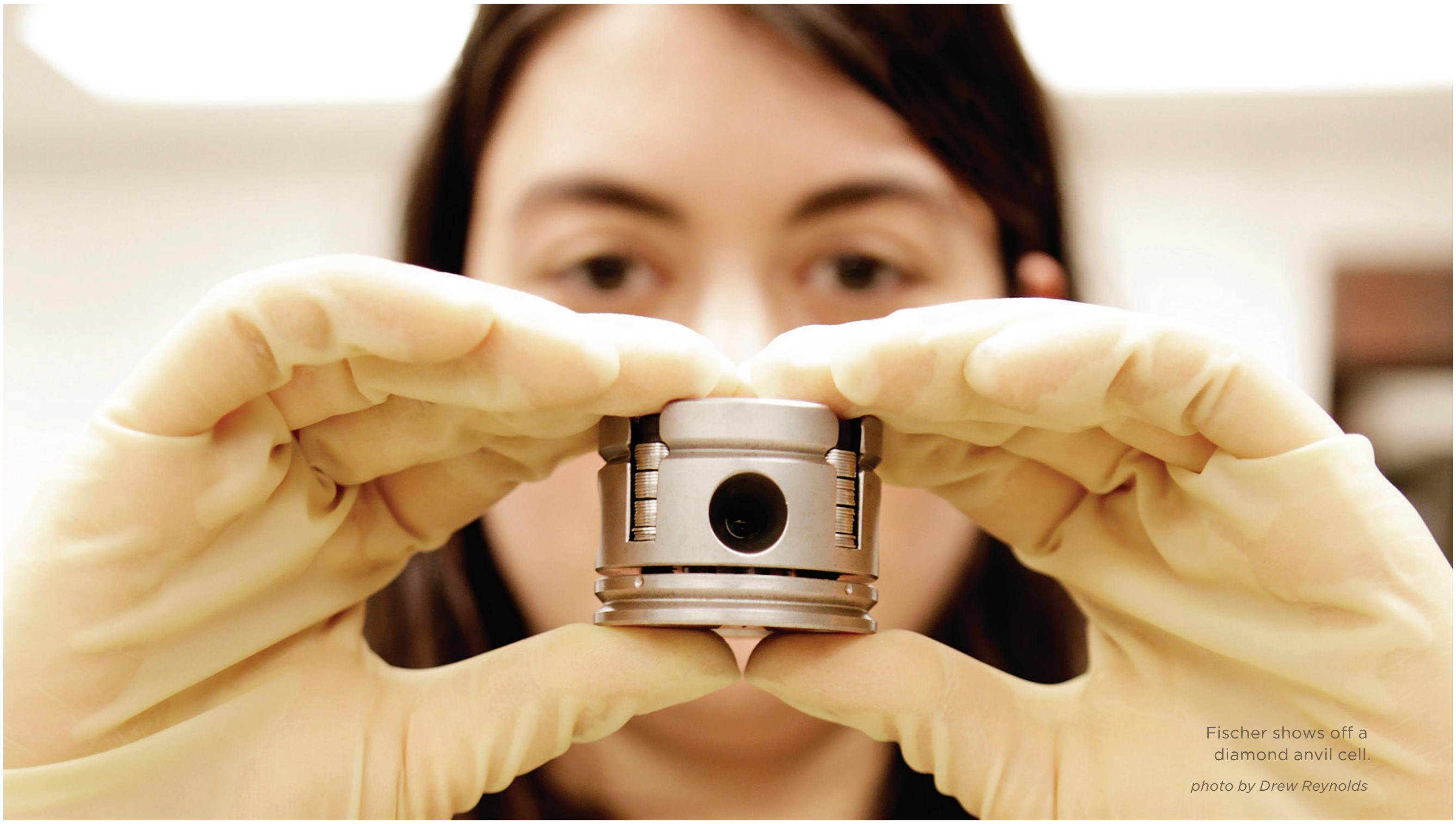
NEWS FROM THE UNIVERSITY OF CHICAGO PHYSICAL SCIENCES DIVISION

INQUIRY



Fischer shows off a diamond anvil cell.

photo by Drew Reynolds

Mystery at the center of the Earth

Q&A with graduate student Rebecca Fischer

Rebecca Fischer, a graduate student in the Department of Geophysical Sciences, earned an undergraduate degree in Earth and planetary sciences and integrated science from Northwestern University in 2009.

What is your research about?
I'm interested in the interplay between the mantle, the rock that makes up most of the interior of Earth, and the core, the metallic center. I'm trying to figure out how the composition of Earth changed while it was accreting. Core formation is thought to occur simultaneously with accretion, and I want to know how the composition changed during core formation.

The main question is how oxidized or reduced Earth was. The oxidation state of the planet dictates the composition of the core. If Earth is more oxidized, you might have more oxygen going into the metal. If it's more reduced, you might have more silicon.

Since we can't access the core directly, most of my research is experimental. We use high-pressure, high-temperature experiments to simulate the conditions deep inside the planet and study the properties of minerals under those conditions. We also use data from seismology to try to constrain what the core might be made of.

I do some numerical simulation too—modeling of planetary formation, looking at how the composition changed early in Earth's history while the core was still forming. It's an attempt to approach the question of Earth's composition from a different angle.

What do we know about what's inside the core?
We know maybe 90 percent of what the core's made of, so there's a lot that's still very unknown. We know it's mostly iron, with some nickel as well. Earth's core is about ten percent less dense than pure iron under the same conditions, so there's something in there that's lighter than iron. We have some constraints on what that might be, from geochemical and cosmochemical analyses. There are a few leading possibilities: oxygen, silicon, sulfur, carbon, and maybe hydrogen.

How do you reproduce conditions in Earth's core in the lab?
I use a tool called a diamond anvil cell. It's maybe two inches in diameter. It's two parts that fit together, a piston and a cylinder. On each side there's a diamond. We put our samples in between the two diamonds and squish them together, generating a force that applies a very high pressure to the sample. We don't apply very much force, but we have a very small area; the tips of these diamonds are maybe a tenth of a millimeter across. Then, to generate high temperatures, we use an infrared laser to heat our sample up. Using these methods we can achieve conditions in Earth's outer core—a couple million atmospheres of pressure and a few thousand kelvin.

Most of my research lately has been at synchrotrons at national labs. We do X-ray diffraction while our samples are at high temperatures and pressures to see how the density of materials changes with temperature and pressure.

Has anything in your work surprised you?
It seems like every time we look at something we think will be simple and straightforward, we discover something complicated. For instance, I was doing some research on iron oxide, which I'd been studying for a while. It's an insulator at one bar, but we discovered it becomes a metal at high pressures, which was pretty unexpected. We frequently discover things like that that are unexpected.

What first attracted you to this field?
I first became interested in geology in college. As soon as I learned about a diamond anvil cell, I thought, "That sounds so cool! You can generate pressures like the inside of the Earth?" I found a faculty member at Northwestern who was working on it and started doing research with him. I just fell in love with it immediately. ■

"We can achieve conditions in Earth's outer core—a couple million atmospheres of pressure and a few thousand kelvin," says Fischer.

CHEMISTRY

The joys of collaborating on "designer atoms"

An interview with Dmitri Talapin, David Mazziotti, and Greg Engel

In January 2012, Gregory Engel, professor of chemistry, David Mazziotti, professor of chemistry, and Dmitri Talapin, associate professor of chemistry, received a $1 million grant from the W. M. Keck Foundation to pursue a project they called "Designer Atoms: A New Paradigm for Designing Materials from Nanoparticle Building Blocks."

What you call designer atoms are actually a kind of nanocrystal. How do they differ from regular atoms—or regular crystals?
Talapin: It's easier to explain by starting not from atoms but from a bulk material or larger object. If you have a large piece of a semiconductor, like a piece of silicon a meter on each side, it has certain optical and electronic properties.

If you move from a big piece of this to a smaller one, one centimeter or one micron on each side, nothing changes fundamentally; you have the same material, just smaller. But if you step down to, say, five nanometers, you will start seeing emergence of fundamentally new physics.

Now it behaves totally differently. This new entity, which is a nanocrystal, can develop features that we used to see only in the atomic world—like discrete energy levels, which are totally nonexistent in bulk materials.

Mazziotti: This is what's called emergent behavior. If you're in the bulk situation, it behaves classically. As you shrink the material down, though, you start to see the quantization of the energy levels that is the hallmark of quantum mechanics. The material is still small enough to exhibit quantum behavior, but it's interesting because it's still large enough to have other advantages.

What's the advantage of nanocrystals from the standpoint of materials science?
Talapin: Nanocrystals have atomic kinds of properties, but they are tunable. We can optimize their properties in a continuous way, just like we're used to doing in the classical world. It gives us a very unusual and very powerful method for material design when we can tailor atoms to each other.

Mazziotti: You build chemistry from atoms, and quantum mechanics provides principles for doing that. In the same way, we envision tremendous opportunities in the future using nanocrystals and arrays of nanocrystals as the building blocks for new structures. We can develop a whole palette of new materials that essentially derives from using the nanocrystals as building blocks.

Engel: It allows us to vary the actual material itself. It allows us to vary the nature of the linkage. It allows us to vary the topology. We should be able to observe different sets of physical and material properties, spectroscopic properties, and electronic structure.

Chemistry is about connections between objects and how these objects' properties change as you bind them together. This is the essence of a chemical bond. It's about new emerging properties coming from strong mixing between the electronic states of molecules, the same way two atoms come together to make a molecule.

How does your collaboration work?
Engel: It's a very exciting team. We have spectroscopy in my group, theory in David's, and synthesis of inorganic linkers between nanoparticles in Dmitri's, each of which were developed in isolation. But this concept of generalized bonding and how to think about it is a shared goal. I don't think that the goal would be realizable without all three of these advances and the three groups working together.

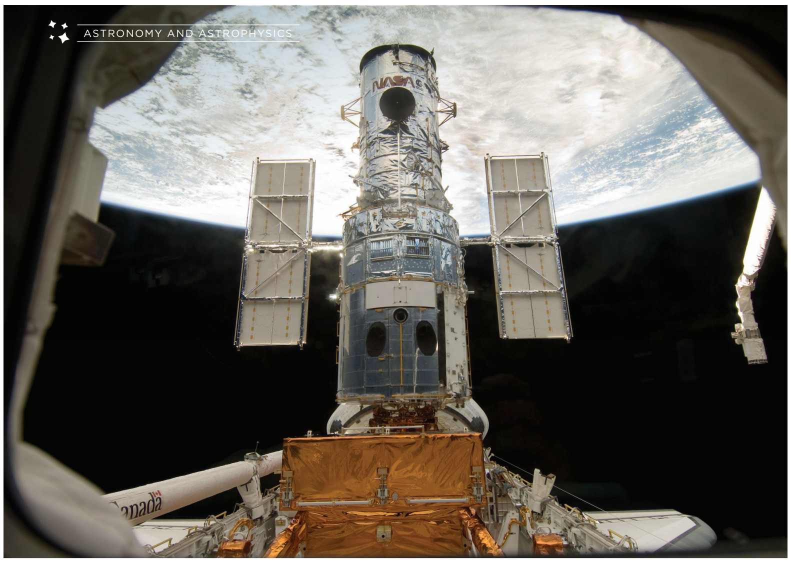
If just David and I work together, we're not going to be able to have the materials to test these ideas. If Dmitri and I work together, we'll get spectroscopy and look at the coupling, but we may not be able to extend these ideas to other systems and understand the full ramifications. And if Dmitri and David work together, it would be very difficult to test whether this is what's actually going on in the system.

What excites you most about this project?
Mazziotti: The fact that we have an opportunity to push the frontiers of science forward in a way that we feel we have the right combination of expertise to do. It's both exciting and also very natural.

Engel: We can push the boundaries of science ahead many, many years in a short period of time.

Talapin: One of the advantages of the way this project is funded is that it forces us to step slightly away from our own comfort zones and really talk to each other and try to find a new ground. That's something that is very important in science, especially for mid-career scientists.

Engel: I put a quote on one of my freshman chemistry exams last quarter: "Science rarely advances when someone yells, 'Eureka!' Science advances when someone scratches their chin and says, 'Huh, that's funny.'" We're looking for areas that we know we don't fully understand, but we know that there are some aspects that could be extremely useful, both technologically and theoretically. That's why this is such an exciting area. ■



When nothing will do but the *Hubble*

Chicago astronomers get a rare opportunity to use the world's premier orbiting observatory.

The *Hubble Space Telescope* (*HST*) isn't large by the standards of today's telescopes, but its unique perch above Earth's atmosphere gives it resolution unmatched by any earthbound instrument. Its quality means that the demand for telescope time far outstrips its supply—by eight to ten times, estimates Jacob Bean, assistant professor of astronomy and astrophysics. Having a proposal accepted by the Space Telescope Science Institute at Johns Hopkins University, which operates the telescope for NASA, is a big break. Bean and Michael Gladders, assistant professor of astronomy and astrophysics, can attest to that: both are principal investigators for projects approved for the next cycle of *Hubble* observations, which began in October.

Gladders and his collaborators—including two graduate students—intend to use *HST* as a time machine. The more distant the galaxy, the younger it was when light departed from it bound for Earth, and thus the younger it appears. They plan to study rates of star formation in galaxies 10 billion years ago, when the universe was one-third of today's size and stars were born more often than they are today—sometimes 100 times more often. Understanding what makes that epoch different, Gladders says, is key to solving the puzzle of the origins of the universe.

Yet even the *Hubble* can't gather enough light from those distant galaxies to resolve detail about their star formation. So Gladders plans to magnify the galaxies by taking advantage of a natural phenomenon called gravitational lensing. The gravity of a massive object—usually a cluster of galaxies—along the same sight line as a distant galaxy can bend light from the latter. That refracted light produces a magnified, albeit distorted, image of the more distant object.

The team will use 107 orbits of *HST*—each one providing 45 minutes of observing time—to observe distant galaxies behind gravitational lenses. The challenge, Gladders explains, is to take the distorted lensed images and reassemble them into a true picture of what the distant galaxy looked like. His collaborators have begun their study with spectroscopy done from ground-based telescopes; having dedicated access to the Magellan Telescopes in Chile for supporting observations, Gladders says, "was critical to the success" of the project. (The University joined the Magellan Telescope consortium in 2010.) For imagery, though, "No ground-based instrument can match the impact or ability of the *Hubble*."

While Gladders will be looking for galaxies billions of light-years away, Bean has his sights aimed only about 40 light-years away—by cosmological standards, right next door. He's studying the atmosphere of the extrasolar planet GJ 1214b, a "super-Earth," sized between small, rocky planets like Earth and large, gas giant planets like Jupiter. Because there are no super-Earths in our own solar system, astronomers can only guess at the composition of their atmospheres.

GJ 1214b has the unusual property of transiting across the face of its sun along our line of sight—quickly too; a "year" on GJ 1214b lasts 36 hours. Bean's project uses the star's light to illuminate the planet's atmosphere. By comparing spectra during the planet's transit to spectra taken when the planet is away, Bean and his collaborators (who include a Chicago postdoc and grad student) should be able to identify what elements are present. Previous studies of the planet have failed to detect atmospheric features, says Bean; the sensitive *HST* observations are an attempt to "throw the kitchen sink at it."

"If the planet were a scaled down version of Neptune, we'd expect it to have a puffy atmosphere dominated by light gases like hydrogen and helium," he explains. The alternative, which he is more excited about, is a dense atmosphere dominated by heavy atoms and molecules, such as water vapor. "It wouldn't be like Earth's atmosphere—it would be much hotter and denser. Rather, it would be fundamentally different from anything we've ever seen."

Bean hopes astronomers can push forward to studying the atmosphere of a potential Earthlike planet within a decade. By that time, though, the *Hubble* likely will be retired, replaced by the newer *James Webb Space Telescope*—an even bigger, better kitchen sink.

CHEMISTRY

Organometallic operator

Faculty interview with Gregory Hillhouse

Gregory Hillhouse, professor of chemistry, is a synthetic organometallic chemist. Hillhouse, who joined the Chicago faculty in 1983, won a Quantrell Award for his undergraduate teaching in 1997 and a Norman Maclean Faculty Award in 2011 for his mentorship of undergraduates. More recently, he won the 2013 American Chemical Society Award in Organometallic Chemistry.

What he does

Hillhouse's primary research interest lies in finding new ways to create multiple bondings with late transition metals—groups 9 and 10 on the periodic table, such as nickel, cobalt, palladium, and platinum—and studying their reaction chemistry. "The ultimate goal is to take one fragment from a molecule and then add it to another small molecule," he explains. "Maybe you take a nitrogen fragment, maybe a nitrene fragment, from an organic azide and add it to an olefin to make an aziridine. Or take nitrous oxide, which is very available and a good source of an oxygen atom, and add that to another organic molecule to undergo a very specific oxidation."

Why precious metals are doubly precious for him

The late metals aren't just for decoration. "They carry out many catalytic processes, like forming carbon-carbon bonds and hydrogenation," he explains. They have a range of uses outside the lab too, which is why cars' catalytic converters contain platinum (and why thieves try to steal them).

The geometry of chemistry

In transition-metal chemistry, the coordination number reflects how many neighbors the molecule's central atom has. A lower coordination number makes it easier for that molecule to create a bond. Typically a group 10 metal has a coordination number 4. As Hillhouse explains, "If you have four ligands, there are two common ways of arranging them around the metal: a tetrahedron and a square plane. Because of the orbitals that are required, those define the electronic structure of the metal." A tetrahedron structure has two unpaired electrons, and a square planar arrangement has none, meaning there are no orbitals available to form a multiple bond. However, "If you move the ligands, you can reduce the coordination geometry from four-coordinate to three-coordinate. Now there are orbitals available for forming the double bond." Hillhouse's group recently pushed forward into two-coordinate geometry, which opens up a new set of possibilities for reactions.

On being first

Hillhouse's group was the first to prepare multiple bonds with late transition metals a decade ago. "Many people thought they couldn't be prepared," he says, for "good reasons—mainly that for certain coordination geometries, they couldn't." Today there are many groups worldwide doing it. "It's quite popular."

His favorite molecule

"My current favorite one would have to be a two-coordinate nitrene complex that we recently reported," he says. "Since that one got us to coordination number 2, that's probably my favorite molecule."

If there was one thing he could do with his career

Hillhouse would like to make a late transition metal bind to an oxygen atom. "That would be a very attractive intermediate. It should have very useful reactivity in synthesis for these oxygen-transfer processes," he says. "Many have been reported, and they've all been wrong."

On working with young people

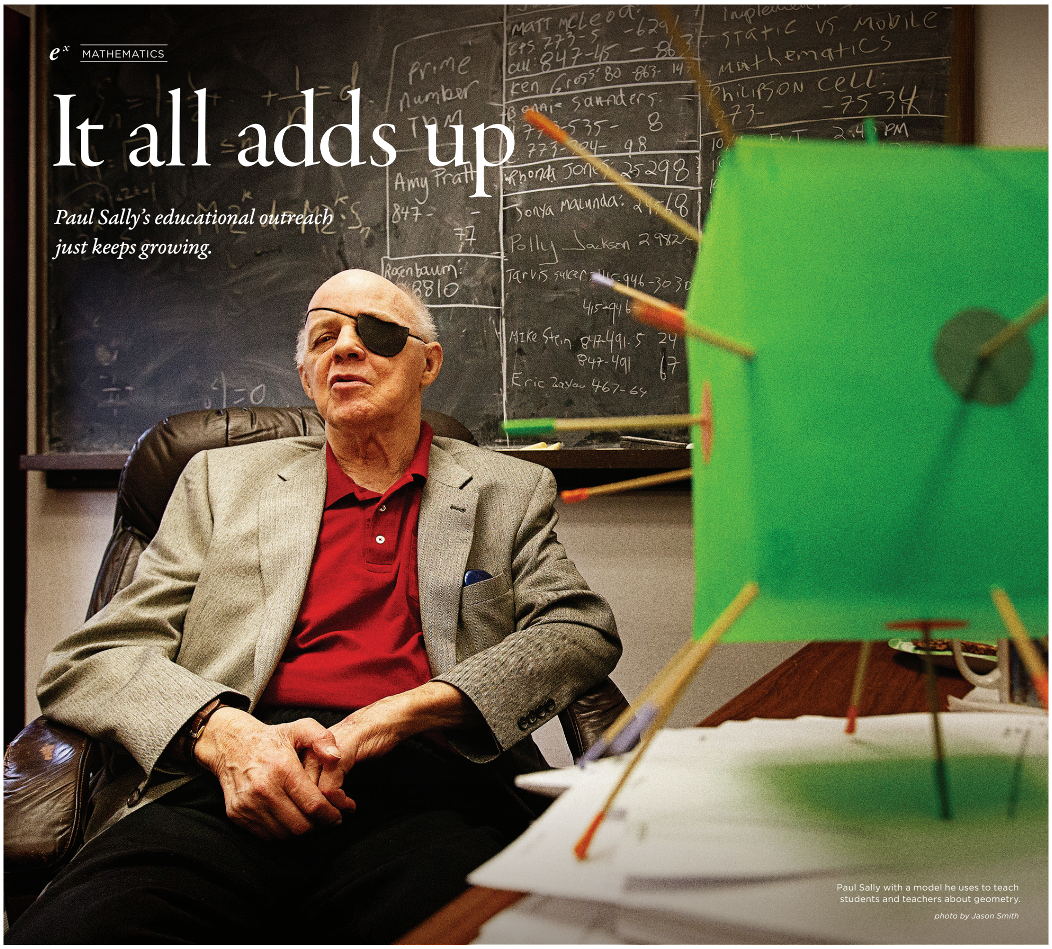
Hillhouse won the Maclean Faculty Award for mentoring undergraduate students. (His research group currently has as many undergraduates as grad students.) "It's nice to see the kindling of a spark of interest in the first- or second-year undergraduates and watch that mature into a successful scientific career."

He works with undergrads outside the lab too: he's a big supporter of the University's athletic department. "They need some mentorship from faculty, so I've served in that role for quite a few years. The sports teams are fighting an uphill battle, and the faculty don't cut them any slack."

e^x MATHEMATICS

It all adds up

Paul Sally's educational outreach just keeps growing.



Paul Sally with a model he uses to teach students and teachers about geometry.

photo by Jason Smith

> " I'm a sucker for new projects. "

"It was an active summer," says Paul Sally Jr., professor of mathematics, with characteristic dryness. He had just spent eight weeks teaching 150 Chicago Public Schools (CPS) students and an equal number of teachers in five different programs (see below). His extensive community outreach continues during the school year, in addition to his faculty teaching and administrative duties—he's also director of the Mathematics Department's undergraduate program.

Sally started his teaching career as a substitute in the Dedham, Massachusetts, public schools after graduating from Boston College in 1954. The next year, he taught high school in Boston full time, "and I've never been out of the schools since," he says. In 1969, after earning tenure at the University of Chicago, he began working with CPS, a commitment to education that has continued to grow. "All these things just happened," he says with a shrug. "I'm a sucker for new projects."

Sally turns 80 in January and has another decade of work planned out, including an application for a five-year grant for the Woodlawn Children's Promise Community. "Don't throw any parties for me," he warns, "because I'm not retiring."

SALLY'S EXTRACURRICULARS:

Seminars for Endorsement of Science and Mathematics Educators (SESAME)

The SESAME program offers courses for teachers, usually but not exclusively working for CPS, leading to an endorsement for teaching mathematics and science in the middle grades. Sally serves as the program's director and teaches some of the math classes.

For: Middle-school and high-school math and science teachers.
Founded: 1992
Teachers served since inception: 2,300-plus

Young Scholars Program

The Young Scholars Program, an enrichment program for mathematically talented high schoolers, is an outgrowth of a 1970s Summer Science Training Program funded by the National Science Foundation. The students are split into two groups, $9^{th}/10^{th}$ graders and $11^{th}/12^{th}$ graders; Sally teaches the former.

For: Students in CPS high schools.
Founded: 1988
Students served since inception: 2,500-plus

University of Chicago Collegiate Scholars Program

The Collegiate Scholars Program places bright CPS students in summer classes with University faculty, with the goal of improving their chances of going to a top-ranked college. Sixty-five percent of the students are low-income, but 100% have gone on to attend a four-year college, including 69 percent who have gone to a highly selective college—and 15 who have earned a full ride to the University of Chicago. Sally teaches in the math portion of the program.

For: 10th, 11th, and 12th graders in the CPS high schools.
Founded: 2003
Students served since inception: 330

Woodlawn Children's Promise Community (WCPC)

Modeled after the Harlem Children's Zone in New York City, the WCPC partners with ten CPS schools and one University-operated charter school in Woodlawn, immediately south of Hyde Park, to improve the education and health of roughly 6,000 school-age children. Around 1,500 students and parents have participated in the Promise Community in some form; Sally coteaches algebra to a small group of sixth, seventh, and eighth graders who are mentored by students from the Collegiate Scholars Program, to prepare them for Chicago's selective public high schools.

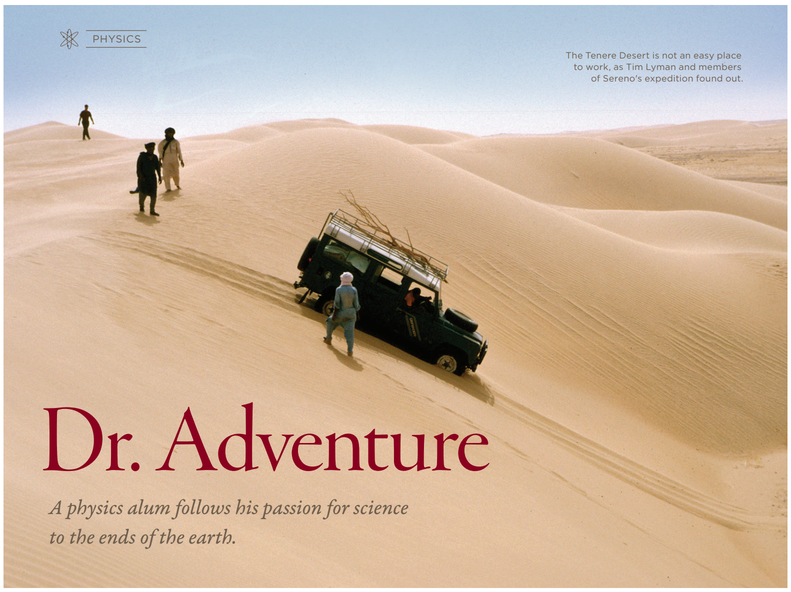
For: Middle-school students in Woodlawn.
Founded: 2009
Students served since inception: 80

Master of Arts in Teaching

Individuals interested in pursuing a teaching career in Chicago Public Schools can earn their certfication and a master of arts in teaching through the Univesity of Chicago Urban Teacher Education Program (UChicago UTEP). The program is targeted toward preparing University of Chicago students and others who already have science, technology, engineering, or math (STEM) backgrounds and are interested in learning how to teach in their content areas. UChicago UTEP is also an option to individuals with degrees in other areas who are interested in pursuing elementary school teaching. Sally and other mathematics faculty teach mathematics to all of the aspiring teachers.

For: Aspiring CPS STEM teachers.
Founded: 2003 (elementary education); 2009 (high-school math and biology)
Teachers served since inception: 150

PHYSICS



The Tenere Desert is not an easy place to work, as Tim Lyman and members of Sereno's expedition found out.

Dr. Adventure

A physics alum follows his passion for science to the ends of the earth.

In 2000, Tim Lyman, AB'74, SM'77, got a phone call from a friend that made him jealous. His friend had been invited by Paul Sereno, professor of organismal biology and anatomy at the University of Chicago, to accompany him on a three-month expedition to the Tenere Desert in Niger to hunt for fossils. "I heard this message, and I thought, 'Oh my God, this guy's got the life that I want,'" says Lyman. He called his friend back and jokingly asked if they needed a physician. His friend replied that they already had one, but he'd pass along the offer to Sereno. Lyman says he figured nothing would come of it, but "You know the old saying about being careful what you wish for." A few days later his friend phoned back: the original doctor pulled out unexpectedly, and Sereno wanted to know if Lyman was still interested.

The soft-spoken and mild-mannered Lyman had studied physics at Chicago and later pursued medicine; he earned an MD from the University of Illinois. Urgent care and occupational medicine at West Suburban Hospital was his day job, but his extracurricular passions were adventure travel and science (he regularly attends Compton Lectures and other public science events on campus). The Niger paleontological expedition would combine all three. So when Sereno beckoned, Lyman secured a leave of absence from his hospital, packed his bags, and went.

Being the team physician didn't exempt Lyman from the paleontology work. "I did basically all the same stuff—the digging, the trenching, the plastering, and the loading—that they did," he says. The most common medical issues the expedition members suffered were temporary gastrointestinal distress or splinters. ("I hate splinters," he says. "They can be really difficult.") His most important role, however, was simply being attentive as someone struggled through a passing illness. "When people are sick in that kind of setting, they're scared. It may just be a stomach thing, but they can't eat, they're throwing up, and they're nowhere near civilization."

Among what civilization there was, once word got out that a Western doctor was nearby, locals would come almost every day seeking medical attention. It was a challenging environment. Lyman had limited supplies, little familiarity with the native culture, and no knowledge of the language. He communicated through two translators: one to translate English to French and the next, French to Tamasheq, the local Tuareg language.

On one occasion, he was called to help a local man with an infected wound. When he got to the village, though, everyone with a medical complaint came by to be looked at first. When he finally saw the original patient, he had to cut open the man's wound with a pair of scissors and drain it without applying anesthesia. Another time, he was asked to treat a woman who hadn't left her hut in years. Lyman realized she was suffering from postpartum depression and improvised a treatment plan without the professional therapy or antidepressants a patient back in Chicago would probably get.

The Niger expedition was a difficult one. The team was attacked by bandits, who held them at gunpoint; took their watches, cameras, and other valuables; and then slashed their trucks' tires to prevent pursuit. The expedition's local guides sewed the tires up well enough to drive to the nearest town, Lyman says, but the journey still took two days. In another incident, a truck pulling a trailer jackknifed and rolled over. "That was the single scariest moment I think I've had on an expedition," he says, "because in the few seconds it took me to jump out of my vehicle and go over there, I didn't know what I was going to find." Most of the passengers walked away from the accident, and the only serious injury wasn't life-threatening.

From a scientific standpoint, the dangers were worth it. The team brought back an enormous number of fossil specimens on that trip, including the fossil for which Sereno became known—a 35-foot-long reptile that lived 112 million years ago called *Sarcosuchus imperator*, better known as "Supercroc." They found fossils of the smallest crocodile ever as well and a large herbivorous dinosaur with more than 500 teeth that Sereno dubbed *Nigersaurus*.

It was the first of four trips Lyman has taken to find fossils of dinosaurs and other once-living things. He participated in a smaller expedition back to Niger to look for amphibian fossils, led by one of Sereno's collaborators from the 2000 trip. He accompanied Sereno to Tibet, but the political situation there, plus an untimely bridge collapse that shortened their stay, meant they left empty-handed.

In December 2011, he returned to Niger yet again with Sereno to follow up on a site of ancient human burials they had stumbled upon in 2000. The place, called Gobero, had been on the shores of a now-vanished ancient lake. After carbon-dating the artifacts, Sereno discovered that Gobero had been a burial site both 5,000 and 9,000 years ago. "For two civilizations 4,000 years apart, this was an important burial site," Lyman says. "No one is actually sure why."

Participating in hands-on science is what he enjoys most about the expeditions, Lyman says. He remembers one camp the team traveled to during his first Niger expedition, where fossils were littered about on the ground, virtually for the taking. "Within minutes we were all finding stuff," he recalls. "There was this incredible sense of excitement." Having found a way to combine his passions for adventure and science, Lyman's not about to give it up: he's headed back to Niger again with Sereno this fall. ∎

COMPUTER SCIENCE

Head in the cloud

Haryadi Gunawi works to usher in a new age of computation.

Whether you realize it or not, you're probably already a consumer of cloud computing, points out Haryadi Gunawi, the Neubauer Family assistant professor of computer science. Search engines, webmail, and social-networking sites all store information and computing power in the cloud, the hardware and software systems users access over a network. Even so, Gunawi argues, the potential of the cloud has yet to be fully tapped—and he intends to help tap it.

The dominant paradigm in the late 20th century was the personal computer; everything a user needed was on his or her PC. As the importance of networking grew, users accessed information and programs running on remote computers. More and more computing functions were transferred off the personal computer and into the cloud. Today the personal computer is in decline as the rise of smartphones, tablets, and other Internet-enabled devices rely on the cloud. Now even slow and inexpensive devices can draw on enormous data storage and processing power.

The cloud will democratize computing, says Gunawi. "In the old days, if you wanted to build big software systems, you needed lots of infrastructure to begin with," he says. "You needed lots of people and lots of machines." Today a small software firm can rent as much storage or computing power as it needs, on demand, from services like Amazon. "You can become successful without taking on too much risk in the beginning."

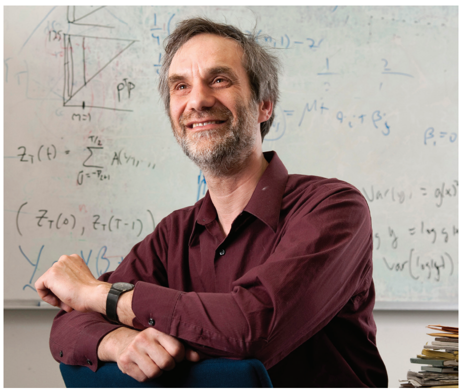
Not everyone is sold on the cloud yet. Data security is a real issue because, in the cloud, so many users share the same computers; banks in particular are hesitant to trust their records to anyone else. System reliability is another challenge. As Gunawi points out, the software must run on hundreds of thousands of machines—personal computers, laptops, smartphones, tablets—each with its own quirks and possible failure points. "Not to mention that as the complexity of the software goes up, you're going to have more bugs."

The reliability of a cloud-based system can make or break its owners. The online bookmarking service Mag.nolia permanently lost its users' data in 2009 and was forced to shut down a year later. Recurring data outages by Research in Motion, which makes the BlackBerry smartphone, have battered the company's sales.

Gunawi is addressing shortcoming with an initiative called UCARE (University of Chicago Systems Research on Availability, Reliability, and Elasticity). In the past, he says, it was enough to test software on a few different machines to verify its reliability. The proliferation of computing devices has created more opportunities for failure. UCARE aims to analyze today's systems and point the way forward to a safer, more reliable cloud.

One aspect of UCARE is writing drill-capable software, which tests itself by deliberately introducing errors into its system. The goal is to identify weaknesses and known failure points, he says, so operators know how to respond to an actual failure without losing users' data. Gunawi also goes a step further than most testers: "Whatever you do with offline testing," he says, "it's not enough." He's developing ways to put real failures in actual data in live systems. "If you don't test your systems online that often, then suddenly you get into a panic situation because you've never been there before."

The future is sooner than you think: Gunawi estimates that cloud computing will become the norm within five years, as storage technology and software become more reliable. Humans are "thirsty for data," he says, and he's interested to see how their demands evolve. As he puts it, "This is an exciting new era for computing." ∎



Master class

Faculty Q&A with Michael Stein

Michael Stein, the Ralph and Mary Otis Isham professor of statistics and collegiate master of the Physical Sciences Division, earned his bachelor's degree in mathematics from the Massachusetts Institute of Technology in 1980 and his master's degree (1982) and doctorate (1984) in statistics from Stanford University.

Your research focuses on statistics of processes that vary in space-time. What does that mean?

I'm looking at models that apply to things that vary depending on where or when you are. That's most everything; we live in a world that varies in space-time. As a field of statistics, it's very new—not only because of a lack of data but also because of a lack of computing resources and lack of ideas about how to deal with these kinds of data sets. The problem is that you get models where everything depends on everything else, so it's not so easy to write down a sensible statistical model. Then, when you have a model, it's not so easy to figure out how to apply it to the data sets, especially large ones.

What kind of applications does your work have?

Right now I'm working mainly on environmental applications. One thing we've been working on is climate projections: what the climate might look like in the future. I'm not a climatologist, but what interests me is not just the fact that the climate's going to shift in a certain direction, but how it's going to vary may also change in the future. Yes, temperatures will go up, but maybe certain processes will vary on longer or shorter timescales or have more or less spatial dependence.

I'm part of a project called the Center for Robust Decision Making on Climate and Energy Policy, which aims to improve the models needed to evaluate climate and energy policy. Part of that is producing these climate forecasts. If you're trying to run agricultural models, telling you "It's going to get warmer in the future" isn't really enough information to say what impact that will have on agriculture. You have to say something like, "It'll be wetter here, but drier over there."

I still feel that our ability to model complex space-time processes is inadequate. I hope that I can come up with some better, generic ways of analyzing big space-time data sets. There are some intrinsically hard aspects to these problems, so a general solution may be unattainable. We're certainly not there yet.

How do you see your role as collegiate master in the division?

I'm an overseer for the physical-sciences classes going on in the College, making sure that they're getting the resources they need. Unlike some of the University's other divisions, the individual departments largely take care of the undergraduate curriculum. My role is much smaller than some of the other masters. I don't have much of a staff—just an administrative assistant and someone responsible for the labs for the general physical-sciences classes.

I think it says something that the position of collegiate master even exists; it says the University values undergraduate education.

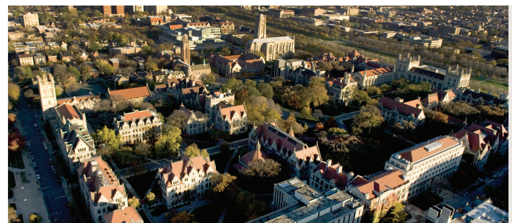
What do you hope to accomplish as master?

Enrollments in our classes are exploding. We need to think about how to respond to that, how to teach a greater number of people in the way we like to teach in this school. Are we just going to let our classes get bigger and bigger? It's a real issue, arising not just from a growing College but from growing interest in many of the fields in physical sciences.

I am hopeful that somehow, on the margins, I can push my colleagues to think about what they can do to contribute to undergraduate education, because there are already a large number of faculty who do a lot of that.

The nice thing about teaching here is, if you come up with some new, challenging class, the students aren't scared; they say, "Yeah! Let's do that!" We have the interest among students to offer classes that they just couldn't get elsewhere, and we should be feeding that demand. ■

> "I think it says something that the position of collegiate master even exists; it says the University values undergraduate education."



Making plans

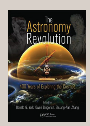
If you are interested in supporting the physical sciences but don't have the resources to make an outright gift, you may wish to consider including a provision in your will for the benefit of the Physical Sciences Division. Your bequest of a specific dollar amount, a percentage of your estate, or a piece of property can:

- » fund student aid;
- » sponsor faculty positions;
- » support groundbreaking research; and
- » provide unrestricted funds.

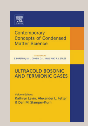
Bequests are simple to arrange, reduce your taxable estate, and allow you to retain your assets during your lifetime. Providing for the physical sciences in your will is a simple way for you to help support the future of science at Chicago.

For more information on the many ways you can give to the PSD, please contact Heather R. McClean in the Office of Gift Planning at 773.834.2117 or hmcclean@uchicago.edu.

Faculty & staff bookshelf



Donald York, the Horace B. Horton professor of astronomy and astrophysics, has edited *The Astronomy Revolution: 400 Years of Exploring the Cosmos* (Taylor & Francis), coedited by Owen Gingerich of Harvard University and Shaung Nan Zhnag of the Institute of High Energy Physics, Chinese Academy of Sciences. The book compiles scientific papers and historical discussions on the intellectual effects of the telescope in Chinese and Western society, presented at the New Vision 400 conference in Beijing in October 2008, commemorating the 400th anniversary of the first telescope.



Kathryn Levin, professor of physics, has coedited *Ultracold Bosonic and Fermionic Gases* (Elsevier) with Alexander Fetter of Stanford University and Dan Stamper-Kurn of the University of California, Berkeley. Part of Elsevier's Contemporary Concepts of Condensed Matter Science series, Levin's book is meant for first-year graduate students in physics, eschewing equations in favor of describing the advances in condensed matter physics over the past 15 years.

Faculty additions

Luca Grandi, assistant professor of physics in the Enrico Fermi Institute (effective March 1, 2013)

Haryadi Gunawi, Neubauer Family assistant professor of computer science

Henry Hoffman, assistant professor of computer science (effective January 1, 2013)

David W. Schmitz, assistant professor of physics in the Enrico Fermi Institute

Jonathan Simon, Neubauer Family assistant professor of physics in the James Franck Institute

Dam Son, University professor of physics in the Enrico Fermi Institute and the James Franck Institute

Andrei Tokmakoff, professor of chemistry in the James Franck Institute and the Institute for Biophysical Dynamics (effective January 1, 2013)

Faculty retirements

Kyle Cudworth, professor of astronomy and astrophysics

Karl Freed, Henry J. Gale distinguished professor of chemistry in the James Franck Institute

David MacQueen, professor of computer science

Hisashi Yamamoto, Arthur Holly Compton distinguished service professor of chemistry

INQUIRY

Tell us how we're doing.
Contact us with your responses or suggestions at psd-inquiry@uchicago.edu.

Inquiry is written and edited by Benjamin Recchie, AB'03.


photo by Dan Dry

NOTE FROM THE DEAN

Leaving the nest

Just about every issue of this newsletter has featured the good work of a graduate student from the Physical Sciences Division. In the fall of 2011, it was Rina Foygel, SM'09, PhD'12, an alumna of the Department of Statistics. One issue earlier, it was Thomas Church, SM'07, PhD'11, of the Department of Mathematics. Both of these students have gone on to do well; Church went straight from graduate school to an assistant professorship at Stanford, and Foygel has secured an appointment as an assistant professor right here at Chicago, starting in 2014.

But there are stellar students who haven't been featured in *Inquiry*. For example, Christina Belanger, PhD'11, is now an assistant professor in the Department of Geology and Geological Engineering of the South Dakota School of Mines and Technology. Eric Feng, SM'07, PhD'12, is the Eugene Wigner Fellow at Argonne National Laboratory. Jelena Pesic, PhD'10, is a process-development engineer at Intel. There are many more like them, in every field of the physical sciences.

It is clear that our students are very successful indeed, and their accomplishments are solid proof of the high quality of a UChicago graduate education. We should all—faculty and alumni alike—take pride in their achievements.

With warm regards,

Robert A. Fefferman, Dean

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