the chemists club

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THE UNIVERSITY OF CHICAGO

Driven by Curiosity

Richard F. Jordan, Paul Snowden Russell Distinguished Service Professor Emeritus

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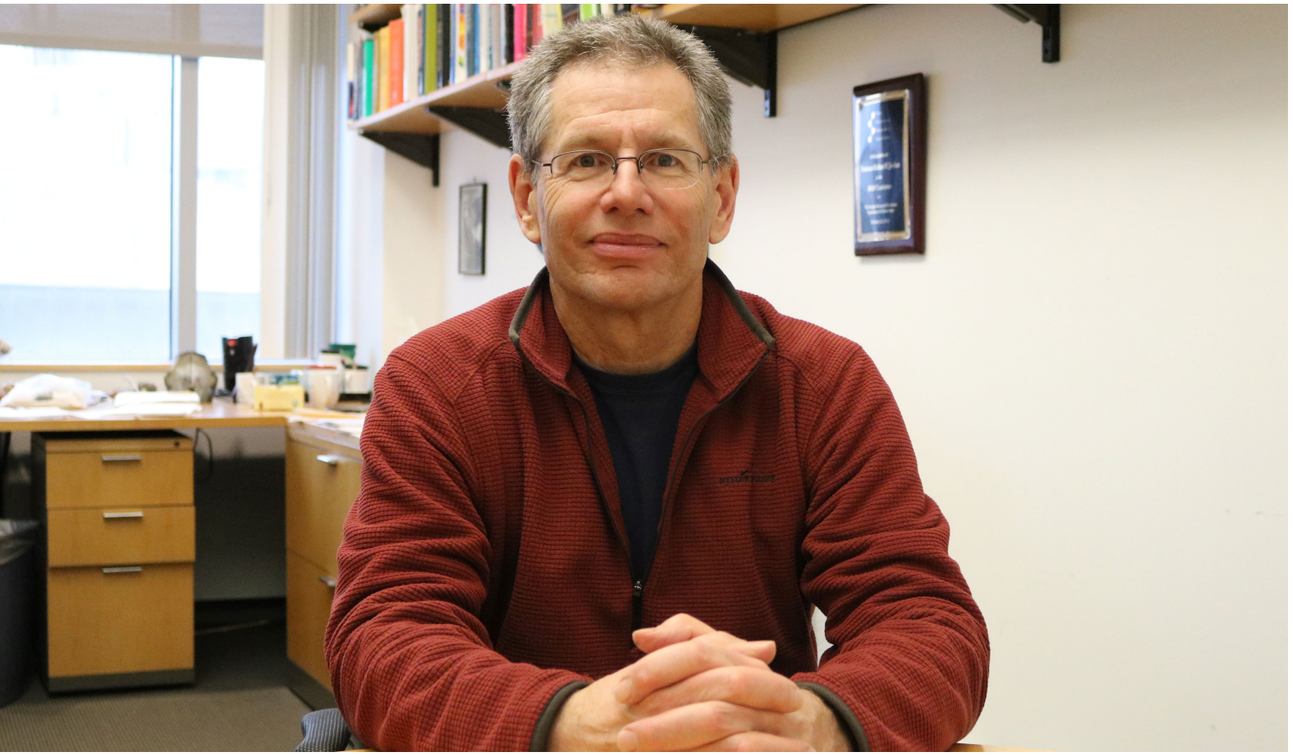
Richard F. Jordan converses with Irene C. Hsiao upon his retirement



Last February, the Department of Chemistry celebrated Richard Jordan, Paul Snowden Russell Distinguished Service Professor, upon his retirement from the University of Chicago. Research in his group has focused on synthetic and mechanistic organometallic chemistry, especially the design of catalysts—notably catalysts for olefin polymerization. Jordan joined the Department in 1999 after eleven years at the University of Iowa and five years at the Washington State University. From 2009 to 2015, Jordan served as Chair of the Department, shepherding the Department through a substantial expansion of the faculty. Jordan is a Sloan Fellow and a Fellow of the American Association for the Advancement of Science, has served on the editorial boards of the Journal of Organometallic Chemistry, Journal of Molecular Catalysis, *and* Organometallics, *and has been invited to lecture around the world, including at UC Berkeley as the Dow Lecturer and the Eastman Chemical Lecturer, at Scripps as the BASF Lecturer, at the University of Vermont as the Humphrey Lecturer, at Case Western Reserve as the Frontiers Lecturer, and at Zhejiang University and the University of Rennes as a Visiting Professor. He has also served as Chair of the Organometallic Division of the ACS, Vice Chair and Chair of the Gordon Conference of Organometallic Chemistry, and board member of the Council for Chemical Research and the University of Iowa Research Foundation. In 2018, he received the Arthur L. Kelly Faculty Prize for Exceptional Service from the Physical Sciences Division.*

Is it true you created catalysts that are used in the manufacture of plastics?

Correct. We developed new catalysts for making polyolefin plastics—polyethylene, polypropylene, and related polymers and copolymers.[1] The kinds of catalysts we developed are used in industry to a significant extent and allow us to make new types of plastics that can't be made any other way.

It wasn't what we set out to do. We started the project in the mid-1980s when I was an assistant professor at Washington State University. We were interested in making organometallic compounds that were highly reactive in order to understand the factors that control reactivity from a basic science perspective. During the course of this work we developed a class of cationic metal alkyls that turned out to undergo an olefin insertion reaction, which is the basic chain growth step in polymerization. We didn't set out to develop polymerization catalysts per se, but, having made this particular class of compounds, we recognized the potential applications and investigated them.[2]

That's often how basic research goes—you're opening up new chemical space and making new types of compounds with new types of bonds, functional groups, and structures to explore the limits of bonding and the types of structures you can make. Then you explore the reactivity of these new compounds and often discover new reactions, new catalytic processes, new applications, and so forth. Our research has always been more exploratory and fundamental than goal-oriented or applied.

Are there catalysts that break down plastics?

Not yet! That's a tough reaction that involves breaking C-C bonds. There's no effective way to do that for simple plastics—that's the problem. Polyolefin plastics are not biodegradeable or easily degradable. You can burn them or recycle them, but recycling is problematic because there are many different grades of polyethylene, polypropylene, and related copolymers that are optimized for particular applications. You can't separate them easily when you recycle, so you end up with a mixture of plastics that can only be used in applications with less stringent requirements. If you think about a bottle cap, that's a very sophisticated material, a linear polyethylene with a certain amount of branching to give you enough flexibility so that when you screw the cap down it seals, whereas a milk jug is also polyethylene but doesn't have the branching, so it's more rigid. When you recycle, they get mixed together and the resulting material would not be suitable for either of the two applications, so it's called "downcycling" instead of recycling. There is a movement now to get rid of single-use plastics like straws and water bottles and to make cheaper, biodegradable plastics. Society needs to move in that direction as rapidly as possible because plastic pollution in the environment is a serious problem. I read the other day that by 2050 the weight of plastics in the ocean will be greater than the weight of fish.

In the last ten years, we've been working on ways to synthesize functionalized polyethylenes by copolymerizing ethylene with other types of monomers, and we've explored new classes of palladium catalysts for this reaction. One of the drivers is the need for biodegradable materials. Polyethylene is just a chain of carbons with two hydrogens on each carbon. If you can replace some of the hydrogens with other functional groups, you can make the material more reactive and hence more biodegradable. We have not solved this problem yet, but we have made significant progress and have done some nice work in this area.

I'm a synthetic chemist. I like to make new compounds and discover new reactions.

Were you morally driven to do that?

I don't know about morally—it was curiosity. It's an important problem for society, and it's a challenging problem scientifically because there's no easy way to do it. A successful solution will require a lot of creativity and new insights and advances on the fundamental science side. I worry more and more about these issues but frankly am probably not any more environmentally conscious or socially responsible than anybody else. I understand the scientific underpinnings of problems such as climate change, but my research has always been more curiosity-driven and exploratory than practical or problem-driven.

I'm a synthetic chemist. I like to make new compounds and discover new reactions. If we can do something useful with them, that's great, and in certain cases that's happened. But if I look back at what my group and I have done, many of what I think of as our

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[1] "Ethylene Polymerization by a Cationic Dicyclopentadienyl Zr(IV) Alkyl Complex." Jordan, R. F.; Bajgur, C. S.; Willett, R.; Scott, B. *J. Am. Chem.* Soc. 1986, 108, 7410-11.

[2] "Chemistry of Cationic Zr(IV) Benzyl Complexes. One Electron Oxidation of d^0 Organometallics." Jordan, R. F.; LaPointe, R. E.; Bajgur, C. S.; Echols, S. F.; Willett, R. D. *J. Am. Chem. Soc.* 1987, 109, 4111-4113."Three-Coordinate Cationic Aluminum Alkyl Complexes Incorporating β-Diketiminate Ligands." Radzewich, C. E.; Guzei, I. A.; Jordan, R. F. *J. Am. Chem. Soc.* 1999, *121*, 8673-74.

most interesting projects and papers don't have a direct practical impact. They uncover some new chemical principle or disclose unusual structures that people didn't think would be possible. It is a long series of steps from that to actually having an impact on society.

Was it surprising that something you made could have a massive impact on society?
Oh yeah—it was amazing. I didn't expect it. It was my best work. It's why they hired me here, and it led to a lot of interactions with industry. I think the basic discoveries that we made and the principles for catalyst design that we worked out have had a broad impact.

Lots of other groups have picked up on what we did and advanced it in many new directions. The field is now called single-site catalysis, single-site olefin polymerization catalysis, or metallocene catalysis. It's now an enormous area that came about from the work we and other groups did in the '80s and developed in a big way in the '90s. We're not doing it anymore; we stopped about ten years ago because we wanted to do other things, but a lot of people around the world are still working in this area.

You say that this was your best work, but you implied that your most interesting work was something else—how do you define and what do you think was most interesting for you?
My favorite was a paper that involved a "self-correcting" catalyst.[3] This was a paper that was originally rejected, and to this day it has not been appreciated by the broader community. In catalysis you have the issue of selectivity: you're converting A to B but A could also be converted to C—a stereoisomer, a geometric isomer, or another compound entirely. You want to convert all of your reactant into a single product in 100% yield with no waste and no byproducts. Typically that doesn't happen; you make a mixture of several products, and you have to modify the reaction conditions and/or the structure of the catalyst to favor the formation of the desired product over the other products. We discovered a catalyst that, like many catalysts, could make two different products, the desired product and the undesired product. But in this case the process by which the catalyst made the undesired product resulted in a change in structure of the catalyst such that it became more


Photos courtesy Rich Jordan

selective and made only the desired product. Every time the catalyst made the wrong product, a series of reactions was initiated that changed the catalyst's structure into a new structure that was totally selective for the desired product. It is a really beautiful and unique system.

Did you intentionally create this catalyst, or was it something that just happened?
We weren't trying to solve a particular problem. We made a new class of compounds, namely early metal carborane complexes. We were exploring their reactivity with different substrates, and we observed unusual behavior. The selectivity of the catalytic reaction increased over time, so in the beginning, there were 2 products, and the ratio was something like 4 to 1, and after awhile it was 5 to 1, 10 to 1, and then 100 to 1. So the ratio of the major product to the minor product increased dramatically over the course of an hour or two as the reaction proceeded. At the same time, by in situ NMR analysis, we could see the structure of the catalyst changing from the original structure to the so-called self-corrected structure. We could correlate the change in structure with the increase in selectivity of the reaction, and from that and some other observations, including a detailed kinetic analysis, we were able to conclude that the formation of the wrong product caused the change in catalyst structure to the new structure that didn't make the wrong product. I thought it was a really interesting case of unusual reactivity and took a lot of interesting detective work to figure out what was happening. At the time we did not see an obvious way to generalize what we found to other systems, but perhaps a young chemist somewhere might be able to do so.

[3] "Catalytic Dimerization of Terminal Alkynes by a Hafnium Carboranyl Complex. A'Self-Correcting' Catalyst." Yoshida, M.; Jordan, R. F. *Organometallics*, 1997, 16, 4508-10.

Do catalysts get modified by their products in nature?
They do—I'm sure they do. One of the main themes of my field—catalysis and organometallics—is the issue of designing a catalyst that is highly selective. In the case of biological catalysts, this has been done through evolution over millions of years, so a typical enzyme is highly active and highly selective. Some synthetic catalysts have exceedingly high performance and high selectivity, and that's always the goal. I thought this was one of our most interesting pieces of work at Iowa because it was a very unusual chemical phenomenon that we discovered and elucidated. It was a significant intellectual achievement to work out what was happening. There was just not a lot of practical application to it.

Is the olefin polymerization catalysis "best" because of its application?
Vincent Van Gogh painted hundreds of pictures. I'm sure he had his favorite, but certain ones, like his self-portrait or *Starry Night*, have become very famous because for whatever reason the broader arts community is more attracted to them than others. You do a piece of work and for whatever reason you may think it's really neat—because it's unusual or because of the intellectual and experimental work you went through to figure out what's going on or maybe the surprise you had at how it turned out. That's the self-gratification that you get from doing it, and connected with that are the interactions with the graduate students with whom you are collaborating. The other part is the impact: does the work influence what other people are doing? Is there some practical application for it? Does the work lead to new fundamental principles that other people can use? If I think about our highest impact work, it's certainly the development of single-site olefin polymerization catalysts. We also did a lot of work in main group chemistry, particularly cationic aluminum alkyls, which also had a big impact because we made "super" Lewis acids that people found useful.[4] In the early 2000s we developed a highly efficient method for synthesizing chiral metallocene catalysts that has received a lot of attention.[5] Those were some of the higher impact studies that we did. But that doesn't necessarily map onto what I think was the most gratifying work.

How did you get into chemistry?
I always was inclined to science and math when I was a kid. My brother and I had chemistry sets—we used to blow stuff up, stink up the basement, etc. In high school [in Westfield, New Jersey], I had a really good chemistry teacher named Mr. Zoranski. I ended up majoring in chemistry [at Rutgers University], and after I got my bachelor's degree I worked as an analytical chemist for several years at ARCO Chemical Company.

When I was an undergraduate, I was not a very serious

[4] "Three-Coordinate Cationic Aluminum Alkyl Complexes Incorporating β-Diketiminate Ligands." Radzewich, C. E.; Guzei, I. A.; Jordan, R. F. *J. Am. Chem. Soc.* 1999, 121, 8673-74.
[5] "Enantioselective Synthesis of *ansa*-Zirconocenes." LoCoco, M. D.; Jordan, R. F. *J. Am. Chem. Soc.* 2004, 126, 13918-19.

It all goes back to Mr. Zoranski, my high school chemistry teacher. He was a really cool guy, we did a lot of fun experiments, and he made chemistry very interesting, which it is.

student. I got good grades, but I wasn't particularly concerned about my future career. I was more interested in surfing than in school. No one in my family had ever gone to graduate school, so I didn't know much about it. During my years at ARCO, I interacted with a lot of PhDs and realized that what they were doing was more interesting than what I was doing as a bachelor's level chemist. When I figured out they would pay you to go to grad school, it was a no-brainer! So I ended up going to grad school at Princeton, and when I became aware of the lifestyle professors were leading—they were doing whatever they wanted to do, basically, in terms of the science they were working on and spending a lot of time with students—it was very attractive to me, so I pursued an academic career.

But it all goes back to Mr. Zoranski, my high school chemistry teacher. He was just a really cool guy, we did a lot of fun experiments, and he made chemistry very interesting, which it is. Chemistry provides an interesting combination of the theoretical and the practical, an intellectual side, as well as a manual side. Doing experiments in lab is really fun, working with vacuum lines and different types of equipment, operating sophisticated instruments, and so forth. It's kind of like woodworking, working on your car, or fiddling around with your computer — if you like working with your hands, which I do, you will enjoy working in the lab.

But it seems so much in chemistry can't be touched or seen with the eyes—

You can't see molecules with your eyes, but the instruments we use are like our eyes. The principal technique that molecular synthetic chemists use is NMR—it's like the eyes of a chemist. Using modern NMR methods, we can, with some creativity and analysis, figure out the exact structures we have and, in effect, see what we're working on. There are high-resolution microscopy techniques that allow you to do that, but you won't be able to see the subtle structural features. But we can get at that through NMR and other types of spectroscopy. And we can use DFT and other computational methods to develop theoretical models to help interpret the experimental evidence about the structures and reactivity and reaction mechanisms. Learning how to do this is great fun. Once you are experienced, you can do some cool stuff: make new kinds of compounds, discover new reactions, and figure out how to control the chemistry.

You don't sound tired of it!

I'm not tired of it. I love it. But academic chemistry is exceedingly competitive. To work at a high level requires a major commitment. It's like a baseball player at the end of their career in their late 30s or 40s; they're just not physically able to play at a high level, so they retire rather than hang on year after year, performing at a lower and lower level. I recognized as I got older that I didn't have the drive that I had when I was younger to be thinking about chemistry all the time, coming in on Saturday, and so forth. It's not fair to my graduate students if I'm not fully committed in that way, so I retired.

Is it hard to step away when you're doing well?

Everybody's different. We have guys in their 80s who still come in. That's what they're into, and I have a tremendous respect for that. It's just not me. I have many other interests that I want to pursue. My goal this year was to ski 100 days; I ended up skiing 107 days, including 7 days of heliskiing in the Canadian wilderness. My wife and I do a lot of outdoor adventure-type stuff. I want to do that while I'm still healthy. Several years ago we bought a home in Avon, Colorado, near some of the best skiing and hiking in the country, and we are excited to spend more time there.

I'm really interested in climate change and will be doing some climate change advocacy work, probably with the Earth Island Institute. There's a large underprivileged Latino community in Colorado serving the ski areas, and I'd like to do something with those kids. In the Vail Valley area, you've got a lot of rich people, and you've got an underclass of mostly Latino people running the hotels, doing all the manual labor, and the school system is not that great out there. Property taxes are relatively low, and retirees and second homeowners who don't have kids in school don't want to invest in education. I'm interested in doing something with the school systems out there, maybe tutoring or a Big Brother type thing.

I felt I had a great career that far surpassed anything I could have imagined when I started. I enjoyed teaching, I enjoyed research, I really enjoyed working with students, I enjoyed being chairman. It was interesting; it was challenging. I felt I had an impact on the Department and the University. It was often a pain in the neck, but we were able to do a lot to improve the Department. All of that was great, but now it's over and time for the next stage.

What do your last days as a professor look like?

My last two PhD students graduated 2019—Alison Johnson Wilders defended in March ["Synthesis and Olefin Polymerization Behavior of Electronically-Unsymmetrical Pd(II)-Alkyl Catalysts"] and Erik Reinhart defended in June ["Metal Complexes Supported by Novel Ligands"]. Erik will spend a few more months with me as a postdoc finishing up several projects. And when he's done, I'll shut down the lab, write a few more papers, and be finished.

What is the work you're finishing your career with?

My last generation of students focused on three projects. We discovered a new class of compounds that we call "cage catalysts," complex structures that form by self-assembly and display interesting performance features in olefin polymerization reactions. We have tried to understand the self-assembly process and the origin of the unique behavior in olefin polymerization.[6] A second area involves the chemistry of palladium fluoride complexes. We discovered that certain Pd catalysts can copolymerize ethylene with vinyl fluoride to generate fluorinated polyethylene and that a key reaction in this process is the insertion of ethylene into Pd-F bonds.[7] This reaction is unique and was very surprising to us, and we are trying to understand how it occurs mechanistically. Finally, Erik is working on multinucleating ligands that are designed to position two metal centers in close proximity to each other in order to achieve new reactivity modes. All of these studies are synthetic chemistry projects aimed at making new types of compounds and structures.

Can you describe how projects are conceived in your lab?

You start out with an idea: maybe a structure we think is going to be interesting. Maybe it has an unusual bond in it, maybe it has unusual steric features, maybe it's chiral and might be used for enantioselective chemistry. Or maybe we have a known reaction, and we'd like to figure out the mechanism. A lot of the ideas come from my students. When I get a new student, I give them an initial project to get started as a vehicle for training them in techniques we use in our type of chemistry, but it's understood that the original goal of the project might not be achievable and/or that we may find something more interesting than the original goal along the way, and we'll go in that direction. It's also expected that the grad student is going to conceive of some new direction to take the research, and that's really going to be their PhD thesis.

I know a student is ready for their PhD when they've reached the point when they're having ideas that I would never have or solving problems I could never solve myself. When that happens, I know they're ready to graduate. That's really the goal of a PhD program, for a student to become an independent scientist, someone who can come up with their own problems and solutions completely independently. At the beginning, I tell the students what to do. At some point they're going to say, "You told me to do this, but I thought it would be better to do it this way, so here's what I've done and here are the results"—that's really what it's all about.

I have found that watching the evolution of students from first-year grad students who know very little to functionally independent scientists is a lot of fun and is very rewarding. It's impressive how smart they are and interesting to see the different kinds of intelligence. People approach things in their individual way. A student may not be good at quantitative analysis but may be great at pattern recognition, or may not be good at seeing the big picture but may be a great detail person. Everyone's got their strengths and weaknesses, and if you work with a student for five years, you really get to know who they are. And they get to know your strengths and weaknesses too! Working with my students and postdocs has been an incredible experience. That's what I'll miss the most.

Do you have any advice for young chemists?

I would say to follow your heart. Do what excites you. You only get one shot at life, so do it your way. What differentiates an academic from an industry career is that in academics we can do whatever we want. We don't have to solve a particular problem. We don't have to make a product that has a million dollars in sales. We're here to train students, to do basic research, and to make discoveries, so take advantage of that freedom if you're going to pursue an academic career. Do what you think is interesting, and you'll be successful because you'll be motivated.

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[6] "Sterically Controlled Self-Assembly of a Robust Multinuclear Palladium Catalyst for Ethylene Polymerization." Liu, Q.; Jordan, R. F. *J. Am. Chem. Soc.* 2019, 141, 6827–31.

[7] "Olefin Insertion into a Pd-F Bond. Catalyst Reactivation Following β-F Elimination in Ethylene/Vinyl-fluoride Copolymerization." Wada, S.; Jordan, R. F. *Angew. Chem. Int. Ed.* 2017, *56*, 1820-24.

Rules for Chaos: Suri Vaikuntanathan develops theories about nonequilibrium

By Irene Hsiao

"As far as we know," writes R. Stephen Berry, James Franck Distinguished Service Professor Emeritus, on the first page of *Three Laws of Nature* (2019), thermodynamics "applies to everything we observe in the universe, from the smallest submicroscopic particles to entire clusters of galaxies."[1] Thermodynamics, described by Albert Einstein as "the science most likely to be true," developed in the eighteenth and nineteenth centuries in parallel with the rise of the steam engine, which not only revolutionized the way that humans harnessed power for manufacture and transportation but posed a practical question that machines and scientists continue to answer today: how can energy most efficiently be converted into work? "In the twentieth century and perhaps even a little before, we have experienced a flow of concepts from basic science into applications," writes Berry. "[T]hermodynamics is an archetypal example of the applied stimulating the basic."

Today, Assistant Professor Suriyanarayanan Vaikuntanathan and his group are developing theories to return the basic science of thermodynamics to its practical origins in the world we live in. "Most of what we understand about reactivity and assembly [has been] developed for systems in a state of equilibrium." says Vaikuntanathan. "But in the real world many systems are not in a state of equilibrium, and our standard frameworks can't capture many complex phenomena seen in biological and chemical systems."

By combining theory with simulations and observations on how a variety of such systems behave—for example, how a cell membrane grows, how particles in liquids and colloids organize themselves, and so on—the Vaikuntanathan group works to understand and predict events in systems that are in a state of nonequilibrium. "The problem of understanding what happens far from equilibrium has been posed as a grand challenge in theoretical chemistry and chemical physics," he says. "It's something I felt I should try my hand at."

One model system Vaikuntanathan has been exploring to elucidate the role played by nonequilibrium activity is a minimal model for membrane of a cell. The fluctuations and dynamics of an ideal membrane at equilibrium can be described using the rules of statistical mechanics and thermodynamics, which allow us to track the behavior of each atom within it. Yet an actual membrane of a cell is not in equilibrium as it lives, grows, divides, and dies—do similar rules govern its fate? "If a cell membrane absorbs particles slowly, the structures can still be predicted using the laws of equilibrium statistical mechanics and thermodynamics," says Vaikuntanathan. "But if it absorbs particles at a rate that pushes it out of equilibrium, it will change shape—and in extreme conditions pinch off. We don't yet have a thermodynamic theory to understand these processes from first principles."

As intricate as nonequilibrium may seem, Vaikuntanathan suggests that an order and a sense can frequently be made of it using terms defined through thermodynamics. "Despite the many forms nonequilibrium may take, there are a few universal laws a system should satisfy, and we have discovered some of these laws using minimal but nontrivial models, like membranes," he says. "That's the beauty of thermodynamics: there are a few simple variables, like temperature, pressure, and entropy, that seem to be important no matter how complex the system is." Systems outside of equilibrium have often been considered chaotic and unpredictable. However, the Vaikuntanathan group has now constructed formalisms that show how material morphology, properties and phase transitions can be anticipated and controlled in terms of a few central thermodynamic quantities—even far from equilibrium.

Ultimately Vaikuntanathan suggests, the answers lie in understanding how energy, which Berry describes as the "grand, unifying concept" uniting heat, work, and motion, flows. "If I want to think about what phase is stable at equilibrium, what structure self-assembles on a microscopic scale at equilibrium, I can think about free energy, and I can be assured that the structure with the lowest free energy is the most stable. By thinking carefully about the various flows induced by non-equilibrium driving, we have achieved some success in understanding how similar design principles can be written for far from equilibrium systems," he says.

That's the beauty of thermodynamics: there are a few simple variables, like temperature, pressure, and entropy, that seem to be important no matter how complex the system is.

"The ultimate test is in experiments. Chicago gives you wonderful opportunities," says Vaikuntanathan. Collaborations with faculty across Chemistry and Physics, including Margaret Gardel, Dmitri Talapin, Norbert Scherer, and William Irvine, offer Vaikuntanathan opportunities to test his ideas and develop new theories in conjunction with a range of experimental work at the University, including systems as diverse as ionic liquids and colloidal solutions, optical matter, and the protein actin modified to form drops, which both inspire inquiry and suggest applications for his work.

"There are systems like these that are very complex, and we have the experimental know-how to visualize them and ask fundamental questions about chemistry and biology. As a theorist, being able to come in and say it's not all a big mess is immensely satisfying. We can contrast our theory to reasonably complicated simulations. We can show there are some simple universal ideas that allow us to predict a few properties that would be tough to extract otherwise. You can actually predict how structures are formed, how assemblies are formed from systems that look chaotic and disorganized. That's satisfying."

[1] R. Stephen Berry, *Three Laws of Nature: A Little Book on Thermodynamics* (New Haven: Yale University Press, 2018), p. 1.

Weldon G. Brown Memorial Fellowship

By Irene Hsiao

Weldon Grant Brown was born 4 February 1908 in Saskatoon, Saskatchewan, Canada. He received his BS with high honors in 1927 and his MS in 1928 at the University of Saskatchewan, publishing several scientific papers by the age of 20. In addition to his evident talent in science, Brown was active and accomplished in many regards. He worked part-time throughout his studies, served as editor of the university newspaper, and played football for the University of Saskatchewan Huskies. In the summers, he studied aviation with the Royal Canadian Air Force, obtaining a Sword of Honour upon graduation. Brown then continued his studies at the University of California, Berkeley, where he received his PhD in physical chemistry in 1931. He did postdoctoral research as a National Research Council Fellow with Robert S. Mulliken at the University of Chicago and Karl Friedrich Bonhoeffer in Frankfurt, before returning to the US for a brief stint at the Titanium Pigment Company. Industry not being to his taste, Brown soon returned to academia, joining Harold Urey's Nobel-winning deuterated water project as a research associate. Brown joined the faculty at the University of Chicago as an assistant professor of organic chemistry in 1935, becoming associate professor in 1941 and professor in 1946. He also held an appointment at Argonne National Laboratory, where he worked full-time for ten years before his retirement in 1973.

Brown worked at the top levels of American science for decades and had a tremendous record of accomplishment in several areas of physics and chemistry. His contributions include early work on the thermodynamics of inorganic systems, groundbreaking studies of the high resolution spectroscopy of the halogens, extensive work in organic synthesis and mechanisms, and some of the first studies of the chemical effects of radiation on organic matter. He was a key player in Chicago's world-leading programs in physical organic chemistry and nuclear chemistry and pioneered the use of isotope tracers to probe chemical reaction mechanisms, an approach that is standard today. In addition to his experimental work, he made pivotal contributions to theory and was a coauthor with Mulliken on a classic 1941 paper, Hyperconjugation, which was a landmark development in our understanding of chemical bonding and electronic structure. While much of Brown's work focused on fundamental scientific questions, he also had a distinct practical bent. He pioneered the development of paper chromatography, perhaps the most widely used separation method in chemistry, and he developed the chemistry used in nerve gas detection kits for the army in WWII. Few scientists have had an impact in so many different areas in their careers.

In 2018, the Weldon G. Brown Memorial Fellowship was established and endowed to support a graduate student in the Department of Chemistry recognized for excellence in research for one academic year. Charles Cole of Scott Snyder's group was the inaugural recipient. Of his work, Cole says, "Pyrone Diels-Alder reactions are viewed as highly valuable transformations given that they lead to bicyclic lactone products containing several stereogenic centers in a single synthetic operation; however, there have been few examples of effecting such transformations in an asymmetric manner to afford optically active products. Our research looks at the use of Jørgensen–Hayashi-type catalysts to achieve a dienamine-mediated [4+2] cycloaddition of a,b-unsaturated aldehydes with electron poor pyrones; this process has led to the enantiospecific construction of a number of [2.2.2]-bicyclic lactones (up to 99% ee) and some quite interesting structural frameworks."

Young at Heart: NMR Facilities Manager Antoni Jurkiewicz Retires

By Irene Hsiao

In May 2019, the Department celebrated the retirement of NMR Facilities Manager Dr. Antoni Jurkiewicz. Born in Poland, Jurkiewicz was fascinated from an early age by electronics. He studied chemistry as an undergraduate at the Cracow University of Technology, where he wrote a thesis about Nuclear Magnetic Resonance studies of ß-substituted Nitroethylenes adducts under the guidance of Andrzej Baranski before pursuing a PhD in physics at the Institute of Molecular Physics in Poznań. His PhD thesis, written under the guidance of Narcyz Pislewski, was about NMR studies of the molecular-macromolecular dynamics of coal structure in the presence of unpaired electrons. A Fulbright Scholar Fellowship brought him to the United States to work on solid-state NMR at the Department of Chemistry at Colorado State University as a visiting scholar in the laboratory of Gary E. Maciel. Jurkiewicz then held positions as a research scientist and NMR lab manager at the Pacific Northwest National Laboratory in Richland, Washington, and at the Phillips Petroleum Company in Bartlesville, Oklahoma. Jurkiewicz joined the Department of Chemistry at the University of Chicago in August 2000 and helped design the current NMR facilities in Searle and GCIS with chairs Mike Hopkins and Rich Jordan.

Looking back overhis nineteen years with the Department, Jurkiewicz fondly remembers his interactions with students in the Department. "I set up more than one thousand NMR accounts for students," he says. ""Every student who came into the lab spent a significant amount of time with me. Writing a thesis is a big accomplishment. That's been the biggest pleasure, people coming in happy they are defending, with thousands of NMR spectra for a single thesis—this was done in my lab." In addition to the critical role NMR has played in the research of students and faculty in the Department, he notes with a smile, "Most people love the exams! Sometimes they come and take them even though they never use NMR. They simply want to learn this technique. It gives me a good feeling."

Jurkiewicz's independence as a facilities manager has also supported the efficiency of the NMR laboratory. "I have never once asked factory service to come on site to fix my problems," he says proudly. His affinity for spectrometer electronics and mechanics also extended to software: the Linux system administration and maintenance of the lab computers and networking were all maintained by him, decreasing the costs of lab operations and maintaining high efficiency with almost no spectrometer downtime. The Linux Centos operation system he applied, as well as the Bind DNS server, Apache server, firewall, and reservation system, all derive from free-of-charge, open-source software.

In addition to his excellent work as a facilities manager, Jurkiewicz also shared his theoretical and practical aspects of NMR experiments freely with NMR community through his website. Jurkiewicz performed research on spin noise and spontaneous NMR maser emission that has led to the application of a novel method for tuning of NMR probes that is distinctive to Chicago. "In spite of the introduction of the NMR in 1945, spin noise and spontaneous maser emission are still challenges in our understanding of NMR," he says. "We are one of a handful of labs in the world that are taking advantage of this kind of special probe tuning. This translates into a better signal-to-noise ratio, better sensitivity, shorter experiment times and more free spectrometer time for our users."

During his retirement, Jurkiewicz anticipates spending time with family, traveling, and attending to "unfinished business" with his research. "I was never bored in my life," he says. "I'm not worried I will have nothing to do—no way. Never in my life. If you have something to do, you are young. If you have nothing to do, you are old. I have to be young until the end."

Scientific Method Guides Cheryl Dembe to Degree

By Irene Hsiao

Congratulations to Cheryl Sundari Dembe (MS 1970), who received her PhD in August 2018. A graduate student in the Department of Chemistry from 1968 to 1971, Dembe conducted research in Lothar Meyer's lab on quantized vortices in superfluid liquid helium at temperatures millidegrees from absolute zero and developed thermometry in this region. On February 1, 1971, just weeks after declaring Dembe ready to write up her thesis for graduation, Meyer unexpectedly passed away.

Following this shocking loss, the Department informed her that she would have to begin her research once more "from scratch" in a new laboratory, as the faculty member conducting similar research would not have a woman in his lab. "No one ever spoke to me about how to progress towards my degree after Lothar Meyer died," states Dembe. "There was no way to think about advocating for myself. "

Dembe drifted for two months before deciding to take a trip to California. There, she took a teaching job at Holy Names College, now Holy Names University, in Oakland, intending to teach for a few years to regroup. However, one year turned into decades, as Dembe devoted her life to teaching as the first female professor on the chemistry faculty at Diablo Valley College, later the first female chair of the Department of Chemistry, the first female head of the Division of Physical Science and Engineering, and one of the first women on the DVC faculty to have children.

Dembe speaks with pride about her career at DVC, noting that students from their chemistry department had an extremely high transfer rate to four-year colleges. "People would get into Harvard and Stanford from our school. I once taught a twenty-five-member organic chemistry class where fourteen got into Berkeley," she says, citing a longer semester, sophisticated instrumentation designed for the teaching of undergraduate chemistry, and student resiliency training as factors in her students' success.

While taking a course on the achievements of women in science during a sabbatical, Dembe read about Stanford physics professor Douglas Osheroff's 1996 Nobel Prize in Physics. The prize (shared with David Lee and Robert Richardson) had been for the discovery of superfluidity in helium-3, research he conducted in 1972 as a student at Cornell. To her surprise, his graduate research looked reminiscent of her own low-temperature studies of helium. She contacted Osheroff, who acknowledged her work and encouraged her to seek her degree from the University of Chicago.

Dembe wrote to the Department of Chemistry in 2000 explaining her case but received no reply. Dembe did not pursue the communication again until the #MeToo movement garnered nationwide attention. In April 2018, she wrote directly to President Zimmer: "The recent #MeToo movement has led me to focus more clearly on the strong injustice done to me at the time, because I was a woman. It has once again led me to write the University of Chicago and ask that redress be made for the substantial and life altering effects the University of Chicago chose to impinge upon the trajectory of my life. I request that The University of Chicago address and make right this matter. I ask to be awarded the doctorate I earned at that time."

This time, her letter did not go unnoticed. A committee in the Department of Chemistry meticulously reviewed her 475-page lab notebook from 47 years prior, concluding that Dembe was on track to receive her degree, had her studies not been interrupted. Undeterred by the time that has passed, Dembe says, "I'm an extraordinarily energetic person. Scientific contemplation continues to inspire me, and there's research I would still love to pursue."

"I went into science to learn the truth," says Dembe, who published a memoir in 2016 called *The Choice of Happiness: Glimpses from an Extraordinary Ordinary Scientific Mystical Life*. "In every aspect of my life, nothing has been more valuable to me than the scientific method. To take the time to observe, take data, check reproducibility, and hold off on conclusions. I see the actions of the Department of Chemistry, the University, and my degree committee as a miraculous template for how to respectfully consider our issues with each other and look for the position of being each other's solution into greater joy and connectivity—a process where each person can leave with the feeling of integrity."

THE DEPARTMENT OF CHEMISTRY

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CHEMISTRY EVENTS The most up-to-date information on Department of Chemistry lectures and events can be found online at events.uchicago.edu/chem/index.php.

LET'S KEEP IN TOUCH The Department of Chemistry is updating its records. Send your current e-mail address and other contact information to chemistsclub@uchicago.edu.

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Congratulations

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Lianne Wang Blodgett
Juana Delao
Irena Feng
Shanee Antoinette Gabbidon
Sarah Patricia Greta
Kelsey Leigh Hopkins
Freda Hu
Elizabeth Faramade Hunpatin
Darren Neville Kahan
Satyajit Narayana Krishnan
Kirk Ryan Lancaster
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Maria Isabel Merolle
Priyadarshini Mirmira
Alice Wen Qin
Jenna Dale Reisler
Gianna Waleska Sparks
Anne Kathryn Ullyot

BS
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Vishwas Srivastava
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Erin Henning Thiede
Hunter Baksa Vibbert
Jianchun Wang
Zongan Wang
Benjamin P. Weissman
Alison Mae Wilders
Nicholas Edward Williams
Yan Xu
Qiancheng You
Lisheng Zhang
Chun Zhou
Ye Zhou

Student Honors

Barnard Memorial Award
Laura Watkins

Closs Teaching Award
William Guy
Sofiya Maltseva
Andriy Neshchadin
Ferdinand Taenzler

Cross Prize
William Carpenter

Gilbert Memorial Prize
Vladislav Lisnyak

Knock Prize
Ellen Purdy (Chemistry)
Sara Warrington (Biological Chemistry)

Nachtrieb Memorial Award
Sam Veroneau

Norton Prize
Matt Ackerman
Pengfei Hu
Vishnu Nair
Hailing Shi

Shiu Department Service Award
Jake Higgins
Josh Portner
Laura Watkins

Sugarman Teaching Award
Sami Abdulhadi
McKenna Goetz
Alexandra Lamtyugina
Sarah Willson

William Rainey Harper Dissertation Award
Clara del Junco
Guangxu Lan

PSD Teaching Prize
Matthew Zajac

Booth Teaching Prize
Gregory Rassolov

Chenicek Fellowship
Jeff Montgomery

Goodman Fellowship
Vlad Kamysbayev

Light Fellowship
Laura Tociu

Nitecki Fellowship
Chang Liu

Olshansky Fellowship
Timothy Grabnic

Sellei-Beretvas Fellowship
McKenna Goetz

Van Dyke Tiers Fellowship
Charles Cole

Dear friends,

This is my last issue as editor of the *Chemists Club* newsletter. Over the past four years, it has been my honor to produce this newsletter, plan our (almost) annual alumni reception, and regularly update you with news of the Department on our social media and website.

I am extremely grateful to have had the opportunity to celebrate the achievements of our community in big and small ways, from curating and hanging an exhibition of paintings by Dr. Danute Nitecki (PhD 1961) in the Gordon Center Atrium, to establishing the Department of Chemistry Distinguished Alumna/us Award. I am particularly proud that the Department honored Dr. Reatha Clark King (PhD 1963) as the first recipient. It has been wonderful to highlight her accomplishments, and those of other outstanding members of UChicago Chemistry, during my time here.

It has been a pleasure to get to know current and past members of this department. I wish you all the best.

Yours sincerely,
Irene Hsiao

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the chemists club

Winter 2020

Dear friends,

Welcome to the Autumn issue of the *Chemists Club* and to the start of another exciting academic year at the University of Chicago! This issue highlights the stories of several individuals who have helped shape the Department of Chemistry.

I would like to congratulate Cheryl Sundari Dembe, SM'70, who returned to the University to receive her doctoral degree in Chemistry this June, albeit nearly fifty years too late. This alumna's story figures prominently in this issue and has been extensively covered by the national media. Dembe was close to completing her dissertation in 1971, but after her advisor's untimely death, extreme gender discrimination in the Department of Chemistry made it impossible for her to continue. We sincerely apologize for this shameful behavior and for how long for us to acknowledge our negligence. Dembe was inspired by the #MeToo movement to reach out to the University of Chicago, successfully petition for her degree, and bring the discrimination she experienced to light on a national scale. We thank Cheryl Dembe for her perseverance and for giving us the chance to partially right this wrong and properly recognize her achievements.

We are happy to welcome some new faces to the Department of Chemistry, but are sad to see some longtime colleagues depart. In this issue we talk with Richard Jordan, Paul Snowden Russell Distinguished Service Professor, who retired this year. In addition to his major contributions to inorganic chemistry and catalysis, Jordan left a lasting impact on the Department as Chair from 2009 through 2015. He worked tirelessly to expand the Department into the highly ranked scientific force it is today. Also, on his retirement we would like to thank Dr. Antoni Jurkiewicz for nineteen years of service as the Department's NMR Facilities Manager, and we welcome Dr. Josh Kurutz who is taking over in that role. Lastly, we are happy to welcome two new junior faculty members to our department: Mark Levin (organic chemistry) and Weixing Tang (chemical biology). We are thrilled that they are joining us and cannot wait to share their future endeavors with you.

Best regards,

Andrei Tokmakoff
Professor and Chair