report provides insight into the ideas that have brought the Institute for Molecular Engineering to life—and the people who took a chance, a challenge, and made it into a program unlike any other. The progress we have already made promises that there is an exceptional future for this young program, the University, prospective students, and the new and exciting field of molecular engineering.

Matthew Tirrell
Pritzker Director
Institute for Molecular Engineering

“We’re trying to create an environment where people aren’t so focused on what the disciplines are, but what the disciplines can do. . . . We aren’t locked into doing anything in any particular way.”

Matthew Tirrell

Pritzker Director

In 2010, when Matthew Tirrell was first contacted by the University of Chicago to interview for the position of director of the Institute for Molecular Engineering, his initial thought was, “This could be a perfect fit for me.” Just a year and a half into his tenure, it appears his instinct was correct.

Tirrell, who joined IME from the University of California, Berkeley, is a pioneering researcher in biomolecular engineering and nanotechnology, specializing in the manipulation and measurement of the surface properties of polymers—materials that consist of long, flexible chain molecules.

“There are two main themes in my own research right now. One is to create nanoparticles that can circulate in the human body and do something good, and the other is a focus on self-assembled materials—or what happens when molecules are mixed and spontaneously form some kind of structure,” Tirrell said. “Structures that form spontaneously can give interesting properties to materials.”

Tirrell also specializes in a skill that has largely helped build IME: persuasion. During his 10 years (1999 to 2009) as dean of the College of Engineering at the University of California, Santa Barbara, he was integral in the recruitment of more than 70 faculty members.

“I dedicated a lot of effort to learning how to hire people. It’s a skill that I think is going to be important here,” said Tirrell, who recently hired IME’s four new faculty members and its executive director. “It really is natural, because I’m just trying to persuade people to make some of the same choices that I did, and for some of the same reasons—the excitement, the newness, and the possibilities that something like IME offers.”

With that newness comes the challenge of defining a program that has never before been explored within the realm of engineering programs. It’s a challenge Tirrell readily accepts.

“In some ways it’s an academic experiment, but one for which the foundation has been laid very well. The best engineering schools do what they do well, but there are limitations to the traditional way of doing it,” he said. “We’re trying to create an environment where people aren’t so focused on what the disciplines are, but what the disciplines can do.”

Tirrell began his academic career in 1977 at the University of Minnesota, where he served as Shell Distinguished Chair in Chemical Engineering, Earl E. Bakken Professor of Biomedical Engineering, director of the Biomedical Engineering Institute, and head of Chemical Engineering and Materials Science. He moved to the University of California, Santa Barbara, in 1999, where he spent a decade as Professor of Chemical Engineering, Materials, Biomolecular Science, and Engineering, and Richard A. Auhll Professor and dean of the College of Engineering. He received his bachelor’s degree in chemical engineering from Northwestern University in 1973 and his doctoral degree in polymer science and engineering from the University of Massachusetts in 1977.

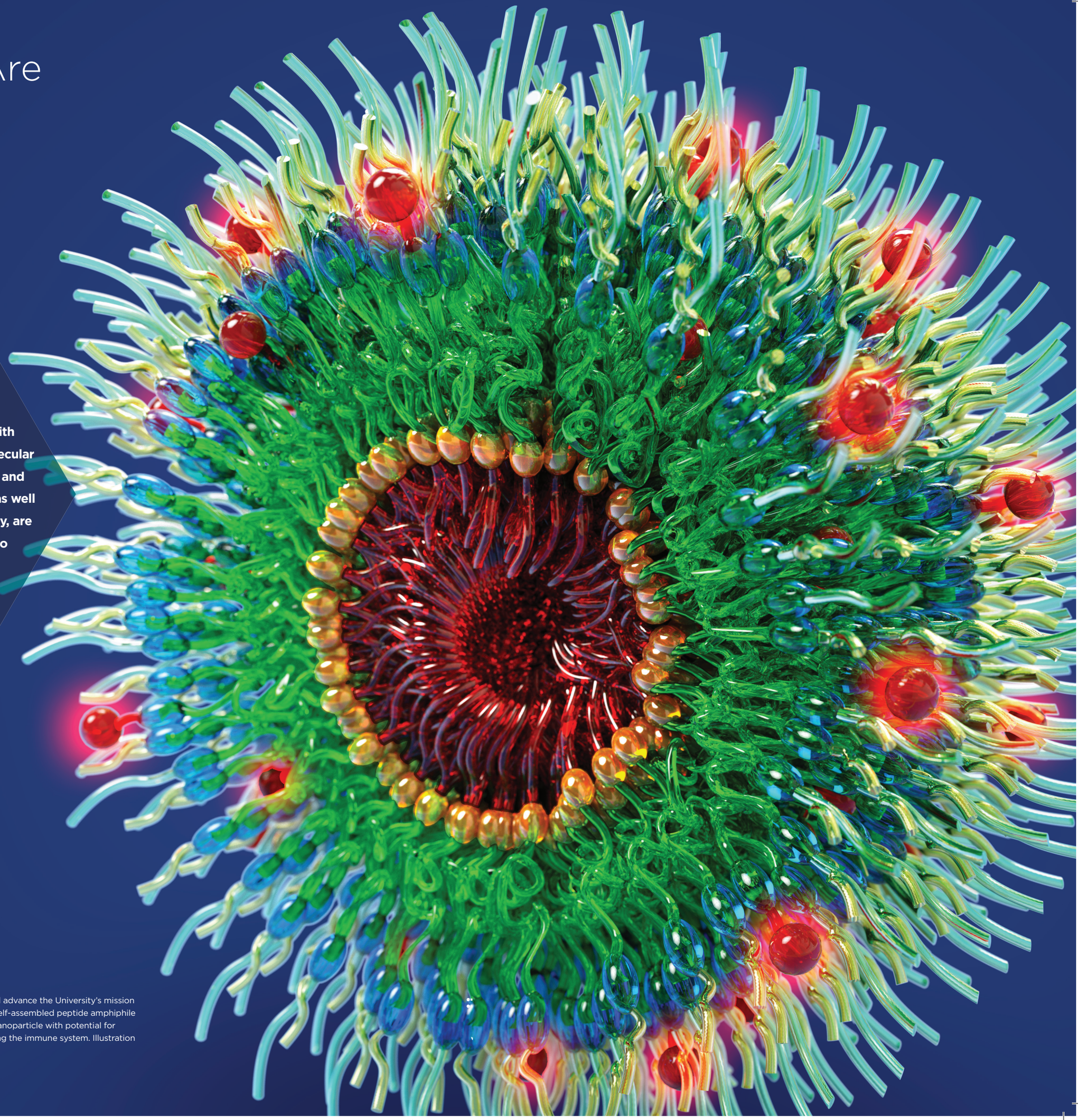
Some of Tirrell’s top priorities, aside from continuing to hire a stellar team and build the academic programming, include developing a robust committee to instill a culture of safety and best practices before the first class is taught. He is also focused on building campus-wide and global relationships, varying from the Pritzker School of Medicine to major corporations to international cooperation in Europe, Asia, and the Middle East.

“I don’t want to miss any opportunities to take advantage of the fact that we’re brand-new,” he said. “We aren’t locked into doing anything in any particular way.”

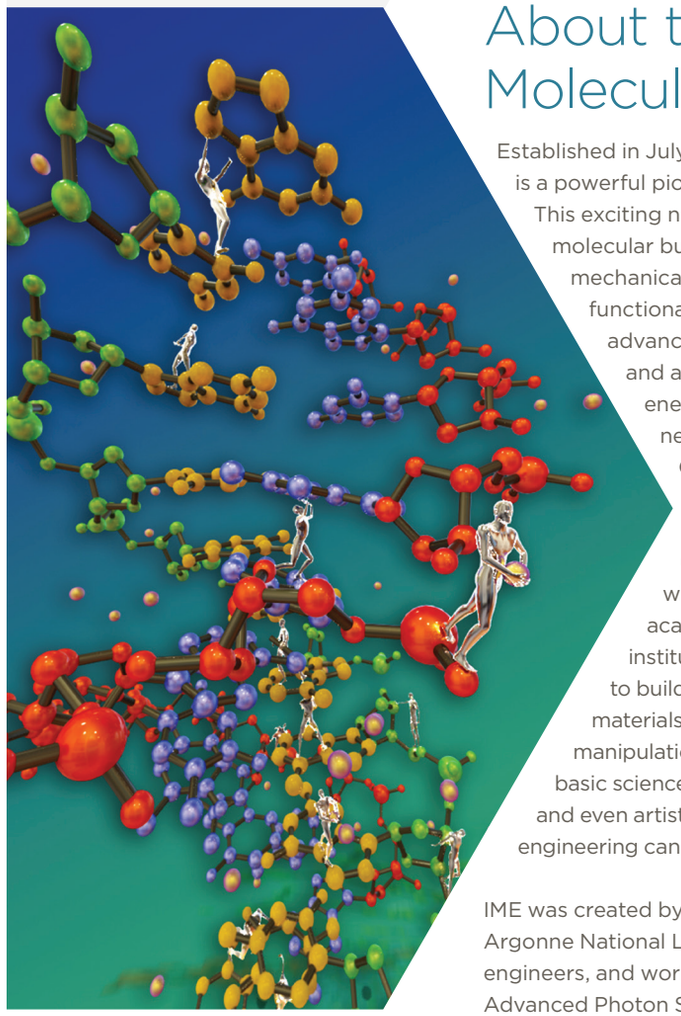
Who We Are

"The Institute for Molecular Engineering has grown from a remarkable conceptual opportunity into a rapidly evolving intellectual centerpiece of the University. Connections linking its engineering focus with our extant strengths in the molecular sciences spanning the Physical and Biological Sciences Divisions, as well as Argonne National Laboratory, are expanding and accelerating into many new directions."

Steven Sibener
Carl William Eisendrath Distinguished Service Professor in Chemistry
The University of Chicago



ABOVE: IME's research and applications will advance the University's mission to enrich society. Pictured is a depiction of a self-assembled peptide amphiphile micelle being explored in the Tirrell Lab as a nanoparticle with potential for targeting pathological tissue and for stimulating the immune system. Illustration by Peter Allen for IME.



ABOVE: Juan de Pablo's research in DNA is an example of how molecular engineering can be used to design molecules that bind to proteins or particles in specific ways.

About the Institute for Molecular Engineering

Established in July 2011, the Institute for Molecular Engineering is a powerful pioneer in engineering research and education. This exciting new field involves the incorporation of synthetic molecular building blocks—including electronic, optical, mechanical, chemical, and biological components—into functional systems that will impact technologies from advanced medical therapies to quantum computing and address pressing societal issues related to energy and the environment. IME is the largest new academic program that the University of Chicago has started since the founding of the Harris School of Public Policy in 1988.

Offering a program unlike any other, IME breaks with tradition by having the character of both an academic unit and an interdisciplinary research institute. Faculty expertise spans the skills necessary to build functional molecular systems, including materials synthesis, device fabrication, biological manipulation, and advanced computing. IME combines the basic sciences, entrepreneurial strategy, medical translation, and even artistic creation to find ways that molecular engineering can be applied to address societal needs.

IME was created by the University of Chicago in partnership with Argonne National Laboratory, which brings leading scientists, engineers, and world-class facilities to the endeavor, including the Advanced Photon Source, the Argonne Leadership Computing Facility, and the Center for Nanoscale Materials.

Thematic Areas

The Institute for Molecular Engineering will be organized around a set of prominent research themes aimed at finding concrete solutions to address societal needs—from environmental to medical to technological. These thematic areas will involve crucial partnerships across the University and industry.

A handful of IME faculty members, along with additional University faculty and external partners, will collaborate within each thematic center.

Here are some possible themes that are emerging:

Center for Quantum Information and Technology
Quantum computing is thought to have the potential to exceed Moore's Law, accelerating the advance of computing power. This field could also lead to "unhackable" communications through quantum cryptography and ultra-sensitive devices to detect biological and chemical changes.

Center for Immuno-Engineering and Cancer (in cooperation with the Biological Sciences Division)
Discovering the mechanisms that control the movement of biological fluids through tissue and the immune responses to tumor invasion could lead to synthetic vaccines against cancer and viral threats.

Center for Soft Active Matter
Certain macromolecules self-assemble into regular morphologies and can be coerced into forming useful structures that are similar to those encountered in electronic circuits. Self-assembled nanostructures could reduce manufacturing costs and enable new generations of electronic, biomedical, and mechanical devices.

Center for Molecular Engineering of Water Resources
Broad-based research will investigate all aspects of water utilization, including purification via membranes, biotechnology, and catalysis; efficient water use in agriculture; and efficient, distributed power sources to support purification.

Center for Energy Storage and Harvesting (in cooperation with Argonne National Laboratory)
IME will develop a major Chicago-based hub for research on batteries, fuel cells, and other devices for storing energy to use with mobile, distributed, or intermittent energy sources, as well as energy harvesting via such molecular devices as photovoltaics.

By the Numbers

4 engineering faculty members

12 publications with IME affiliations

21 potential corporate partnerships

23 postdoctoral researchers

25 graduate student researchers

10 undergraduate student researchers

"There is potential for partnering in entre-preneurial and corporate spaces, so it's a very natural fit for someone like me to act as a liaison, to facilitate the dialogues between academic researchers and industrial partners."

Sharon Feng

Executive Director

When Sharon Feng first spoke with Pritzker Director Matt Tirrell about the executive director position, she was impressed by the University of Chicago's commitment and Tirrell's vision of IME, though it was still in its infancy.

"It was eye-opening to learn that the University, a known knowledge-seeking, scholarly institution, could take such a bold step toward the direction of applied research," she said.

Feng, who joined IME in September 2012, oversees nonacademic operations and management to maintain day-to-day planning, business strategy, and facilities management for all things related to the institute.

Her 15 years of experience leading innovation for Bayer MaterialScience, one of the world's largest producers of polymeric raw materials for various industrial applications, coupled with an extensive scientific background, makes her well suited to lead the administrative aspects of IME.

"IME's mission really aligns with my passion and my experience. We take scientific discoveries and translate that into solutions, systems, or devices that can help society to solve a problem," Feng said. "There is potential for partnering in entrepreneurial and corporate spaces, so it's a very natural fit for someone like me to act as a liaison, to facilitate the dialogues between academic researchers and industrial partners."

Feng's ability to develop and understand partnerships from both the industry and academic standpoints will continue to benefit IME as it creates a comprehensive corporate affiliate program that will fulfill its mission to translate science into technology.

During her time with Bayer, she was responsible for the construction and development of various research facilities in North America and Asia, including the Polymer R&D Center in Shanghai, China. The experience lends itself well to her role overseeing IME's new facility, the William Eckhardt Research Center, which will house IME alongside some labs and researchers of the Physical Sciences Division.

"We wanted to design this building to be more than a typical lab building—it is designed to showcase technology and foster interdisciplinary interactions," Feng said. "It's going to be fabulous."

Until Eckhardt Center opens in 2015, Feng is overseeing the renovation of laboratory space and offices to accommodate incoming faculty. She is also building the administrative support staff and establishing policies and procedures for institutional operation, including a comprehensive safety program.

Feng joined Bayer in 1992 after completing her postdoctoral work at the Medical University of South Carolina. She earned her PhD in bioinorganic chemistry from Massachusetts Institute of Technology, her master's degree in organometallic chemistry from the University of California, Davis, and her BS/MS degrees in chemistry from Nanjing University in China. She is a member of the board of directors of Koppers Holdings Inc., where she chairs the board's safety, health, and environmental committee. She is the author of more than 30 technical publications and patents and has spoken at numerous professional and technical conferences.

"It's a big transition into an academic institute like this after 20 years in industry," said Feng, "but I think the nature of being able to be a part of something from the ground up and make history is very rewarding and exciting."

IME's Future Home

The Institute for Molecular Engineering will be housed in a new state-of-the art facility on the west side of Ellis Avenue between 56th and 57th Streets. Currently under construction and scheduled to be completed in 2015, the William Eckhardt Research Center will embody the spirit of innovation that will thrive within its walls.

The building is named for Chicago-based investment manager William Eckhardt, SM'70, in recognition of his $20 million gift to support scientific research at the University. Two premier architecture firms have teamed up for the project: the global leader HOK and James Carpenter Design Associates, both of which fuse creative inspiration, technical mastery, and commitment to environmental sustainability in their work. The floor plan, featuring 265,000 square feet distributed across seven floors, will provide ample space to accommodate IME faculty members, along with students, staff, and affiliated researchers. IME will share Eckhardt Center with colleagues in the Physical Sciences Division and will also benefit from the close proximity with the Biological Sciences Division in the Gordon Center for Integrative Science as well as the University of Chicago Medicine to consult and collaborate as partners. Cutting-edge clean rooms and molecular imaging facilities will be located on the lower level.

"Eckhardt Center will foster broad interactions between IME and other University partners," said IME executive director Sharon Feng. "It's also designed to showcase our technology and research."

The site, once home to the University's Research Institutes, is rich with history and symbolism. Just across the street, outside the glass dome of the Mansueto Library, a Henry Moore sculpture commemorates the spot where Enrico Fermi and his colleagues on the Manhattan Project engineered the first controlled, self-sustaining chain reaction in 1942. That proud legacy of discovery has been strengthened on campus in recent decades. And at the Eckhardt Center, it will continue to flourish for many years to come.

ABOVE: The new William Eckhardt Research Center, opening in 2015, will put IME at the heart of the University's basic and physical sciences research. Rendering courtesy of AJSNY.

"This combination of physics, chemistry, materials research, electrical engineering, and computer science creates an interdisciplinary research effort that is ideally suited for IME's fresh approach to science and technology."

David Awschalom

Liew Family Professor in Molecular Engineering

David Awschalom is an expert in quantum information engineering and spintronics, fields that could change the face of computation and communication and thereby create infinite possibilities for new applications in science and technology. Spintronics is the atomic–scale manipulation of an electron or nuclear spin to alter its quantum state. Altering the spin of particles leads to new schemes for computing, energy efficiency, imaging instrumentation, and high–density information storage.

Currently the Peter J. Clarke Director of the California NanoSystems Institute and professor of physics at the University of California, Santa Barbara, Awschalom will join the Institute for Molecular Engineering in early 2013.

"This field allows us to think about information in a fundamentally new way. An electron spin has an infinite number of quantum mechanical states; exploiting this property to store information in a single particle could let us ultimately leap beyond the capabilities of today's classical devices," said Awschalom. "When you imagine networking millions of these quantum states, you approach computational capabilities and storage densities that are truly astronomical."

Awschalom and IME Pritzker Director Matt Tirrell interacted frequently during Tirrell's tenure as dean of engineering at UCSB, and Awschalom is eager to work alongside him and the rest of the IME faculty to stretch the boundaries of their research.

"This combination of physics, chemistry, materials research, electrical engineering, and computer science creates an interdisciplinary research effort that is ideally suited for IME's fresh approach to science and technology," said Awschalom. "We have an opportunity to reimagine applied science and engineering for the 21st century and to prepare a new generation of 'quantum engineers' to impact broadly different areas of society, from information technologies to medical imaging to energy conservation. IME is launching at a very exciting time to help transition science to technology."

Awschalom received his bachelor's degree in physics from the University of Illinois. After earning his doctorate in experimental physics from Cornell University, he served as a research staff member and manager of the Nonequilibrium Physics Department at the IBM Watson Research Center in New York. He joined the physics faculty at UCSB in 1991, then obtained an additional appointment as a professor of electrical and computer engineering in 2001.

He holds several patents, including one in quantum computing, an experimental computer technology that would dwarf the capabilities of modern digital computers.

Awschalom is a member of the National Academy of Engineering, the National Academy of Sciences, and the American Academy of Arts and Sciences, as well as a fellow of the American Association for the Advancement of Science and of the American Physical Society. His awards include the American Physical Society's Oliver E. Buckley Prize, the European Physical Society's Europhysics Prize, the AAAS Newcomb Cleveland Prize, the Materials Research Society's Turnbull Award, and, from the International Union of Pure and Applied Research, the International Magnetism Prize and the Néel Medal.

At IME, he will expand his research by exploring the behavior of quantum states within organic systems of chemical and biological structures. His experiments will include studies of transporting quantum information between the organic and inorganic worlds, and will also focus on developing new types of quantum-limited measurement tools.

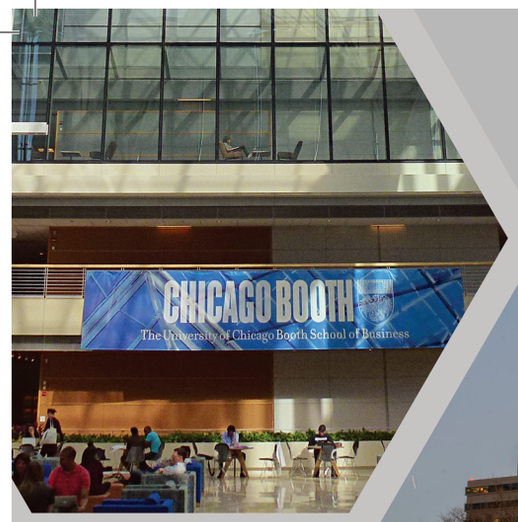
"We're going to broaden our research and take advantage of the University of Chicago's world-class research activities in chemistry, biology, and medicine," said Awschalom, who will be accompanied by approximately 10 of his UCSB researchers. "In a unique environment like IME—a place where people, research areas, and ideas mix together in one institute—I expect exciting research and surprising discoveries."

Partnerships

"The Institute for Molecular Engineering will dramatically strengthen the University's ability to serve the surrounding community and society as a whole. With a focus on technological innovation aimed at tackling complex social problems, the institute has great potential to improve outcomes in a wide range of fields, including medicine, computing, and clean energy."

Derek R. B. Douglas
Vice President for Civic Engagement
The University of Chicago

ABOVE: IME faculty will partner extensively with Argonne National Laboratory to take advantage of unparalleled research and technology. Pictured is an interpretation of a coarse-grained model of double-stranded DNA developed by the de Pablo group. Illustration by Peter Allen for IME.



Strengthening Interdisciplinary Collaborations

The Institute for Molecular Engineering is founded on the principle of building partnerships with other University entities. Such partners—already making powerful impacts in their respective fields—will have even more opportunities when paired with IME.

CLOCKWISE FROM TOP: IME will partner with the University of Chicago Booth School of Business to develop, market, and sustain innovative technological solutions; the University of Chicago Medicine's new Center for Care and Discovery is one potential place where IME diagnostic solutions and technological devices can be applied to help patients; IME faculty will collaborate extensively with the scientists at Argonne National Laboratory, taking advantage of unmatched resources and expertise.

Argonne National Laboratory

The dual appointment with Argonne National Laboratory was a major draw for IME faculty, as it offers a wealth of resources, including world-class facilities, leading scientists, incomparable access to new energy technology, and expertise in managing projects for industrial and commercial applications. This partnership will not only benefit Argonne and IME, but could potentially strengthen the Chicago-area economy and community.

"IME has forged strong new connections between Argonne and the University of Chicago, attracting some of the finest scientific minds in the world to this new shared enterprise," said Eric D. Isaacs, director of Argonne National Laboratory. "I look forward to a wide range of productive new collaborations with Argonne, and with the greater Chicago innovation community, as IME's new faculty work to discover and develop transformative technologies at the molecular scale."

The University of Chicago Booth School of Business

Because IME finds real-world applications for its research, the partnership with Chicago Booth's Polsky Center for Entrepreneurship and Innovation will maximize the scope and impact of future technologies. The Polsky Center is aimed at new venture creation and start-ups, and IME Pritzker Director Matt Tirrell expects this partnership to add a new dimension to IME's entrepreneurial endeavors.

"The Institute for Molecular Engineering is intended to be an interdisciplinary department designed to address societal problems from a technological perspective. One avenue by which technology can have impact on society is through creation of commercial ventures," said Sunil Kumar, Chicago Booth dean and George Pratt Shultz Professor of Operations Management, who has an engineering background. "In creating ventures based on intellectual property developed by IME faculty and students, Chicago Booth and its Polsky Center are natural partners to IME."

IME will use Polsky's expertise in business plans and strategy to find ways to sell new IME inventions such as devices, biotechnologies, and medical tools. "Scientists and engineers sometimes struggle with discerning the difference between good technical ideas and good business ideas," Tirrell said. "That's the kind of lesson the cooperation with Chicago Booth will give us."

The University of Chicago Medicine

Some of the most exciting research happening at IME can be applied to help medical patients. Beyond developing innovative diagnostic tools and therapies, molecular engineers can manipulate human tissue and cells. A partnership with medical researchers and physicians can mean leaps in the way patients are diagnosed and treated. Clinical physicians are strong partners for IME because they are practical-minded and want to help the patients they see every day at the University of Chicago Medicine, according to Tirrell.

"Close collaboration with IME will open an entirely new spectrum of approaches that University of Chicago Medicine researchers can bring to bear on the clinical and translational research problems they study," said Julian Solway, associate dean for translational medicine at the Biological Sciences Division and Walter L. Palmer Distinguished Service Professor of Medicine and Pediatrics. "This new partnership will speed our joint development of new and better treatments and diagnostics, thereby improving the care and outcomes of patients at the hospital, in Chicago, and beyond."

“There’s a need for a new breed of engineers—molecular engineers—and we hope to be the first school that actually specializes in and emphasizes that new branch of modern engineering.”

Juan de Pablo

Liew Family Professor in Molecular Engineering

The face of engineering is changing dramatically, and Juan de Pablo finds himself at the crux of it.

“We’ve gone from the era of big industrial operations, the birth and growth of the petrochemical industry, the textile industry, and the food industry to an era in which we’re actually starting to think of manufacturing new systems and devices at the molecular level,” said de Pablo. “There’s a need for a new breed of engineers—molecular engineers—and we hope to be the first school that actually specializes in and emphasizes that new branch of modern engineering.”
De Pablo develops detailed molecular models of how fluids and materials behave, then applies those models to design structures and processes that will benefit society. His current activities are organized into five subgroups: protein folding and aggregation, DNA folding and hybridization, glassy materials, block copolymers, and liquid crystals.

De Pablo, who joined IME in July 2012 from the University of Wisconsin, has partnered extensively with Paul Nealey, who also came to IME from Wisconsin. De Pablo holds more than 15 patents on various technologies, nine of them with Nealey.

“He’s someone I can rely on for scholarly pursuits, as well as more operational and strategic ventures,” de Pablo said of Nealey. “What he does is in a sense orthogonal to what I do. He focuses on the experimental characterization of these systems. In that area of self-assembly, I focus on the theoretical and computational aspect of the systems, so we feed off of each other. I can have the most advanced theories of anyone, but without experimental validation, they’re of little use.”

One of the biggest draws that brought de Pablo to IME after two decades at Wisconsin was the dual appointment with Argonne National Laboratory. “Argonne has amazing technical staff, phenomenal scientists, and an incredible infrastructure for world-class science,” he said. “In my particular case, we will have access to some of the world’s largest supercomputers to conduct research and simulations.”

A fellow of the American Academy of Arts and Sciences and of the American Physical Society, de Pablo received the 2011 Charles Stine Award from the American Institute of Chemical Engineers. He has authored or coauthored approximately 380 publications.

De Pablo earned a bachelor’s degree in chemical engineering from the Universidad Nacional Autónoma de México in 1985. After completing his doctorate in chemical engineering from the University of California, Berkeley, in 1990, he conducted postdoctoral research at the Swiss Federal Institute of Technology in Zurich, Switzerland. He joined the University of Wisconsin faculty in 1992, where he served as the Howard Curler Distinguished Professor and Hilldale Professor of Chemical Engineering.

He is looking forward to the challenges and excitement that come with developing a new program, curricula, and a well-rounded faculty.

“The fact that we’re identifying new faculty and colleagues together implies that some incredible synergy is going to be built into the structure of IME,” de Pablo said. “You almost never get the chance to create a department from scratch. This opportunity to have a series of senior faculty assemble a department from the ground up will lift it to a place that’s highly collaborative, where everyone benefits from each other’s presence. That is already happening, and it’s only been five months.”

“There is not a precedent, and you have to establish a path, but it’s a dynamic pathway because you are always learning about and reevaluating almost every aspect of the job.”

Paul Nealey

Brady W. Dougan Professor in Molecular Engineering

Paul Nealey compares the Institute for Molecular Engineering to a start-up company.

“There is not a precedent, and you have to establish a path, but it’s a dynamic pathway because you are always learning about and reevaluating almost every aspect of the job,” said Nealey, who joined IME in July 2012. “I don’t think I’ve ever heard of a new program being started from scratch targeting a new paradigm of engineering research and education. The idea is to start a whole new way to think about engineering—it’s really about looking into the future.”

Prior to his appointment to IME, Nealey spent 17 years at the University of Wisconsin as the Shoemaker Professor of Chemical and Biological Engineering. He is one of the world’s leading experts on patterning organic materials and a pioneer of directed self-assembly of materials that spontaneously form structures at the nanometer length. He works to guide self-assembling materials to form structures in patterns that are useful in the construction of such applications as computer chips and information storage devices.

“We try to engineer those molecules to do things that they normally wouldn’t want to do in order for them to be useful for applications,” said Nealey.

Nealey works closely with his colleague Juan de Pablo, who also joined IME from Madison. Together, using Nealey’s expertise in self-assembling materials and de Pablo’s theoretical modeling and simulation, they have become a powerful force in the research of block copolymer films, which spontaneously self-assemble to form structures that range from three to 50 nanometers (one nanometer is equivalent to one-billionth of a meter, or the width of 10 hydrogen atoms sitting side by side).

“Sometimes the theory leads and sometimes the experiment leads,” said Nealey. “The theories from the de Pablo group are so good that the models are actually predictive, so you can use them to design the experiments. It’s a super-powerful combination, and you advance much further together than if you tried to work individually.”

Nealey received his bachelor’s degree in chemical engineering magna cum laude from Rice University in 1985. He then spent three years working as an engineer for Solvay et Compagnie in Brussels, Belgium. He completed his doctorate in chemical engineering at the Massachusetts Institute of Technology in 1994, then conducted postdoctoral research at Harvard University.

His many honors include a fellowship in the American Physical Society, the 2010 Nanoscale Science and Engineering Forum Award from the American Institute of Chemical Engineers, and a 2009 Inventor Recognition Award from Semiconductor Research Corporation.

Nealey, who holds 14 patents and has authored more than 180 publications, is eager to see how his self-assembling materials might make it into production. “The ultimate reward for most engineers is when something that you developed actually gets commercialized and makes a difference,” he said.

Photo courtesy of Argonne National Laboratory.

"It's precisely the kind of approach that we must invest in to solve the great problems in sustainability. The IME partnership of pairing novel engineering at the molecular scale with Argonne's unique blend of expertise in energy and sustainability may prove to be revolutionary."

Peter B. Littlewood
Associate Laboratory Director, Physical Sciences and Engineering
Argonne National Laboratory

Building Connections for Broader Impact

At the nexus of research, teaching, and application, the Institute for Molecular Engineering strengthens connections between the University of Chicago and Argonne National Laboratory. IME is a joint vision of the two institutions, sharing its foundation as well as its faculty and resources with the University and national lab.

"Argonne is a huge asset and partner for IME, but IME can really be an agent drawing Argonne and UChicago closer together as well," said Matt Tirrell, Pritzker Director of IME.

IME builds on what has been a powerful partnership since Argonne's 1946 founding. The national laboratory began as an outgrowth of the Manhattan Project and UChicago's Metallurgical Laboratory, and the lab has been managed by the University for the US Department of Energy ever since. Joint faculty appointments and initiatives have sparked important collaborations. For instance, the Computation Institute's CIM-EARTH gives crucial insight into the human dimensions of climate change to provide policy makers with better tools to mitigate its harmful effects and the long-standing collaborations in high energy physics and computational astrophysics have made fundamental contributions to our understanding of how the universe works.

One avenue for closer connections is through IME's faculty, which includes joint appointments at the University and national lab. These appointments add to both institutions and provide an effective recruiting tool for the world's top academics.
"Many scientists enjoy working on a span of problems from fundamental to applied because that breadth in itself produces unexpected synergy and outcomes," said Peter B. Littlewood, a joint faculty appointee who serves as associate laboratory director for physical sciences at Argonne and Professor in Physics at UChicago. "My ideal is the UChicago-Argonne partnership, which gives me that inspirational range."

"I hope to spend a significant amount of time at Argonne," said Paul Nealey, Brady W. Dougan Professor in Molecular Engineering. "To have a presence there is the best way to tap into that expertise. We hope to bring something to the table, too, not just the research direction but also bringing together teams to do new and exciting things, in my case synthesis and characterization of polymer soft material systems."

Increased interaction between the institutions has important implications. IME will have its home on UChicago's Hyde Park campus in the new William Eckhardt Research Center, immersed in UChicago's culture of interdisciplinary scholarship and in close proximity to the University's schools and divisions, 140+ centers and institutes, and premier medical center.

IME scholars also have access to Argonne's powerful research infrastructure, including the Advanced Photon Source, which generates the most brilliant high-energy X-ray beams for research in the Western Hemisphere, and the Argonne Tandem Linac Accelerator System (ATLAS), the world's first superconducting linear accelerator for heavy ions.

"Argonne has incredible computers and fantastic facilities, so we can do experiments that are essential to our work and can't be done anywhere else. And having that link to the US Department of Energy, which funds some of the best science in the country, is tremendous," said Juan de Pablo, Liew Family Professor in Molecular Engineering.

Enhanced research efforts augment science on a broader scale, producing high-impact technologies and educating future generations of talented scientists.

"IME is of course a new kind of engineering school, and to think of engineering as a discipline that is built around manufacturing from molecules on up is audacious," said Littlewood. "But it's precisely the kind of approach that we must invest in to solve the great problems in sustainability. The IME partnership of pairing novel engineering at the molecular scale with Argonne's unique blend of expertise in energy and sustainability may prove to be revolutionary."

“We want to have everyone in the room at the same time—artists, scientists, technologists, and multimedia experts—as we create and develop projects in a collaborative environment.”

Nancy Kawalek

Professor and Distinguished Fellow in the Arts, Sciences, and Technology

The Institute for Molecular Engineering is founded on interdisciplinary collaboration that will extend far beyond the pure sciences. Such breadth is exemplified in Nancy Kawalek, an artist and innovator who will be joining the IME in 2013 as a professor and distinguished fellow in the arts, sciences, and technology.

Kawalek, who is currently a studio professor in the Film and Media Studies Department and the Media Arts and Technology Program at the University of California, Santa Barbara, has been integrating science and technology into the arts for the past seven years.

“So many great scientific discoveries have evolved out of an ‘aberration’ in experimental data. Instead of looking at that deviation as a mistake and then eliminating it, following it with further exploration revealed something new and exciting,” said Kawalek. “I started thinking about how to implement that same approach in the world of theatrical creation, where it has become so risky to fail. Maybe if artists are truly permitted the time and freedom to follow the unexpected, just as scientists do in their investigations, we can also make new discoveries and create great work. I think that’s one of the many things to be learned from scientists.”

Kawalek’s creative talents will be applied across IME and the University’s Arts | Science Initiative, an innovative project with a mission to cultivate collaboration between artistic and scientific inquiry. Specifically, Kawalek will be implementing the Chicago arm of her *STAGE* (Scientists, Technologists, and Artists Generating Exploration) Collaboratory, a developmental and improvisational lab for creating multimedia theater pieces that are infused with science and technology. She founded *STAGE* in 2005 at UCSB’s California NanoSystems Institute, where it began as an international script competition for the best new play about science and technology.

“When we work, we want to have everyone in the room at the same time—artists, scientists, technologists, and multimedia experts—as we create and develop projects in a collaborative environment,” she said. “It’s extremely unique for a scientific institute such as IME to so fully embrace an arts-driven entity like the *STAGE* Collaboratory. It’s just another example of how imaginative IME Director Matt Tirrell can be, and how he thinks big.”

The *STAGE* Collaboratory’s first theatrical creation, *The Brain Project*, is a story about perception that parallels the functions of the brain and explores critical themes emerging from modern neuroscience. Work on the play began at UCSB and will continue at UChicago.

Kawalek, a New York theater–trained actor, has 25 years of professional experience that includes acting on and off Broadway and in regional theater; roles in film, television, and radio; and extensive work as a writer and director. A graduate of Northwestern University, where she received her bachelor’s degree in theatre and oral interpretation, she has also studied at Second City and performed at Skokie’s Northlight Theatre and Chicago’s Victory Gardens Theater.

In addition to the *STAGE* Collaboratory, Kawalek is eager to implement new opportunities for artists and scientists to engage and develop sophisticated interdisciplinary programming together.

“I believe IME can change the face of science. That there is a scientific institute innovative enough to bring on a faculty member in theater is extraordinary,” she said. “We can have an impact on the way people work in and think about both science and theater.”

ABOVE: Paul Nealey is frequently invited to speak on his research involving the patterns and structures formed by self-assembling materials. Pictured is an artist's interpretation of a top-down scanning electron microscope (SEM) image of a macrophase separated blend of symmetric block copolymers. Illustration by Peter Allen for IME.

Activities

UPCOMING EVENTS

Biotechnology Industry Organization (BIO) International Convention
April 22–25, 2013
Chicago, IL
convention.bio.org

Spintech VII: 7th International School and Conference on Spintronics and Quantum Information Technology
July 29–August 2, 2013
Chicago, IL
spintech7.cnsi.ucsb.edu
Abstract submission deadline: March 29, 2013
David Awschalom, organizer

NOTABLE ACTIVITIES AND LECTURES*

13th Dresden Polymer Discussion: Molecular Bioengineering
April 2, 2012
Dresden, Germany
Matt Tirrell, invited speaker

Network of Excellence for Functional Biomaterials Annual Retreat
June 19, 2012
Galway, Ireland
Matt Tirrell, keynote speaker

Building Illinois Innovation Economy
June 29, 2012
Northwestern University
Evanston, IL
Matt Tirrell, invited speaker

Israelachvili Symposium
August 13, 2012
Cancun, Mexico
Matt Tirrell, invited speaker

Statistical Mechanics: Interplay of Theory and Computer Simulations
September 20, 2012
University of Mainz
Mainz, Germany
Juan de Pablo, invited speaker

Nanomanufacturing Sciences Patterning Annual Review
September 25, 2012
Semiconductor Research Corporation
Chicago, IL
Juan de Pablo and Paul Nealey, organizers

Sydney Ross Lecture
October 2, 2012
Rensselaer Polytechnic Institute
Troy, NY
Matt Tirrell, speaker

William H. Schwarz Lecture
October 15, 2012
Johns Hopkins University
Baltimore, MD
Matt Tirrell, speaker

25th International Microprocesses and Nanotechnology Conference
October 31, 2012
Kobe, Japan
Paul Nealey, plenary lecturer

American Institute for Chemical Engineering Annual Meeting
October 31, 2012
Pittsburgh, PA
Juan de Pablo and Matt Tirrell, invited speakers

Symposium on Directed Self-Assembly for Nanopatterning
November 25, 2012
Materials Research Society Fall Meeting
Boston, MA
Paul Nealey, invited speaker

Symposium on Structure-Property Relations in Amorphous Solids
November 25, 2012
Materials Research Society Fall Meeting
Boston, MA
Juan de Pablo, invited speaker

6th International Meeting on Molecular Electronics
December 4, 2012
Royal Society of Chemistry
Grenoble, France
Paul Nealey, plenary lecturer

Materials Genome Initiative Workshop
December 13, 2012
National Science Foundation
Washington, DC
Juan de Pablo, organizer
Matt Tirrell and Paul Nealey, invited speakers

*Activities participated in by indicated faculty after appointment to IME. David Awschalom's appointment is effective early 2013.