Chad Mirkin Now Elected to All Three Branches of the National Academies


Chad Mirkin

Northwestern University scientist Chad A. Mirkin, a world-renowned leader in nanotechnology research and its application, has been elected a member of the prestigious Institute of Medicine (IOM).

He is the first at Northwestern and in the Midwest and the 10th in the world to be elected to all three branches of the National Academies. Mirkin was elected a member of the National Academy of Sciences earlier this year and a member of the National Academy of Engineering in 2009.

Mirkin is the George B. Rathmann Professor of Chemistry in the Weinberg College of Arts and Sciences and professor of medicine, chemical and biological engineering, biomedical engineering, and materials science and engineering and director of Northwestern's International Institute for Nanotechnology.

Membership in the IOM is one of the highest honors in the fields of health and medicine in the United States. Mirkin is among 65 new members and five foreign associates recognized for their major contributions to the advancement of the medical sciences, health care, and public health.

Mirkin will be inducted into the Institute next October during its annual meeting in Washington, D.C. At least one-quarter of the institute's membership is selected from outside the health professions. The newly elected members raise IOM's total membership to 1,817.

Mirkin, a member of President Obama's Council of Advisors on Science and Technology, is the recipient of more than 60 national and international prizes. He is known for the invention and development of biological and medical diagnostic systems based upon nanomaterials and new approaches to cancer therapeutics based upon gene regulation.

Mirkin is best known for the invention, development, and commercialization of two revolutionary technologies: the nanoparticle-based medical diagnostic assays underlying the FDA-approved Verigene IDTM system, and Dip-Pen Nanolithography, an ultra-high-resolution molecule-based printing technique.

Both inventions were born, in part, out of Northwestern's Nanoscale Science and Engineering Center, funded by the National Science Foundation, and were conceived, managed, and directed by Mirkin. His research at the University, with the help of Northwestern graduate students and colleagues, has formed the basis of several start-up companies that are helping to bring his inventions from the lab to the market.

Current medical diagnostic tools make it challenging to detect molecules circulating in the human bloodstream that provide early warning signs of disease. Mirkin invented a highly precise method of identifying low concentrations of disease-signifying molecules.

He cofounded Nanosphere, Inc. with colleague Robert Letsinger, professor emeritus of chemistry at Northwestern, to commercialize many of the nanoparticle-based medical diagnostic assays invented in their laboratories. Nanosphere recently launched the Verigene ID System, a low-cost medical diagnostic system that can test patients for several different disease targets at the same time, on-site in a research laboratory or in a community hospital, with results in under an hour. The point-of-care technology is poised to decentralize the medical diagnostics industry.

Mirkin's work with nanostructures made of gold continues to lead to new ventures, including the recent founding of Aurasense, a company focused on developing a novel class of nanotherapeutics that are nontoxic and extremely effective in gene regulation for application in oncology and heart disease.

The challenge of creating flexible tools that allow one to print on the nanoscopic scale led Mirkin to invent Dip-Pen Nanolithography (DPN).

This technology, licensed by the company NanoInk, can be used to print features of proteins, DNA and other biological materials on surfaces with sub-50 nanometer resolution. Commercialized in the form of the NscriptorTM, it has become a novel research tool, allowing scientists to better understand how cells interact with surfaces and function, the chemical and physical consequences of miniaturization, and how structures — including individual viruses — behave at the single-particle level.

This knowledge is important for learning how viruses infect cells, understanding the chemical and physical differences between a healthy cell and a cancerous cell, and discovering the genetic code associated with a new flu virus — all of which could lead to new therapeutics and diagnostics. DPN's applications extend even further than this to highly miniaturized polymer- and molecular-based electronics.

Mirkin's invention Polymer-Pen Lithography, which uses millions of polymer-based tips, is designed to cover a larger surface area and has more commercial applications ranging from computational tools, medical diagnostics like gene chips, and pharmaceutical discovery through combinatorial biomolecule arrays for screening drug candidates.

Fengqi You Joins ChBE


Fengqi You

This fall, Fengqi You will join the Department of Chemical and Biological Engineering as an assistant professor. You obtained his BS with highest honors from Tsinghua University in 2005 and a PhD from Carnegie Mellon University in 2009, both in chemical engineering. His graduate research with Professor Ignacio Grossmann focused on the development of large-scale optimization models and algorithms for the design and operations of chemical processes and supply chains under uncertainty. Much of this research was done in collaboration with petroleum, chemical, and engineering companies. The stochastic process optimization strategies developed in his graduate research have been successful applied to complex industrial processes at Dow Chemical and Praxair, Inc. After completing his PhD, You joined Argonne National Laboratory, where his efforts concentrated on analysis, design, and optimization of renewable energy systems that address the growing energy crisis.

At Northwestern, You's research will focus on the areas of energy systems engineering, process synthesis and design, planning and scheduling, supply chain management, and optimization theory and algorithms. His objective is to develop novel computational models, optimization techniques and systems analysis methods for the design, operation, and control of complex chemical, physical, biological, and engineered systems.

Fengqi You has published more than 20 journal articles and book chapters. His recent honors include the Director's Postdoctoral Fellowship from Argonne National Laboratory (2009-2011) and the Ken Meyer Award for the best PhD thesis from Carnegie Mellon University (2010).

Fengqi You is married to Zhixia Zhong and has one son, Benjamin, who was born in the summer of 2010.

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WINTER 2011

Julio M. Ottino Named 62nd Annual AIChE Lecturer


Julio Ottino

Julio M. Ottino, Walter P. Murphy Professor of Chemical and Biological Engineering and dean of the McCormick School of Engineering and Applied Science, was named the American Institute of Chemical Engineer's 62nd Institute Lecturer.

Ottino presented his lecture, titled "Chemical Engineering in a Complex World: Grand Challenges, Vast Opportunities," on Nov. 10 at the AIChE Annual Meeting in Salt Lake City, UT.

"I felt honored to receive this recognition," Ottino said. "Chemical engineering is where I grew and developed, and even though my scope has expanded in the last few years, I still have a warm place in my heart for chemical engineering."

In his lecture, Ottino spoke about how over the past 30 years chemical engineering has expanded into areas including materials, biology, and molecular-based elements.

"When I was doing my PhD at the University of Minnesota, chemical engineering became more molecular right before my eyes," he said. "It was a truly exciting time. I am convinced that the most interesting times are the messy times, when things are in flux, when people are looking for the next big thing. One has to train oneself to thrive on these moments of frenzied chaos, because they are rare."

The most spectacular ideas happen when someone sees connections between two different fields that no one saw as connected before.

Ottino holds the idea that engineers should be "T-shaped"; that is, they should have both a deep knowledge of one area as well as broad knowledge of several areas.

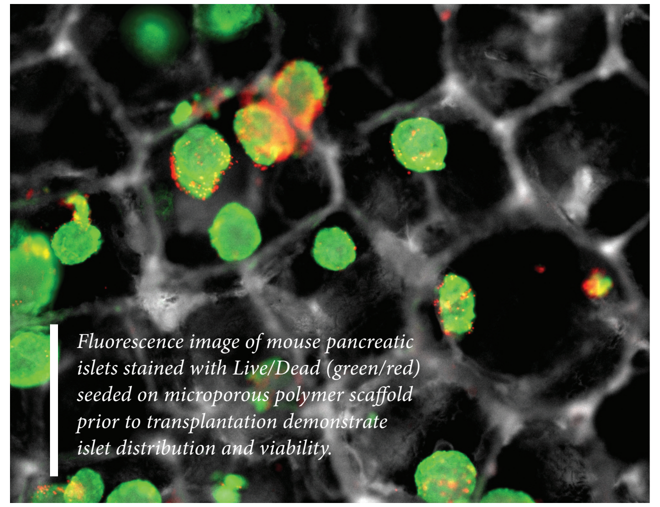
"I believe that finding new things requires a prepared mind, and a prepared mind is being aware, consciously or not, of surroundings," he said. "The most spectacular ideas happen when someone sees connections between two different fields that no one saw as connected before. If I have to give credit to someone for consciously trying to expand the broadness of graduate students in chemical engineering, it is Gus Aris at the University of Minnesota. He said, 'That a graduate student should emerge with the title of "doctor of philosophy" without the least contact with modes of thought outside his own field is in the highest degree deplorable.'"

In his lecture Ottino also considered the idea of seeing complexity in simplicity and simplicity in complexity. Pablo Picasso, for example, in a well-known series of bull sketches, started with a realistic bull and ended with a bull that was drawn with only a few lines.

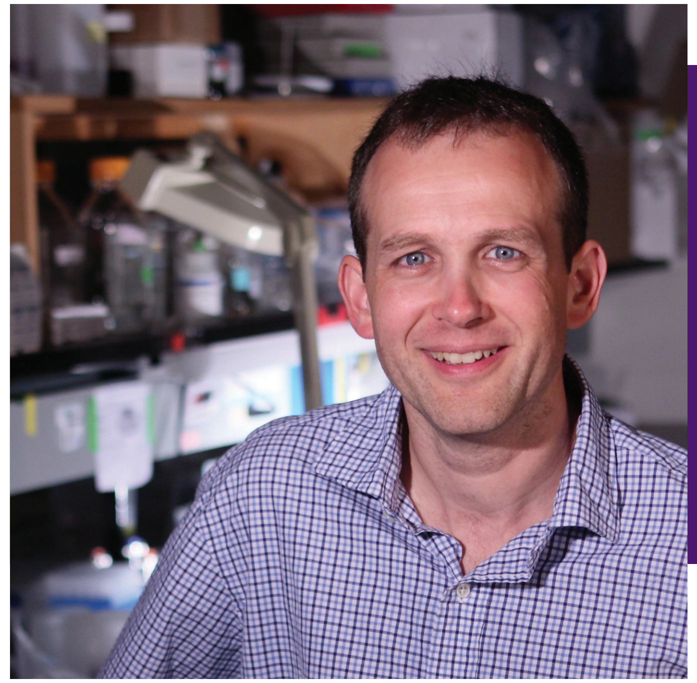
"It's the idea of extracting the essence of an idea – seeing the simplicity behind dizzyingly complex series of facts," Ottino said. "Chemical engineering has been able to do this: extracting that essence, or starting with foundation and studying the consequences. It is remarkable how things can branch out from seemingly simple origins. At the end this is all about seeing simplicity in complexity, and complexity in simplicity. What are the essential issues and how the branching and divergence will take place?"

That, Ottino said, is the future of chemical engineering.

"There are now tremendous opportunities for chemical engineering. In many respects, a current confluence of factors – energy, global health, environment, and many others arising from increased connectedness and complexity – make it more relevant than ever," he said.



Fluorescence image of mouse pancreatic islets stained with Live/Dead (green/red) seeded on microporous polymer scaffold prior to transplantation demonstrate islet distribution and viability.



Lonnie Shea

Lonnie Shea Looks for Ways to Make Islet Transplantation Viable

For the more than 23 million diabetics in the United States, disease management can range from cumbersome to critical. For many of those with type 2 diabetes, the disease often can be managed with diet and exercise. For type 1 diabetics, the disease can be managed with daily injections of insulin. But there are complications related to manual monitoring of blood glucose — some as severe as blindness, kidney damage, and lower-limb amputation.

So researchers continue to search for alternatives for managing blood glucose. Within the past decade, a new option has emerged: islet transplantation. Islets are clusters of cells from the pancreas that include beta cells, which regulate blood glucose levels. Though the cause of type 1 diabetes is unknown, researchers do know that a diabetic's own immune system mistakenly destroys the islet cells in the pancreas. Researchers also know that it's possible to take working beta cells from a donor and transplant them into a diabetic. Attempts have shown that this procedure essentially cures the diabetes; injections of insulin are no longer needed.

There are drawbacks, however. The patient must take immunosuppressant drugs to prevent the body from rejecting the cells, and the beta cells tend to stop working after only a couple of years.

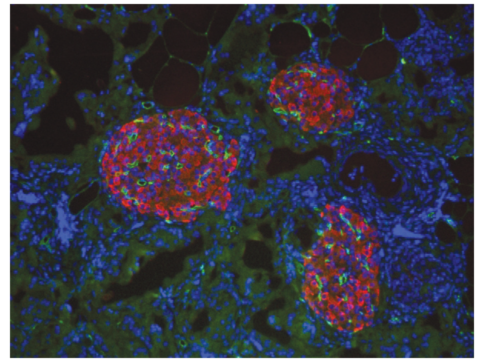
No one really knows why the islets fail: maybe they aren't getting enough nutrients, or maybe they are attacked by the recipient's immune system. So researchers are trying several methods to try to improve the success of the transplanted islets.

Professor Lonnie Shea is trying to create a tiny home for islets as they become part of their new body. "Typically researchers have tried to isolate islets from the immune system to help them survive," he says. "Islets occupy 1 percent of the mass of the pancreas but get 10 to 15 percent of the blood supply. If you're isolating islets from the immune system, you're not allowing blood vessels to access them."

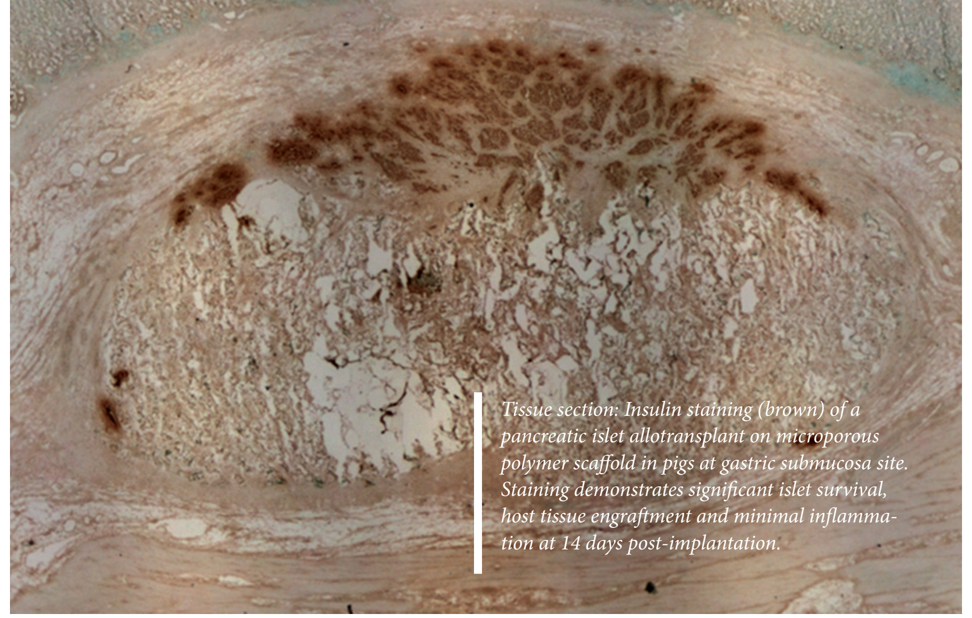
> *I hope our research can one day end the need for any children and their parents to be burdened by the constant strain of insulin regulation and the associated impact to the quality of life.*

Shea's group creates tiny structures called scaffolds out of a biodegradable polymer — the same material from which biodegradable sutures are made — and shapes them into a sponge. Each pore in the sponge is about 250 to 400 microns across and holds one or two islets, resulting in about 75 islets per sponge (normal mice pancreases have about 200 islets). Surgeons can then implant this sponge into the body. This technique, Shea says, gives surgeons an easy-to-use material, keeps the islets from aggregating (so they don't compete for nutrients), and allows blood vessels to grow through the scaffold and into the islets. Shea also puts a coating of extracellular matrix proteins around the scaffold that makes the islets easier to graft onto an organ; islets in the pancreas are normally surrounded by a fibrous matrix. "We're trying to deliver a minimal mass of islets and have them engrafted for a long time," he says.

Shea and his group have tested the scaffold in the fat pad of a mouse -- the equivalent of the omentum (a layer of fat around the stomach) in humans. The results



Tissue section: Immunofluorescence of syngeneic pancreatic islets transplanted on polymer scaffolds in peritoneal fat pad in mouse model of Type-1 diabetes. Insulin (red), vasculature (green) and nuclear (blue) staining demonstrate islet engraftment and significant functional revascularization at 14 days post-implantation.



Tissue section: Insulin staining (brown) of a pancreatic islet allotransplant on microporous polymer scaffold in pigs at gastric submucosa site. Staining demonstrates significant islet survival, host tissue engraftment and minimal inflammation at 14 days post-implantation.

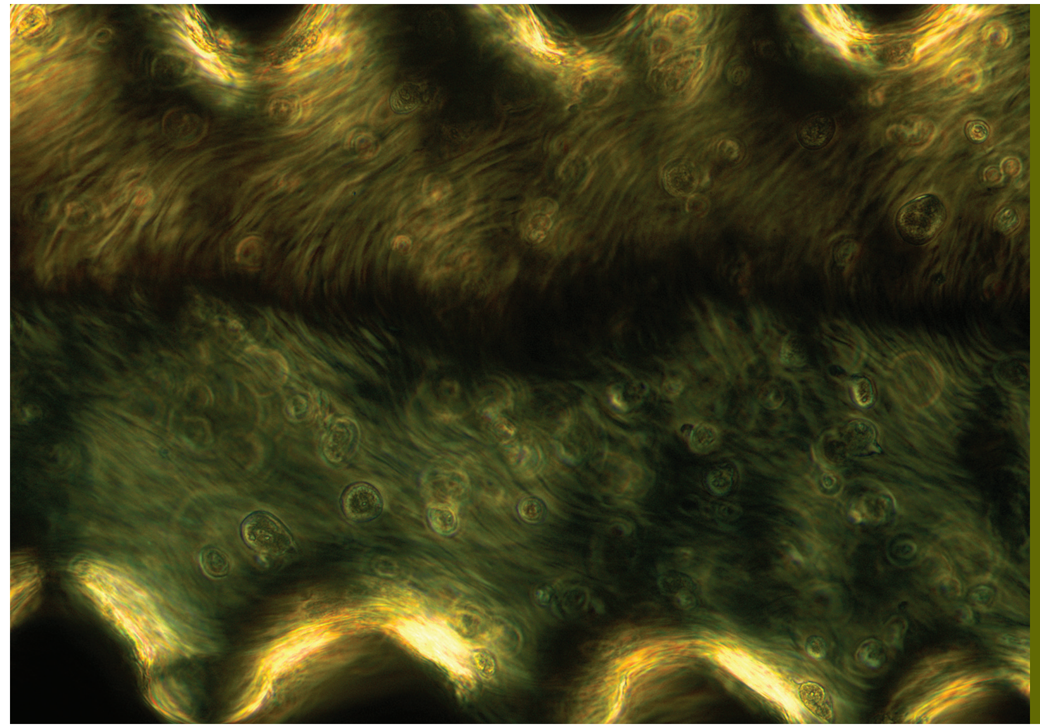
showed that blood vessels grow through the scaffold, and the scaffold itself degrades in 100 days. The islets continued working in the mouse for 300 days. "That's a large portion of the lifespan of the mouse," Shea says. "We're optimistic." Shea and his group have begun testing the scaffolds in pigs and primates. Early results from these ongoing studies have been encouraging.

Immune response to the islets is still an issue. Shea has been collaborating with Steve Miller, professor of microbiology-immunology at Feinberg, to develop strategies for inducing tolerance by coupling antigens from donor cells with islets, reducing attacks from the recipient's immune system. Shea hopes to create synthetic particles that would mimic these strategies to induce tolerance from the immune system.

Shea also collaborates with Dixon Kaufman, director of the Pancreas and Islet Transplantation Programs of Northwestern Memorial Hospital, and Bill Lowe, an associate professor of medicine at the Feinberg School of Medicine and an expert on the genetics of diabetes and islet cells. "I think the collaboration is great," Shea says. "No one person has solutions to all aspects of this problem. The materials we have are platforms for targeting the various barriers to engraftment and function."

Shea eventually hopes to be able to test his scaffold in diabetic humans who cannot have islets transplanted into their livers. "I'm hoping it can be a cure for type 1 diabetes," he says. "I am fortunate to have three healthy children. I hope our research can one day end the need for any children and their parents to be burdened by the constant strain of insulin regulation and the associated impact to the quality of life."

For more information on McCormick professors' research in islet transplantation, visit magazine.mccormick.northwestern.edu



"Science is always beautiful, but not all science is so easily captured by an image," says Mark Trosper McClendon, a chemical and biological engineering graduate student in Samuel Stupp's research group. "I'm lucky enough to be in a field that is very photogenic. When you are culturing cells with advanced materials such as nanofibers it is hard not to get an impressive image. The funny thing about this image is that the sample was an accident. I was attempting to create uniformly straight alignment of nanofibers, but I botched the procedure by ejecting the solution too fast and got this ripple effect. Even though the sample was not good for that experiment, it produced a beautiful pattern under the polarized light microscope. I never thought I would get recognition for it." McClendon's image won first place in the 2010 Northwestern Scientific Images Contest, sponsored by Science in Society. The image shows many millions of nanofibers together making up a gel.

–Northwestern Office for Research

Alumni Successes

Daniel Stouffer

Daniel Stouffer, an alumnus of the Amaral lab, has taken a tenured position of lecturer in the School of Biological Sciences at the University of Canterbury, in Christchurch, New Zealand. His research group will focus on the study of complexity in ecology and its implications for the sustainability of natural ecosystems.

Chris Ellison, an assistant professor at the University of Texas, was awarded a CAREER Award from the National Science Foundation.

James Gilchrist

James Gilchrist, former student of Julio Ottino, was promoted to associate professor with tenure at Lehigh University.

Rodney Priestley, who is now an assistant professor at Princeton University, received an NSF CAREER Award.

Roger Guimerà, adjunct professor at the Department of Chemical and Biological Engineering, was the recipient of the first ever Catalan Research Award in the category Young Researchers. The Catalan Research Awards aim at increasing social recognition of science and, particularly, of the scientific activities of researchers working in Catalonia.

Marta Sales-Pardo, adjunct professor at the Department of Chemical and Biological Engineering, has been awarded a Marie Curie Reintegration grant with the project "Decomposition and Discovery of complex Networks".

Guy Metcalfe, a former postdoctoral researcher with Julio Ottino, was the winner of a 10xE award ("increase efficiency 10 times") at Australian Commonwealth Scientific and Research Organization (CSIRO). Metcalf's winning project is on the based on the "Rotated Arc Mixer" concept, which was developed by the Ottino lab.

News and Awards

FACULTY

Luis Amaral was invited to join the editorial advisory board of *Nature Communications*.

Linda Broadbelt

Linda Broadbelt was appointed to the Board of Directors of the American Chemical Society Petroleum Research Fund. Along with Vassily Hatzimanikatis and Stacey Finley (former graduate student) were selected as the recipients of the 2011 Gaden Award. The Gaden Award is named in honor of Elmer L. Gaden, Jr., the founding editor of *Biotechnology & Bioengineering*, and is given in recognition of a truly outstanding paper published in the journal during the previous year.

Bartosz Grzybowski

Bartosz Gryzbowski was selected as the recipient of the Nanoscale Science and Engineering Forum of the American Institute of Chemical Engineers Young Investigator Award for his outstanding contributions to the fundamental understanding of self-assembling systems and the application of these systems in the synthesis of functional micro- and nanoscale materials. He delivered a plenary lecture as part of the NSEF Chemical Engineering Principles of Nanotechnology session during the AIChE Annual Meeting in Salt Lake City.

Harold Kung has been selected as the recipient of the 2011 Gabor A. Somorjai Award for Creative Research in Catalysis of the American Chemical Society. The award will be presented at the spring meeting of the ACS in 2011. This award recognizes outstanding theoretical, experimental, or developmental research resulting in the advancement of understanding or application of catalysis.

Josh Leonard

Joshua Leonard testified in Congress to the Subcommittee on Research & Science Education on 21st Century Biology.

Justin Notestein was selected as the McCormick Adviser of the Year.

John Torkelson

John Torkelson was elected as the vice-Chair and chair, respectively, of the 2012 and 2014 Polymer Physics Gordon Research Conferences.

Keith Tyo's work on engineered bacteria to synthesize a precursor to a potent cancer drug was published in *Science*: "Isoprenoid Pathway Optimization for Taxol Precursor Overproduction in *Escherichia coli*".

STUDENTS

Sabil Huda, a graduate student in the Grzybowski group, was selected as one of the recipients of the Kemin Industries Travel Awards for his presentation at the Experimental Biology 2011 Conference.

Derek Kiebala (McC '12) received an Undergraduate Research Grants award from Northwestern University's URG program. Derek received $1,000 in support of his project, "Optimizing a Self-Assembling Catalytic Membrane for Light-Driven H2O Splitting" advised by Sam Stupp.

Graduate students **Jisun Lee** (Packman Lab) and **Xiaohan Zeng** (Amaral lab) were nominated by Northwestern University for a Howard Hughes Medical Institute International Student Graduate Research Fellowship.