the chemists club

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THE UNIVERSITY OF CHICAGO

A Platonic Relationship

Philip Eaton converses with Irene C. Hsiao at the Quadrangle Club, 4 April 2016

Interview with Professor Philip Eaton

How do you define chemistry?
It's a field that is being assimilated into other fields: materials research, various forms of molecular biology, biochemistry, molecular engineering, and so on. I guess there are parts of chemistry which have remained fundamental to its initial mission, for example, natural product synthesis, which is an enormous intellectual challenge and reaps great rewards, for example, new drugs, new biologically active materials. I predicted a long time ago that this area of chemistry would be subsumed by other areas of chemistry, but it hasn't been.

But cubane is not found in nature?
No, it's an unnatural product. This is a thing that nature either can't do or decided not to do, as far as anyone knows. There are many compounds like that that have been useful as synthetic challenges and define the boundaries of bonding in organic chemistry—a field that has answered the great majority of [its] challenges. It has become a part of molecular engineering. Unnatural products have special physical properties that are of interest in the design of molecular devices.

What interested you in chemistry?
I got my first Gilbert chemistry set as a kid. My parents gave it to me. It was not like the chemistry sets nowadays. Those are safe, which means that they're uninteresting. I think many of the present rules of the game are not good for budding scientists. A young anybody is fascinated by the element mercury, and that's considered to be a no-no in modern chemistry sets.

Chemistry is beautiful. The unnatural products that interested me had very high symmetry. The symmetry of a molecule makes it easier to study because each of the carbon atoms in it are the same, have the same properties, have the same angles, the same lengths. This helps [us] understand the molecule in depth, and that's what I had as a goal, to understand these unnatural molecules in depth and to make other strange molecules.

Cubane led to a lot of derivatives of cubane that were special in their own right. Its bonding is unusual, exceptional. In an ordinary carbon-carbon double bond, the 2p orbitals are parallel to each other. But you can make compounds in which the geometry is different. The properties of [the bonds in cubane] are different, and the bonds [result in] twisted orbitals. Cubane is a rigid structure, so you can hold them in a particular way. From cubane we went to cubene.

You like to know what the boundaries of molecules are. That's one way you can look at what we did, as defining the boundaries of organic compounds. That sounds a bit pompous. Looking back, it seemed to help to understand the boundaries of bonding between compounds by showing what they're like when you move away from the norm. Most

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natural products have the tetrahedral carbon. There are also natural compounds that have the strained ring, the cyclopropane ring.

When you set yourself the challenge of creating something like cubane, do you start with the shape or the properties?
I was assigned a project when I started to work in industry in the summers, and that logically led me to an interest in cubane. Sometimes one gets led by the nose. I can follow in detail how each thing I did followed from the thing before. In reflection, I think that's rather boring. TThere was an article in a recent *Wall Street Journal* about students looking for what career they should have. This one goes back to Confucius and other Chinese philosophers about how to find oneself and how one should leave oneself open to experience. I stayed pretty much in a line—in retrospect I wonder if I should have had more bumps.

Is there a relationship between chemistry and philosophy?
If I were really compelled to answer a question like that, I could force something out.

The same way you can force carbon bonds?
On the surface, I don't think so. I saw last night for the umpteenth time [Bertolt] Brecht's *Life of Galileo*, and the point is made so many times that reason is a better thing than the rigidity of the church. I think science is basically reasoning as a philosophical stance because you don't just follow what other people are saying. In chemistry, people say things are impossible—cubane was once thought to be impossible. I can't say that I thought that cubane was possible and that's why I did it. I said, "I'm not really sure it's impossible; let's see."

Don't you arrive there by an act of intuition?
A good guess.

Isn't a good guess is a form of reason?
No. I had an idea that actually goes back to an exam I failed, a question I couldn't answer in graduate school which always bothered me. It was about a particular reaction, the Favorskii reaction, and it just so happened that other things we were doing offered the possibility of using it to try to make cubane. So, for other reasons, we got ourselves in the position where we knew we could make the compound on which to try the reaction, that, if it worked, went to cubane.

So you knew in advance it would work?
Yeah, I took an NMR, and I suppose I could have said "Eureka!" But it was very clear that it worked.

Before the NMR?
The NMR would have to happen. Afterwards, we said, as any scientist would, "Well, what if this is just deceiving us?" It survived all [the] tests, so we concluded it had worked. It was just luck that the reaction worked. But even if it had not worked, we had been able, in a systematic way, to prepare a compound on which to try the reaction, and this to me was the most important part. In many nonnatural product cases, the product is an accident; it comes about serendipitously. In this particular case, we had developed a good path to get just what we needed to try the reaction. And that changed the way people thought about natural product synthesis; that is, you didn't need a flash of lightning to make it. This is certainly true of natural product chemistry. People lay out paths, and along the path they have some reactions that they are hoping to develop, so the path is not just a combination of old hat stuff but takes what's available and builds on it. Now a lot of the design of a synthesis can be done by computer. A lot of the interrogation of what a molecule is like can be done by calculation.

So do you even need the molecule?
There are some things a theoretical chemist wouldn't have even bothered with or thought of as a problem because they were so outrageous. We made a cubocation, which is just not supposed to be. But it is!

Nowadays people would do more calculation before they started to try the synthesis. I'm afraid it's moving to the point where people are happy with the calculation and would not bother with the synthesis.

What would be the point of knowing the properties of something that doesn't exist?
From my point of view, nothing. I'm a hands-on chemist. Theory has become a powerful tool, which it was not when I went to school. It was basically complicated algebra. In that form it didn't turn me on. To my misfortune, I ignored it. Now it's a different matter. Lots of things change, as they should. The biggest question facing organic chemistry as a field right now is, what do you stop teaching? What is no longer sufficiently useful for a chemist to know? You have to draw a line somewhere.

Chemistry is a thriving field, but it's thriving within other disciplines, and those disciplines are new over the past decades. I go to some of the seminars in the department, and I don't understand anymore. I don't have the vocabulary to understand the new world. I try to keep up in the department in a nominal way, with advances in chemistry. The ones in my field specifically I don't find very important anymore, because the field has been pretty well defined. And you can add a little bit here, add a little bit here.

But maybe there's something that will really go BOOM! I don't mean boom in terms of an explosive. Cubane has become a more interesting compound than it was because it has been found just recently that you can use cubane as a bioisostere of benzene. There are certain aspects of cubane that are similar to benzene, not the aromaticity, but the arrangement of groups. Recently cubocaine was made. It's an exact analogy to benzocaine, in which the benzene ring has been replaced with a cubane. On the surface it has twice the activity of benzocaine.

Isn't it harder to make?
Oh yes, it's enormously harder to make and certainly not practical at all. But there was a very important point here: the geometry of the system has something important to do with how it behaves biologically, and in this particular case depends on the benzene ring to hold things where they are supposed to be. Cubane can do the same thing. With more interest in compounds like this, people will discover better ways of making cubane. I for years have pointed out that cubane can be made from acetylene. Acetylene is a very cheap compound, and if you are clever enough to bring four acetylenes together in the right way, you would make cubane.

Wouldn't you like to do it?
Oh yes, I'd love to do it! [But] I don't know how! I think it will ultimately be done by somebody in inorganic chemistry because I think you need a framework to hold the acetylenes in the right position. The energetics of this reaction are fine. What's not fine is finding a way to hold four acetylenes just the way you want them. It has to be four acetylenes, not three, which makes benzene. If you build some inorganic compound that complexes in just the right way with acetylene, then maybe you could do it. I don't think it is a problem that will be worked on until we have to have this molecule. That's what happened initially with octanitrocubane. People in the military decided we have to have this compound.

Were they happy when they got it?
Not really, because it took a long time to get it. When Star Wars was going, and guided missiles were in their infancy, computers were also in their infancy, and you had to have huge computers on the rocket.

The real question for a scientist is whether a scientist is in the position to make philosophical decisions. Do you cure cancer? Do you provide food? Is that the role of a scientist? I don't know.

That would be destroyed immediately?
Yes. The problem was that these computers took up too much space, and there was no space left for the explosive. So the idea the military had was to develop a better explosive.

Don't you think a lot of brainpower was wasted on things like that?
I don't think it was wasted—not at all! Most of research the military has supported has been very profitable. You never would have had the Internet, and so on. Most of the explosives made over the years have been made because of military efforts. Almost none of them have ever been used because they're too expensive, and their properties are just not as good as the few that are around. But the chemistry that was developed was just fantastic. It took us years to make octanitrocubane. In the process, all these things I've been talking about were discovered, and the military funded all of that.

The military knew in advance that the only way they were going to get this compound was to investigate thoroughly the properties of cubane. From my point of view, that was fine! I certainly knew in advance that this thing, if we could actually make it, would be so expensive, it would have no chance of replacing TNT. So there was no moral issue about it. It was perfectly straightforward.

These moral, philosophical issues are complicated for any scientist. Suppose you had a drug to cure cancer. Brilliant! Everyone says it's wonderful. And I think it's wonderful. But you use the principle of unintended consequences: what happens? You cure cancer, so the population increases enormously, and you have all the problems [Thomas] Malthus says you were going to have. The same people who object to genetically modified foods would ultimately object to curing cancer. You can generate philosophical problems out of anything, but they are real problems, depending on where you have developed as a society.

I just want it on the record that I actually had written here, "What is more important, an explosive or a cancer drug?
I think the obvious answer to the public is a cancer drug! But if you look back to how things get discovered, it's another matter altogether.

Do you have advice for those pursuing chemistry?
I still think chemistry is a fascinating field. For me, hands-on chemistry, for others, calculational chemistry. I think you have to be careful that you don't get trapped in the routines of chemistry. You need to look at what the frontier will be five to ten years from when you finish your education, and make sure that's interesting and that you're not being caught by chemistry because of your Gilbert chemistry set, which has got nothing to do with where chemistry is now. It is difficult to do.

[Chemistry] is a good discipline to learn because where you have to get your mind in order, your memory in order, your thinking processes in order, [but] make sure you understand that memory is not enough! Everyone complains that in organic chemistry, you have to memorize every damn thing. That's why I say it's important to start thinking about what can be left out. There's a lot of simple organic chemistry being taught that is very fundamental to chemistry but, if you were doing advanced chemistry and came up to a problem that was really solved long ago, you could go back and look it up.

In the past, various forms of spectroscopy—UV spectroscopy, infrared spectroscopy—were very important. When I first started I remember making an enormous fuss to get money from the department to buy an infrared spectrometer. It was an important instrument at the time. It's been replaced. Years ago, my colleague here did X-ray structure determination. It took weeks to gather the data. We just finished a new structure on new X-ray machines, literally done in a day, that gave information that was incredibly better than what was done years ago. I don't know if they still teach the details for X-ray crystallography. It's irrelevant now—you could just pop a crystal into a commercial machine and get the answer. It's nice but they have to understand instruments whose use is new to the game.

When I first started NMR spectroscopy was new to the game, and we spent enormous amounts of time learning about it. I still think people should know about it, and it's very nice to say, "I want to understand all these instruments in depth," but it's not practical. We have to get to teaching what's happening at the frontier early on rather than teaching what happened twenty years ago, fifty years ago. Benzene chemistry is fundamental to organic chemistry, but it was developed almost a hundred years ago. It's still a fundamental part of organic chemistry, but it's nowhere near the frontier.

Will people be able to process what's happening at the frontier without completely understanding the past?
What do you do about specialization versus generalization? I don't know. When it was much more possible to get much of what chemistry was about into courses, I sort of knew what the field was. It's no longer possible to do that in chemistry. Are you in better shape to advance science because you know some small subdiscipline inside out and can really move in it, or should you sit back and smoke your pipe and look at it from a general point of view? It faces even the uneducated who are out of the market because they haven't been trained in some small, specialized thing.

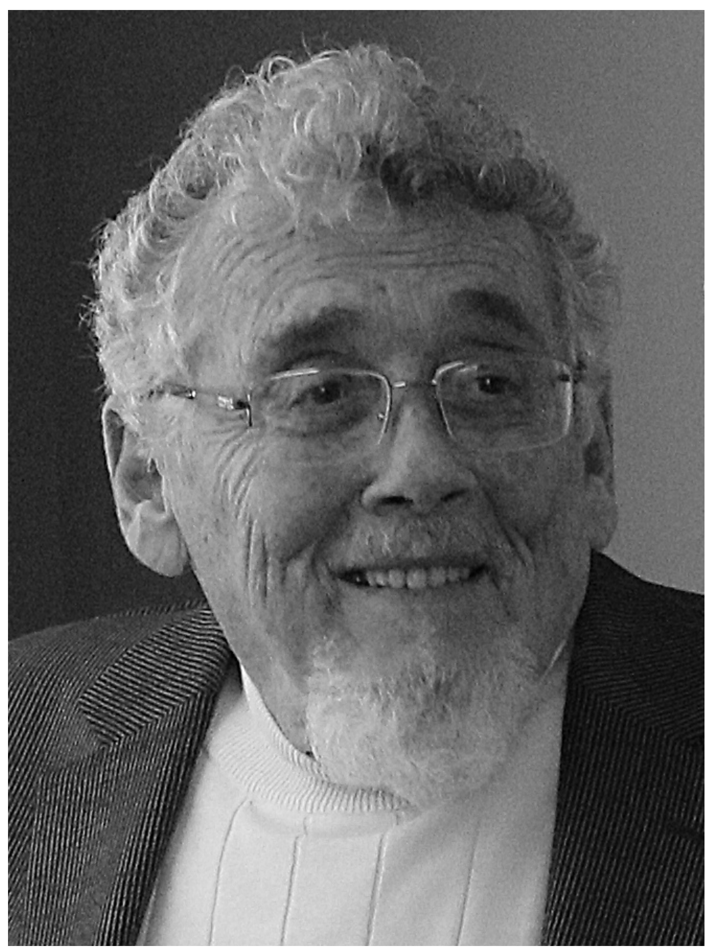
Do you think technological advances are frightening because people fear being replaced by machines?
In Brecht's *Galileo*, Galileo says that people are so frightened of technological advance that they're going to attack the sciences. Galileo's problem was between reasoning and the church, but nowadays climate change is the church. Ninety percent of scientists believe it's true. I don't think any of the scientists would deny that carbon dioxide levels are going up. The rest of it is how you decide to think about it.

I don't think anybody can challenge climate change. It always happens. Whether or not you're going to have global warming; I'm skeptical about that conclusion. I think the evidence is about as good that we're going to have global cooling, but I don't know. Take a congressman and an environmentalist who think that the climate skeptics are members of a kind of conspiracy and should charged with criminal abuse—it's exactly what Galileo predicted! The same questions come up with genetically modified foods. People are starving because their governments refuse to allow genetically modified seeds into the country. It's absurd. You have the question of actual starvation versus the possibility of some other unintended consequence!

Well, you'd have millions more people, right? And then you'd have the question of who deserves to eat.
Talk about philosophy! The real question for a scientist is whether a scientist is in the position to make philosophical decisions. Do you cure cancer? Do you provide food? Is that the role of a scientist? I don't know. I would have said years ago that no, it's not the role of the scientist; it's the role of the public. But you can't expect people to make decisions when they have no idea what [scientists] are talking about. There certainly are incredible unintended consequences as science proceeds. And with whom you elect. Well, there was a Chinese saying, a curse: may you live in interesting times. And that hasn't changed in the past five thousand years.

Reflections on Professor Philip Eaton on the Occasion of his 80th Birthday

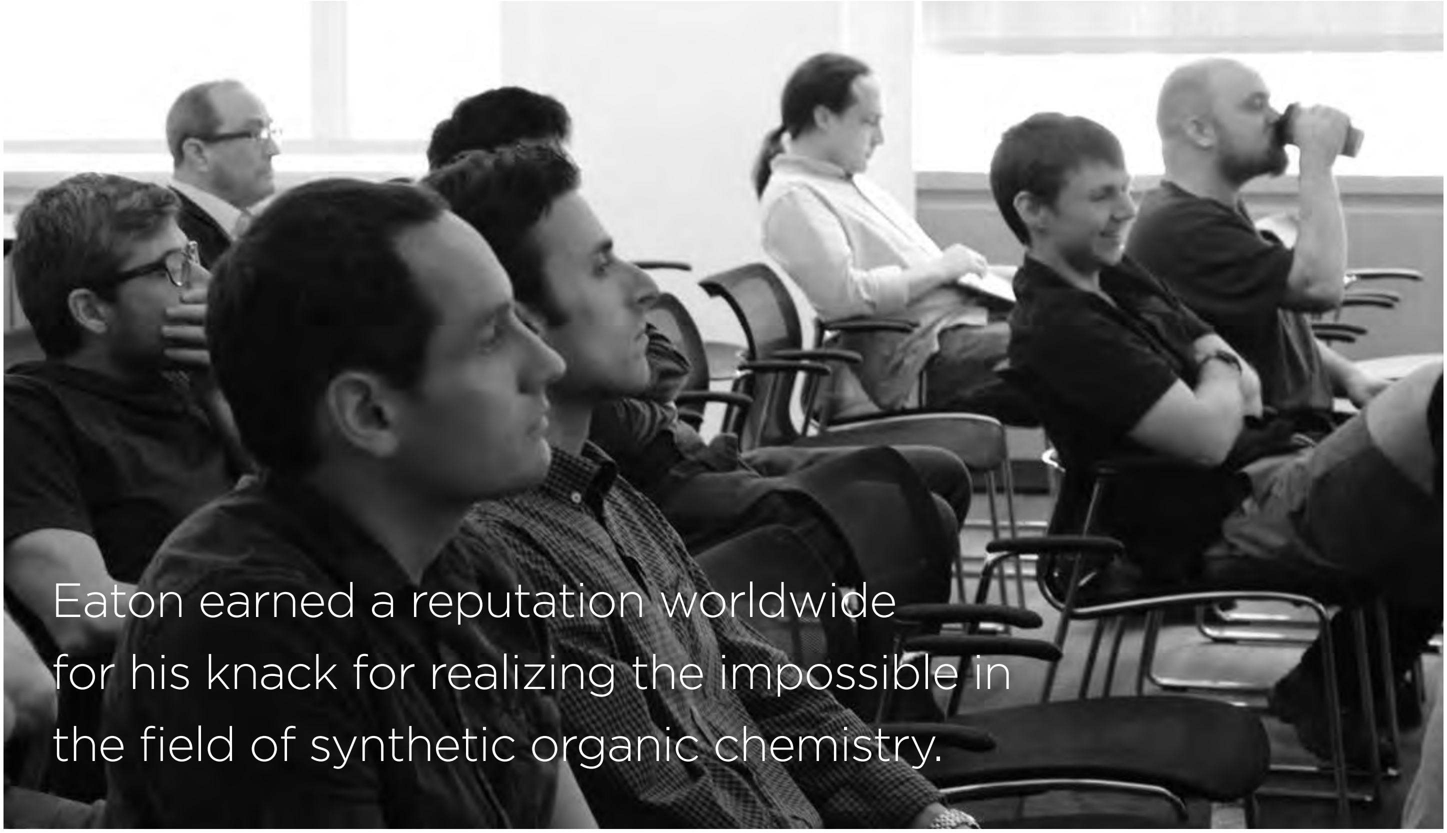
By Gregory Zayia



Over the course of a forty-three-year career at the University of Chicago, Professor Philip E. Eaton established himself as one of the all-time great organic chemists. As a young graduate student at Harvard in 1960, he made the landmark discovery of Lewis acid catalysis of the Diels-Alder reaction—a discovery that heralded the emergence of a brilliant young scientist with a tremendous future in chemistry. In every sense, this potential was realized to the fullest over the course of a stellar career at the University of Chicago.

Professor Eaton stands as a patriarch in the field of unnatural products chemistry, an outstanding experimentalist who gave the world cubane, pentaprismane, [2.2.2]propellane, [n.2.2.2]paddlanes, octanitrocubane, and many other highly strained, structurally exceptional organic molecules. Indeed, he rightly earned a reputation worldwide for his knack for realizing the impossible in the field of synthetic organic chemistry. Time and again, molecules once deemed impossible to make by theoreticians and the chemical community at large—whether based on daunting strain predictions, unnatural carbon bonding angles, predicted instabilities, or the like—would eventually yield to his masterful, elegant syntheses and open the door to the exploration of new applications and important mechanistic and physical organic discoveries.

A late career milestone for Professor Eaton—undertaken in collaboration with his longtime postdoc, Dr. Maoxi Zhang—was the synthesis in 1999 of octanitrocubane. The successful synthesis of this great white whale of the unnatural products world represented the culmination of an intensive two-decade quest by the Eaton group, which was characterized by the



development of a considerable amount of new and important chemistry along the way. The colossal synthetic achievement was even reported in the *New York Times,* a testament to its significance.

While Professor Eaton's research achievements are well-known and have been memorialized in numerous publications that he authored with great clarity and style, his contributions as an educator and mentor may be less well-known. On this, the occasion of his 80th birthday, it is my privilege to share a few thoughts on a man who made a profound and lasting impact on my life and who remains a constant source of inspiration.

Upon joining the Eaton group in 1994, I learned in short order that Professor Eaton had no tolerance for slipshod thinking. Although he expected careful and rigorous reasoning from his students, he applied the same standards to his colleagues and himself. Any organic chemist who had the good fortune to take a class with Professor Eaton or attend one of his lectures likely marveled at the clarity of his presentations. As it turns out, this was not a product of chance. After joining the Eaton group, I quickly observed that the secret to Professor Eaton's prowess in the lecture hall was the hours of concentrated study he devoted to preparing and marshaling his thoughts in advance.

Professor Eaton's commitment to education did not end in the classroom. On the contrary, he spent considerable time in the laboratory training his students in experimental techniques, a rare occurrence amongst chemistry thesis advisors in general and even more so among those having achieved his level of renown. Nonetheless, Professor Eaton happily demonstrated the finer points of crystallization, vacuum distillation using ebullition capillaries, spinning band distillation, sublimation, and other classical techniques increasingly in danger of becoming lost arts. In addition, he took great pains to explain the *raison d'être* and correct usage of various pieces of exotic glassware he had commissioned over the years for various projects.

To say that Professor Eaton influenced me as a chemist is a given. However, as I reflect, his impact on the formation of my character and my fundamental way of thinking has been even more profound. The day I joined the group, Professor Eaton explained that he had no interest in simply adding another pair of hands to his laboratory. Rather, he expected his students to set their own course in research and prove to him that they possessed the capacity for independent thought, creativity, and problem-solving. He then made two statements that have stayed with me throughout the years and inspired me in my subsequent pursuits.

First, he explained that while I may have been told at some point in my life that there is no such thing as a stupid question, he did not subscribe to this belief. Rather, he affirmed that there most certainly is such a thing as a stupid question, which he defined as any question posed to somebody else that I should be able to answer for myself. Second, he told me that if I succeeded in making it through his group, I would emerge on the other side as someone who would never be beholden to others for solutions to life's problems but instead would be able to think for myself and stand on my own two feet.

As the years have passed, these two statements have come to represent to me the very essence of what I learned from Professor Philip Eaton. I owe him an enormous debt of gratitude for all that he taught me—about chemistry, integrity, and life—but above all for teaching me to think for myself and stand on my own two feet. Happy eightieth birthday, Professor Eaton, and many, many more!

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DNA Nanobots get to work inside living cells

Yamuna Krishnan's bionanotechnology measures microenvironments in organelles

One of the images ineluctably associated with scientific discovery of the past century is the double helix, the elegant spiraling ladder of nucleotides that contains the blueprints for life. James Watson described the elucidation of the structure of DNA as "revelatory," and entirely new subdisciplines in evolution, medicine, and engineering evolved from the observation. Yet Professor Yamuna Krishnan, one of *Cell*'s 40 Under 40 in 2014 and *Chemical Science*'s Emerging Investigator of 2015, admits that she was never interested in using genetic material to further biological understanding or to improve the human condition. When she set up her first lab at the National Centre for Biological Sciences in Bangalore, she vowed never to venture beyond the abstract pleasures of basic science. "I refuse to think that I'm going to be the one to cure cancer! I refuse to write a grant pretending I'm going to cure a disease—I'm going to work on fundamental science, and that's it!"

Fascinated by the bizarre structures formed when nucleic acids bind as four-stranded DNA, Krishnan had decided to devote herself to the architecture of complex molecules that may not even exist in nature. Yet Francis Crick once said, "If you want to understand function, study structure," and Krishnan, despite her staunchest intentions, found herself at the University of Chicago in 2014 to investigate the molecular basis of disease that originated with what she cheerfully describes as "very small, even trivial questions."

From her roots as an organic chemist, Krishnan "fell in love with nucleic acids" during her postdoctoral studies at the University of Cambridge. There, she examined the simple sequences of nucleic acids artificially sequenced early in the course of genetic research. "When people found out they could form DNA, they said, 'Let's study simple homopolymeric sequences like GGGGG," she explains. "But these so-called simple sequences turned out to show complex structures." While a mixture of all four bases forms the familiar double helix, repeated sequences of the same nucleotides bind into tangled, four-stranded structures. "It's a very exotic structure, but what can you do with it beyond gazing at its beauty?"

When she returned to India, she combined her structural investigation with another question that had long intrigued her. "I always wondered why cells had so many compartments. But, when I thought about it, I realized that each compartment had its own chemistry," she explains. "In the golgi, you stick on sugars. In the lysosome, you degrade proteins. They have different microenvironments because you need to have different chemistry occur on different proteins, and each requires different reaction conditions." Noticing that the "strange shapes" of four-stranded DNA were sensitive to ions and small molecules, she wondered if they could be used to measure the concentrations of these ions inside the cell. "That's how we starting making measures of chemistry inside the cell." While this particular four-stranded DNA has no known natural function, Krishnan and her lab have discovered a way to use them to assess pH, as well as chloride concentrations within the organelles. "That is not what nature intended DNA to do," she says. "We created DNA sequences with a completely artificial function and then stuck them inside cells. We are trying to understand what is happening inside organelles by looking at a measure of chloride or a measure of pH."

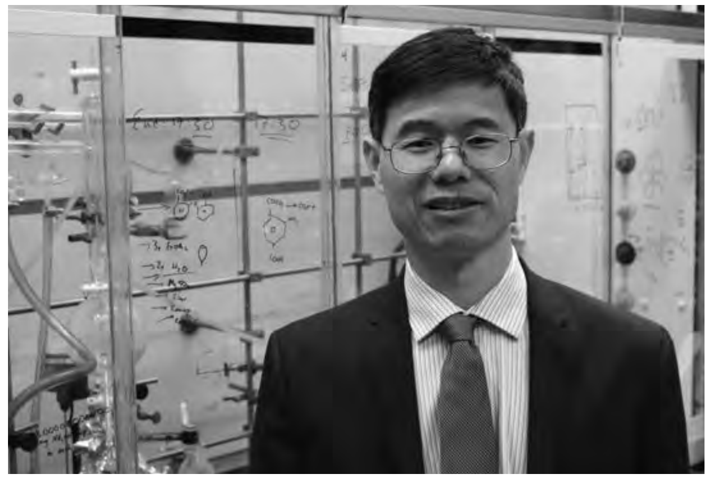
Krishnan's shift to bionanotechnology was practically inevitable. "In certain kinds of diseases, specific signaling events go wrong. The ionic microenvironments reflect this perturbation," she explains. "I asked, 'Could we try to look at the microenvironment as a whole in an organelle and see how alterations in that microenvironment correlate with a disease? What is it that goes wrong? So that's what got me started." Observing phenomena in cultured and live cells from a variety of organisms, including worms, fruit flies, and mammals, Krishnan and her lab have begun exploring ways of using nucleic acids to measure chemical concentrations and report protein activity within cells.

"The reason why I relocated to the US is that I wanted to get this technology out into the world as fast as I could. It's my reason for living," she says, noting that the opportunity to do medical research at the University of Chicago was crucial to her decision. "Nowhere in the world is the barrier to interdisciplinary science lower than in the US. Although this is a technology that really comes from basic chemistry and basic molecular biophysics, the applications are all in biomedical and clinical science. What's the point in being able to grow fabulous chicken without the capacity to cook it and eat it?" Naming Wei-Jen Tang in Biochemistry and Molecular Biosciences, Bozhi Tian of Chemistry, and Deborah Nelson of Pharmacological and Physiological Science as collaborators, Krishnan looks upon the coming years with gusto.

"We started out with something that seemed so trivial, I'm almost embarrassed about it now," she confesses. "But it was pure curiosity, and after five or six years it transformed into something with great potential. When you're staring in the face of something that has such potential that was born in your lab, you have a choice. You can either take it to its logical conclusion or you can say, 'No, I do not want to take that path; I'm going to find some other fundamental science.' But I chose to take it to its logical conclusion." (ICH)

Practical Passion, Functional Designs, Diverse Purposes

Wenbin Lin devises metal-organic frameworks for potential applications—including a possible cure for cancer



Wenbin Lin runs a lab of more than twenty people—six postdocs, twelve graduate students, five undergraduates, and a handful of others—who follow his lead in the pursuit of four research initiatives: sustainable catalysis, renewable energy, actinide sequestration, and nanomedicine. The common denominator—besides the disciplined scientist, who can be found days, nights, weekends, and holidays on the fifth floor of the Gordon Center—are metal-organic frameworks, or MOFs: customizable, porous materials made of metal nodes coordinated with organic ligands. MOFs, first brought to the attention of chemists worldwide by Australian scientist Richard Robson in the 1980s, have been explored for many applications, including gas storage, nonlinear optics, biomedical sensing, and drug delivery.

No one has been more determined in the investigation than Lin and his group, who turn out over twenty papers a year. One of Thomson Reuters' Highly Cited Researchers for several years running, Lin joined the University of Chicago as the James Franck Professor of Chemistry in 2013, after serving as a postdoc at Northwestern, an assistant professor at Brandeis University, and Kenan Distinguished Professor of Chemistry and Pharmacy at the University of North Carolina at Chapel Hill. However, Lin's greatest distinction is his tenacity, a trait that has carried him from his origins in rural China to his position in academia's upper echelons.

Born a peasant in the coastal village of Cendou in 1966—the year Mao launched the Cultural Revolution—Lin began working in the fields at the age of five. The experience and his upbringing were, he believes, essential to his development as a scientist. "To be good at doing science, you have to work hard—not just for one or two days. Hard labor was what we did. When you need to fish, you fish. When you need to grow rice, you grow rice."

Like millions of others in 1970s China, education was secondary to survival for Lin. "I was the first in my family to receive any sort of education. I'm not talking about college. I'm talking about middle school," he says. Lin was unrivaled in his studies from the start, and, recognizing his gifts, his parents scraped together the money to send him to a boarding school for eighth grade. The investment was worth it: Lin entered the best high school in the county the next year, and he rapidly rose to the top of his cohort.

There, his love for chemistry was far from instantaneous. "I wouldn't say I was inspired," he admits. Rather, in a motif that has marked his career, he confesses that his interest was partly fueled by the intense need to prove himself: "I knew I was good at chemistry, but I don't think my chemistry teacher felt the same way." When a teacher encouraged another student to apply to the University of Science and Technology of China, at the time the country's preeminent university, his competitive spirit was spurred to action. "I said, 'Okay, I want to apply to that school,'" he remembers, laughing.

Once at USTC, room and board were paid for by the government, allowing Lin to truly focus on his studies for the first time. "I had one un-

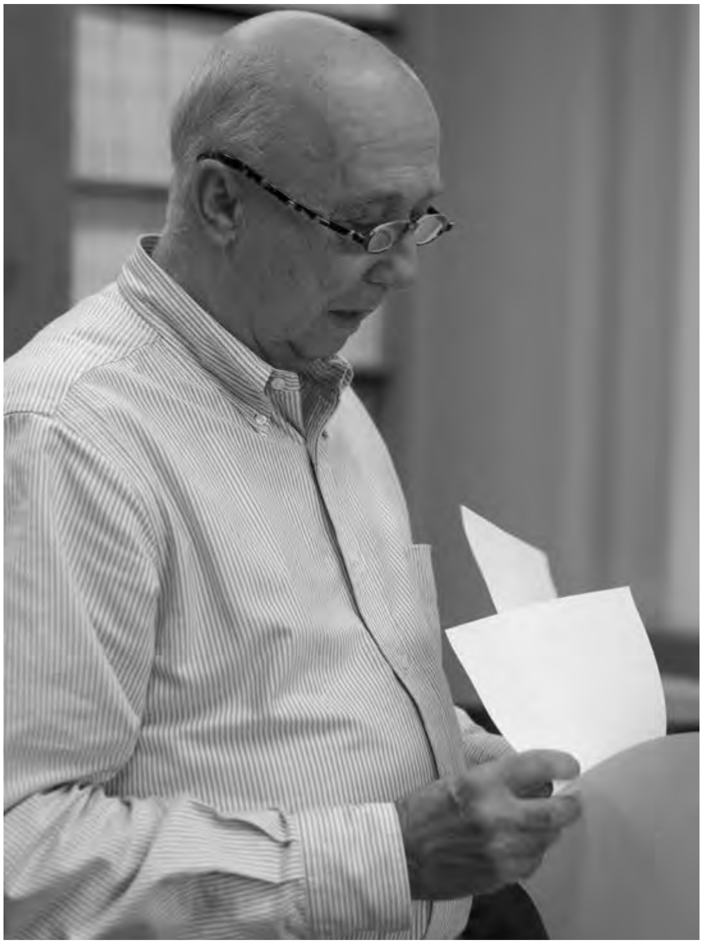
One hundred percent of my work is aimed at using molecular knowledge for functional design, but in the end you ask, “Does it work?

dergraduate research professor, coordination chemist Jianmin Li, who sparked my interest in inorganic chemistry,” he recalls. But he credits his graduate work at the University of Illinois at Urbana-Champaign with his formative training as a chemist, another endeavor initially stymied by sociopolitical conditions. “I came to this country in 1989. It was difficult to get a passport. I was three weeks late for class, and I couldn’t speak one sentence of English.” Though initially intending to pursue bioinorganic chemistry, Lin wound up in the organometallic chemistry lab of Gregory S. Girolami, the professor he describes as his greatest mentor.

Studying metal-organic frameworks turned out to be a serendipitous move. “It was one area of chemistry I could do with limited resources,” he says, recalling early years setting up his lab as an independent investigator at Brandeis. Yet from the beginning he knew he wanted to use MOFs to design functional materials. “I’m interested in using chemical knowledge to solve societal problems,” he says. “One hundred percent of my work is aimed at using molecular knowledge for functional design. You can say whatever you want, but in the end, you ask, ‘Does it work?’”

To that end, Lin is pushing for widespread use of his discoveries by founding two startup companies, RiMO Therapeutics and Coordination Pharmaceuticals, to manufacture MOF-based technology for delivering cancer medications. Both companies are well on their way: RiMO is expected to start its first human trials in the fall, and Coordination Pharmaceuticals has just closed its first round of financing, with the aim of initiating its first chemotherapy and gene therapy clinical trials before 2018. “It’s my newfound passion to advance what we’ve discovered to solve real world problems,” he says. “I can see the most likely immediate impact of MOFs on human health. We hope to revolutionize radiotherapy and significantly enhance immunotherapy with our technology.” Yet he remains just as driven in his other research areas, noting that his team is uncovering “totally new design rules” in catalysis and aiming to understand fundamental aspects of harvesting energy from the sun. “I’m very practical. My job is to make sure we solve problems.”

His competitors may think him fearless, his colleagues, profoundly ambitious, his students, challenging, but Lin’s cool objectivity extends to his view of his own career as a scientist. “I wouldn’t call myself successful by any stretch of the imagination,” he says. “Remaining critical of what you and others do in the field and knowing what problems are key takes guts. I haven’t seen any geniuses yet. It takes hard work; it takes dedication; it takes sacrifice.” (ICH)



Professor Brice Bosnich (1936–2015)

By James D. Crowley, W. Gregory Jackson, S. Bruce Wild

Excerpted from an introduction to the May 2016 special issue of the Australian Journal of Chemistry *dedicated to Professor Brice Bosnich. Bos, as he was universally known, spent most of his career at University College London, University of Toronto, and the University of Chicago. He died in Canberra on 13 April 2015. Reproduced from Crowley* et al. *(2016), with permission from CSIRO Publishing.*

Bos was born in 1936 in the Queensland country town of Tully, the son of Croatian parents who had emigrated to Australia in 1928 after the devastation of their country during WWI. Bos's mother died when he was three years old. He lived with his mother's sister until he was ten and then with his cousin George's family until he began high school as a boarder at St Gregory's College, Campbelltown. Bos enjoyed cricket and was a good fast bowler. He was also a good tennis player.

Bos graduated in Chemistry from the University of Sydney in 1958 and completed his PhD at the ANU in 1962 under the supervision of Francis Dwyer in the John Curtin School of Medical Research. Frankie Dwyer held a Personal Chair in the Biological Inorganic Chemistry Unit of the JCSMR and had a formidable reputation for his insights into transition metal coordination chemistry, especially stereochemistry and optical activity. Alan Sargeson (Sargo) was a junior colleague of Dwyer at that time and the influence of these two leaders remained with Bos throughout his career. Sargo and Bos maintained a lifelong friendship. It was clear from an early stage that Bos was an extremely talented scientist, his first and second papers being published in *Nature*. Most of Bos's PhD work, however, was published in the *Australian Journal of Chemistry* after Dwyer's untimely death in 1962.

After completing his PhD, Bos moved to University College London as a postdoctoral fellow, initially as a DSIR Postdoctoral Fellow (1962–63) and then as an ICI Fellow (1963–66). As a postdoc he carried out early work on the coordination chemistry of 1,4,8,11-tetraazacyclotetradecane (cyclam). In 1966, Bos was appointed to a lectureship in UCL, where he shared a small laboratory with Martin Tobe next to Sir Ronald Nyholm's office. Here he began to examine the use of circular dichroism spectroscopy to determine the absolute configurations of coordination complexes. Bruce Wild and Jack Harrowfield joined his group in 1968 and then moved with him the following year to the Lash Miller Chemical Laboratories of the University of Toronto. Greg Jackson followed shortly thereafter. Bos and these early Australian postdoctoral fellows carried out pioneering work on the resolution and coordination chemistry of chiral tertiary arsines and investigations into the circular dichroism spectra of octahedral cobalt(III) complexes.

Building from his expertise in topological and conformational stereochemistry, Bos became interested in asymmetric synthesis (catalysis) and developed a rational approach to the design of chiral diphosphine ligands, the premier member being Chiraphos. Unlike other ligands of this type, the chirality of Chiraphos resides in the organic backbone linking the two phosphine donors. This concept underpins the design of most of the C2-dissymmetrical ligands subsequently developed for use in metal-catalyzed asymmetric synthesis. Michael Fryzuk was among Bos's first PhD graduate students at the U of T and carried out the pioneering experimental work on the rhodium-catalyzed asymmetric hydrogenation of prochiral enamides. In later work, in association with David Fairlie and Steve Bergens, Bos discovered that the rhodium–diphosphine catalyst was highly efficient for intramolecular enantioselective hydroacylation. Also while in Toronto, Bos developed with Peter Mackenzie and John Whelan highly enantioselective palladium-catalyzed allyl–alkylation reactions and investigated the origins of the enantioselectivity. This beautiful chemistry, along with penetrating investigations into the origins of catalytic enantioselection, helped lay the foundations for the multitude of metal-catalyzed asymmetric syntheses employed by the pharmaceutical industry. While in Toronto, Bos and co-workers also developed a series of ligands that mimicked the spectroscopic properties of the blue copper proteins. As part of this work Bos spent time with crystallographer Hans Freeman in the University of Sydney working on plastocyanin.

In 1987, at the invitation of Jack Halpern, Bos was appointed to a professorship in the University of Chicago, and, in 2004, to the Gustavus F. and Ann M. Swift Distinguished Service Professorship in Chemistry. Pak-Hing Leung and John Whelan moved with Bos from Toronto to Chicago as postdoctoral fellows. Chicago is one of the ten most senior universities in the US and one could say that Bos by then had really made it—a long way from Tully! While in Chicago Bos continued to work on asymmetric catalysis, in particular hydroacylation, hydrosilylation, and chiral transition-metal Lewis acid catalysis, with Bergens, Hollis, Leung, and McMorran making contributions. A major achievement for Bos (with Steve Bergens) in Chicago was the catalytic isomerization of allylic alcohols into the corresponding enols. The isomerization allowed for the preparation of simple enols, through kinetically controlled conditions, leading to high yields free from the corresponding keto isomers. Remarkably, the simple enols were kinetically stable for up to two weeks at room temperature in the rigorous absence of acid or base. The demonstrated stability of an enol was unprecedented and is a fine example of the ground-breaking chemistry achieved in Bos's group over a distinguished career in transition metal-catalyzed organic synthesis. Additionally, inspired by the oxygen binding protein hemerythrin, Bos, along with Cassandra Fraser and others, worked on the development of bimetallic complexes that were capable of one-site addition two-metal oxidation as observed in hemerythrin. In the last ten years of his career, Bos became interested in the field of supramolecular chemistry, and with James Crowley and others published a series of papers on self-assembly, molecular recognition, and molecular machines. Bos's contributions to coordination/organometallic chemistry and asymmetric synthesis were wide-ranging, with his work being an elegant intellectual blend of organic and inorganic synthesis along with insightful mechanistic analysis to solve the problem at hand.

Bos remained in Chicago until his retirement at 70, when he moved to Canberra and was appointed to a Visiting Fellowship in the Research School of Chemistry of the ANU. Bos was happy to be living in Canberra near to his close friends Malcolm and Gywneth Gerloch and the late Glen Robertson. He had met and married Jayne in Chicago in 1992. Jayne died in Canberra in November 2014 from the rare Creutzfeldt–Jacob disease.

Bos received many academic awards throughout his career. These include the Canadian Society for Chemistry Noranda Lecture Award in Inorganic Chemistry (1978), the Royal Society of Chemistry Organometallic Chemistry Award in 1994, the Nyholm Lectureship of the Royal Society of Chemistry for 1995/6, the American Chemical Society Award in Inorganic Chemistry in 1998. In 2004, he presented the Francis Lyons Memorial Lecture at the University of Sydney. Bos was elected Fellow of the Royal Society of London in 2000.

Bos had a blend of idiosyncratic traits like no other colleague we have known. He delighted in getting a rise out of people, often smiling while providing well-directed abuse. He loved a joke, enjoyed a smoke, and the best of red wine. He could be cantankerous. Bos always dressed well, claimed he was a fine cook, and patronised fine restaurants. While in Ontario, he used his students to till land at the country property of his good friend, Doug Butler, an Australian who was professor of organic chemistry at York University, Toronto. He then planted grapes in the belief that he could make better wine than the Canadians. Bos also imported French red wines through Buffalo, USA, again using his students' assistance to avoid problems with border customs, and kept the wines in an expensive thermostat in his apartment. To Bos's great chagrin, Sargo sampled much of this wine while staying in the apartment during a brief visit by Bos to Australia. Another close friend of Bos's in Toronto was Australian carpet-dealer Peter Templeton. Peter's daughter Clio attended Bos's funeral in Canberra.

Over the years colleagues learnt a whole new language from Bos: neither Italian nor Croatian (in both of which he was fluent), nor classic English. Expressions like "Rat up a drain pipe," "As the actress said to the bishop," and "Here's to looking up your kilt" come to mind.

Bos was a gifted academic who emerged through difficult times as a youngster to make it to the top. More important, he was a great friend and mentor to us and we will miss him. RIP, Bos.

James D. Crowley (PhD, 2005) was Bos's last graduate student at the University of Chicago and is associate professor of chemistry at the University of Otago. Former postdoctoral researchers with Bos at the University of Toronto, W. Gregory Jackson is professor emeritus of chemistry at the University of New South Wales, and S. Bruce Wild is professor emeritus of chemistry at Australian National University.

Congratulations

AB and SB recipients

Spring 2014
Chu, Hang
Greene, Samuel Martin
Wu, Marie Teng-Pei
Radhakrishnan, Prathima
Butt, Charmaine M.
Khadivi, Amir
Murray, Graeme Fritchen
Raigosa, Matthew
Swan, Randy John Thomas
Ajiboye, Ifedayo
Bertels, Luke Wilbert
Chockanathan, Udaysankar
Clayman, Naomi Esther
Coleman, Adam Francis
Daskalova, Eleonora S.
Dejongh, Ethan Alan
Ezzyat, Taha
Garcia, Robert
Ge, Liang
Gellen, Tobias Amory
Guo, Jia
Helmer, Paige Lucile
Hillegass, Mary Elizabeth
Hu, Jennifer Chi Wei
Klein, Ryan Alexander
Kodaimati, Mohamad Saeed
Larkin, Isaac Nathaniel
Lee, Alexandra Katarina
Levin, Mollye Sarah
Liu, Victor Yao
McDonough, Andrew
Momkus, Jennifer Rose
Myles, Ava Elizabeth
O'Neill, Hannah Teresa
Park, Catherine Y.
Paul, Michael Davis
Rasic, Mladen R.
Reszutek, Brian James
Salat, Justin James
Smith, Jacob Anthony
Smith, Michael Steven
Stroscio, Gautam Dutta
Taylor, Madison Denali
Vervilles, William John Kenneth
Waldeck, Anna Rose
Weber, Jessica Marie
Williams, Brittany Danielle
Witzke, Ryan Josef
Huang, Jane

Autumn 2014
Moskalenko, Grigoriy Yulyevich

Spring 2015
Browne, Michael Elliott
Bustetter, Joshua Albert
Cheng, Kathleen Tian
Dadoo Lomeli, Clemente Shankar
Dennis, Griffin Gahagan
Derken, Meghan C.
Eastlack, Devon Elizabeth
Feldman, Jay Evan
Koziel, Mark L.
Lee, Jee Hee
Ma, Kristine Y.
Mulvihill, Ellen Augusta
Ng, Andrew Alexander
Penido, Isabella
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Tan, Nathaniel Kaili
Verma, Raghav
Wang, Gloria Zhujun
Agarwal, Rishabh
Andersen, Jr., Michael James
Bishop, Camille Elizabeth
Bohac, Tabbetha Jean
Britz, Jacob Christopher
Burnett, Ariel Isabelle
Castelnuovo, Laura Michele
Chen, Alexander Nicolas
Engel, Kyle Andrew
Ganguly, Anisha Priya
Gannett, Theodore Reid
Getz, Theodore
Go, Benjamin Matthew Lim
Goldfeld, David Justin
Guerrero, Anthony Dionte
Hwang, Andrew Wayne
Hwang, Theresa
Iyengar, Nishanth Srivaths
Kim, Yejoon
Liao, Thomas Hua-Ming
Lo, Klevin
Margossian, Khatcher Orbeli
Marsden, Anne Christina
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Mullen, Jacob Carter
Naziemiec, Magdalena Ivona
Nieweglowska, Eliza Sara
Norris, Graham James
Rodgers, Cameron Alan
Saucedo, Joshua A.
Shivanandan, Kathleen Charlotte
Tanygin, Vadim Sergei
Trybula, Marcus Allen
Weidenbacher, Payton A.
Wheeler, Michael Thomas
Wu, Megan Sophia
Morse, Mallory Caitlyn
Wong, Derek Perseus
Zullow, Hayley Jessica

SM recipients

Autumn 2014
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Yuijie Cao
Sara Christine Chamberlin
Weiwei Chu
Morris Eli Cohen
Joseph Louis Colaruotolo
Patrick David Cunningham
Thomas Philip Dannenhoffer-Lafage
Noah Daniel Easton
Jason Ryan Elangbam
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Olivia Brooke Yu
Lisheng Zhang
Chun Zhou
Ye Zhou

Winter 2015
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Spring 2015
Ved Prakash Singh

PhD recipients

Spring 2014
Michal Avital Shmilovici
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Zhonglei Chen
Wenyong Liu
Jay Gardner Nelson
Susumu Oda
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Marcela Maheu Wanderley
Tuo Wang
Yating Wang

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Toan Huynh
Quanjiang Ji
Kenley March Barrett Pelzer
Raman Anand Shah

Autumn 2014
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Yuxing Peng

Winter 2015
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Hao Huang
Luyao Lu
Srikant Veera Raghavan
Junjie Zhai

Spring 2015
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Zhen Cao
Zoya Cheglakov
Yunjie Chen
Bobo Dang
Dmitriy Dolzhnikov
Hsin-Yu Kuo
Shuheng Li
Wei Qin
John Savage
Mijo Simunovic
Kin S. Yang

Student Honors

Barnard Memorial Award
Landon Durak (2014)
Rebecca Black (2015)
Judith Kamm (2015)
EW Malachosky (2015)

Booth Prize
Nicole James (2014)

Chenicek Fellowship
Xingyu Lu (2014)

Churchhill Scholar
Anne Marsden (2015)

Closs Teaching Award
Rebecca Black (2014)
Marek Piechowicz (2015)
Erik Reinhart (2015)

Cross Prize
Mijo Simunovic (2014)
Boxuan Zhao (2015)

Gilbert Memorial Prize
Di Liu (2014)
Pavel Elkin (2015)

Goodman Fellowship
Kenneth Ellis-Guardiola (2015)
Yuanwen Jiang (2015)

Goldwater Scholar
Anne Marsden (2014)
Ryan McGillicuddy (2014)
Allen C. Zhu (2015)

Knock Prize
Samuel Greene (Chemistry, 2014)
Jane Huang (Chemistry, 2014)
Jia Guo (Biological Chemistry, 2014)
Anne Marsden (Chemistry, 2015)
Mallory Morse (Chemistry, 2015)
Hayley Zullow (Chemistry, 2015)
Thomas Liao (Biological Chemistry, 2015)
Derek Wong (Biological Chemistry, 2015)

Nachtrieb Memorial Award
Jane Huang (2014)
Anne Marsden (2015)

NDSEG Fellowship
Sara Chamberlin (2015)
Aleksander Durumeric (2015)

Norton Prize
Wei Qin (2014)
Xiao Wang (2015)

NSF Fellowship
Luke Bertels (2014)
Payton Anders Weidenbacher (2015)
Brion Koronkiewicz (2015)

Olshansky Memorial Fellowship
Ved Singh (2014)

PSD Teaching Prize
Hannah Rutledge (2014)
Kevin Nihill (2015)

Rhodes Scholar
Samuel Greene (2014)

Sellei-Beretvas Fellowship
Hao Yang (2014)
Mary Andorfer (2015)

Shiu Department Service Award
Jonathan Raybin (2014)
Frank Olechnowicz (2014)
Hunter Vibbert (2014)
Kevin Nihill (2015)

Sugarman Teaching Award
Sara Chamberlin (2014)
Preston Scrape (2014)
Guohua Shen (2014)
William Carpenter (2015)
Kade Head-Marsden (2015)
Polina Navotnaya (2015)

Sugarman/Closs Teaching Award
Frank Olechnowicz (2014)
Justin Teesdale (2014)

Weil Fellowship
Kai Chen (2015)
Kuangda Lu (2015)

Windt Memorial Fellowship
Zhiliang Gong (2015)
Ruibin Liang (2015)

Yang Cao-Lan-Xian Best Thesis
Qianqian Tong (Physical, 2014)
Wenyong Liu (Organic/Inorganic, 2014)
Nathan Contrella (Organic/Inorganic, 2015)

Dear friends,

I am delighted to be reviving the *Chemists Club* after a two-year hiatus. To conserve paper, future issues of the *Chemists Club* will be issued electronically. If you would like to continue receiving hard copies of the *Chemists Club*, please send an e-mail with your current address to chemistsclub@gmail.com.

Please stay in touch – tell us about your ongoing or post-chemistry life, pitch stories, or simply send your thoughts! Connect with current and former members of the department on Facebook at facebook.com/uchicagochemistsclub.

We look forward to hearing from you!

Best wishes,
Irene C. Hsiao
Editor

JOHN LIGHT MEMORIAL FUND

On May 14-15, the Department held a memorial service and symposium in honor of Professor John Light, who passed away earlier this year. Using his bequest, the Department has established the John Light Memorial Fellowship in Theoretical Chemistry, which will support an exceptional graduate student in theoretical chemistry.

The Department welcomes your contributions to this fellowship.
Please send a check, with the fellowship noted, to:

THE UNIVERSITY OF CHICAGO DEPARTMENT OF CHEMISTRY
ATTN: VERA DRAGISICH
5735 SOUTH ELLIS AVENUE
CHICAGO, IL 60637

Any questions may be directed towards vdragisi@uchicago.edu

CHEMISTRY EVENTS

The calendar of named lectures, as well as the most up-to-date information about Department of Chemistry lectures and events, can be found online at event.uchicago.edu/chem/index.php.

LINK WITH US

The Department of Chemistry encourages all alumni to connect with current chemistry students and each other on LinkedIn. The department's group can be found at tinyurl.com/7efp2t2.

the chemists club

Summer 2016

Dear friends,

Although I have been in this role for less than a year, I have come to fully appreciate what a privilege it is to be at the helm of the Department of Chemistry at the University of Chicago. We have seen incredible advances in all facets of the Department under the direction of our previous chairs. Jim Norris and Mike Hopkins led us through major construction, placing all of our researchers in new, world-class facilities. More recently, under Rich Jordan's leadership, we have enjoyed unprecedented growth in the size of our faculty. Over a dozen new members, each among the best in his or her respective field, joined our program between 2010 and 2015, and three more (theoretician Tim Berkelbach from Princeton, organometallic chemist Guangbin Dong from UT Austin, and nanomaterials scientist Jiwoong Park from Cornell) will come on board this summer. This exceptional growth has allowed the Department to stand at over thirty members, up dramatically from the steady state of the past two decades of around twenty-two. Not only have we strengthened traditional areas of inorganic, organic, physical, and theoretical chemistry, but we are now establishing prominence in emergent fields including chemical biology and materials chemistry. The broad-based strengthening of our program has invigorated the Department to a level that is palpable.

The Department recently celebrated the lifetime achievements of our esteemed colleague, the exceptional synthetic chemist Philip Eaton, with a symposium on April 18 to honor his eightieth birthday. An interview with Phil and an essay by his former student Dr. Gregory Zayia appear in this issue of the *Chemists Club*. Further in you will also find profiles on two of our recent faculty, inorganic/materials chemist Wenbin Lin and chemical biologist Yamuna Krishnan, both trailblazers in their respective fields.

In the midst of our flourishing, the Department has also experienced some deeply felt losses. We reprint a tribute that Chicago alumnus James Crowley and others wrote for a special issue of the *Australian Journal of Chemistry* in honor of our colleague Brice Bosnich, who passed away in 2015. We also mark the recent passing of our much-admired colleague John Light with a symposium and memorial service May 14-15. The Department is establishing the John Light Memorial Fellowship in Theoretical Chemistry, which will support an exceptional graduate student.

This is an exciting time for Chicago's chemistry department, and in coming issues I look forward to sharing our latest developments in our program with you.

Best regards,

Viresh Rawal
Professor and Chair

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