Northwestern

RESEARCH

	2013 **NAISE** Northwestern Argonne Institute of Science and Engineering	2014 **CHiMaD** Center for Hierarchical Materials Design	2015 **CSMI** Convergence Science & Medicine Institute	2000 **IIN** International Institute for Nanotechnology	2004 **CLP** Chemistry of Life Processes Institute
	2008 **ISEN** Institute for Sustainability and Energy at Northwestern	2016 **NCWR** Northwestern Center for Water Research	2014 **NNIN** NTU-Northwestern Institute for Nanomedicine	2005 **CCNE** Center for Cancer Nanotechnology Excellence	2011 **CDT** Center for Developmental Therapeutics
2014 **CBES** Center for Bio-Inspired Energy Science	2018 **LEAP** Center for Light Energy Activated Redox Processes	1983 **CCSS** Center for Catalysis and Surface Science	2015 **WCNO** Willens Center for Nano Oncology	2015 **C-ABN** Center of Excellence for Advanced Bioprogrammable Nanomaterials	2009 **CMIDD** Center for Molecular Inovation and Drug Discovery
2012 **CRN** Center for Regenerative Nanomedicine	2016 **CAMEE** Center for Advanced Materials for Energy and Environment	2008 **SOFI** Solar Fuels Institute	2002 **NUANCE** Northwestern University Atomic and Nanoscale Characterization Experimental Center	2016 **NIMSI** Northwestern Initiative for Manufacturing, Science and Innovation	2009 **CR-PSOC** Chicago Region Physical Sciences and Oncology Center
1959 **MRSEC** Materials Research Science and Engineering Center	2018 **CuBISM** Computationally-Based Imaging of Structure in Materials	2012 **CSSA** Center for the Scientific Studies in the Arts	2015 **SHyNE** Soft and Hybrid Nanotechnology Experimental Resource	2017 **CAMSIM** Global Center on Advanced Material Systems and Simulation	2009 **PCE** Proteomics Center of Excellence
2017 **DevSci** Institute for Innovations in Developmental Sciences	2016 **ISGMH** Institute for Sexual and Gender Minority Health and Wellbeing	2016 **CSB** Center for Synthetic Biology	1995 **CSCB** Center for Sleep & Circadian Biology	1989 **CRS** Center for Reproductive Sciences	2007 **NUCATS** Northwestern University Clinical and Translational Sciences Institute

SPRING/SUMMER 2019

"By encouraging collaboration within Northwestern and between the University and other institutions, we create a discovery ecosystem with the tools and culture to enable great scientists to pursue high-impact research."
Northwestern Vice President for Research Jay Walsh

MARCH 1, 1972

Fermilab produces its first high-energy particle beam. Since then, hundreds of experiments have used Fermilab's accelerators to study matter at ever-smaller scales and to investigate physical processes thought to have occurred in the universe's early evolution.

Alexander Romanenko, a senior scientist and head of superconducting quantum systems at the Department of Energy's Fermi National Accelerator Laboratory (Fermilab), evaluates a superconducting radio frequency (SRF) cavity placement in the dilution refrigerator at the facility's quantum lab. The physics of SRV cavities, from high-voltage fields to individual quantum-level photons, is core to the research conducted by the **Center for Applied Physics and Superconducting Technologies** (CAPST). Romanenko, a CAPST member, holds an adjunct appointment in physics and astronomy at Northwestern.

$470,000

Research Funding from the National Science Foundation is helping CAPST researchers explore "The Science and Fundamental Understanding of the Radio Frequency Surface Resistance of Nitrogen Doped SRF Cavities," says James Sauls, physics and astronomy, CAPST co-director, and principal investigator on the grant.

2017

Northwestern and Fermilab established CAPST in June 2017 with a focus on superconductivity at the forefronts of accelerator physics, quantum simulation and computing, and discovery of superconducting materials for next-generation quantum devices.

Northwestern | RESEARCH

Office for Research

Jay Walsh
Vice President for Research

Matt Golosinski
Director of Research Communications

Roger Anderson
Publications Editor

Jeanine Shimer
Designer

Writers

Roger Anderson
Aaron Dorman
Matt Golosinski
Glenn Jeffers
Valerie Nikolas

Northwestern University
Office for Research
1801 Maple Street, #5313
Evanston, Illinois 60208

This publication is available online at:
research.northwestern.edu/pubs/magazine

research.northwestern.edu
facebook.com/NorthwesternResearch

twitter.com/researchNU

Northwestern
RESEARCH

CONTENTS

SPRING/SUMMER 2019
VOLUME 4, NUMBER 2

On the cover: Northwestern's vibrant University Research Institutes and Centers (URICs) play an important role in advancing interdisciplinary discovery. In this depiction, the reddish tiles represent standalone knowledge hubs. The other tiles represent URICs and their affiliates by matching colors to indicate a research relationship.

This spread: A three-dimensional graphene melt composed of nanosheets, which characteristically exhibit a glass-transition behavior analogous to ordinary polymers. The image is part of a 2018 *ACS Nano* publication on the "Structure and Dynamics of a Graphene Melt" that included contributions from members of the National Institute of Standards and Technology (NIST) and the Northwestern-hosted Center for Hierarchical Materials Design (CHiMaD), co-directed by Peter Voorhees and Gregory Olson, both materials science, and University of Chicago's Juan De Pablo. Over the past five years, CHiMaD has helped solidify Chicago as a hub for high-tech materials innovation. In January, ChiMaD began the second phase of its work with an additional $25 million, five-year NIST grant.

A NETWORK OF KNOWLEDGE

At Northwestern, interdisciplinary research is in our DNA, and our **University Research Institutes and Centers** (URICs) are a remarkable example of our commitment to breakthrough discovery at the convergence of knowledge domains.

Photo by Nathan Mandell

Jay Walsh, vice president for research

These institutes and centers bring together talent and ideas from across our schools to spur creative collaboration at the intersection of fields — from the life sciences and physical sciences to the social sciences and the arts and humanities. This magazine showcases some of the exceptional work catalyzed by our URICs, now numbering nearly 50, and suggests how they help set the tenor for Northwestern's overall research enterprise.

Our University's research has transformative impact, producing innovative advances that foster both deeper fundamental understandings and solve challenges to improve people's lives and create a stronger society. We've designed our URICs ecosystem to support and encourage faculty, students, and postdoctoral fellows who seek to explore the possibilities of cross-disciplinary investigation.

Northwestern has long valued interdisciplinary research and was among the pioneers promoting it. In fact, our first URIC dates to 1948, with the founding of the **Program of African Studies.** Certainly, over the last two decades this approach has grown increasingly prominent within academia. But creating a culture that nurtures these complex efforts truly requires a "village." It requires strategic vision and the partnership of a lot of people — notably our faculty, deans, and senior administrators, who are key to our ecosystem.

Those efforts have been rewarded, with the most important return on investment being the research outcomes themselves and the education that our students and postdocs receive at the intersection of traditional fields. That work is integral to Northwestern's mission.

In tandem with those research outcomes, the URICs have helped attract new talent to our campuses: faculty, students, and postdocs who are excited about the possibilities of actively engaging colleagues from around this University to pursue answers to exciting and difficult questions. The URICs also have played an important part in the phenomenal research growth at Northwestern over the past 10 years or so, especially as government agencies have looked to fund more collaborative, interdisciplinary research — the kind of work that flourishes within the URICs and across our University.

These exciting discoveries and the passion of those who make them possible inspire us each day at Northwestern. I hope the following pages make it abundantly clear why this is so!

RESEARCH NEWS

Photo by Monika Wnuk

EXPLORING SEX RISKS

Sexual and gender minority adolescents in the United States are at high risk for negative sexual health outcomes like HIV and sexually transmitted infections. Yet their needs are often overlooked by sex education and HIV prevention programs designed for heterosexual adolescents and adults. **Kathryn Macapagal,** medical social sciences and core faculty at the **Institute for Sexual and Gender Minority Health and Wellbeing,** conducts innovative research that sheds light on sexual risk and protective factors among these adolescents. In one recent study she found that most gay and bisexual adolescent boys have used smartphone dating applications to find adult men. Although this use is associated with elevated rates of condomless sex, it is also linked with benefits — such as reduced sense of isolation, meeting other gay and bisexual peers, increased rates of HIV testing, and awareness of a once-daily HIV prevention drug called PrEP.

56

Northwestern boasts 56 University Core Facilities — shared instrumentation and staff expertise — across its Chicago and Evanston campuses. Nearly half of all core facility staff members hold a PhD.

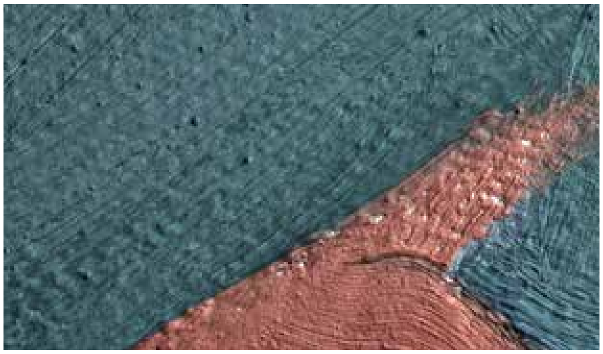
$291 MILLION

Through the start of June, URIC research proposals have risen to $291 million this fiscal year, a 56 percent increase over last year and a 117 percent increase over 2017. In the first nine months of FY19, awards have risen 25 percent, to more than $40 million.

Photo by Eileen Molony

"There has been a progressive push to image smaller and smaller blood vessels and provide more comprehensive, functional information. Now we can see even the smallest capillaries and measure blood flow, oxygenation, and metabolic rate."

Vadim Backman, the Walter Dill Scott Professor of Biomedical Engineering and a member of the **Chemistry of Life Processes Institute,** on a pathbreaking study he led that revealed a new tool that images blood flow through capillaries — tiny, hair-like blood vessels.



DIAGNOSING 'ACNE' IN O'KEEFFE PAINTINGS

Even Georgia O'Keeffe noticed the pin-sized blisters bubbling on the surface of her paintings. For decades, conservationists and scholars assumed these tiny protrusions were grains of sand, kicked up from the New Mexico desert where O'Keeffe lived and worked. But as the protrusions began to grow, spread and eventually flake off, people shifted from curious to concerned. A multidisciplinary team from Northwestern's **Center for Scientific Studies in the Arts** and the Georgia O'Keeffe Museum in Santa Fe, New Mexico, has now diagnosed the strange paint disease: The micron-sized protrusions are metal soaps, resulting from a chemical reaction between the metal ions and fatty acids commonly used as binder in paints.

GRANT BRIDGES COMMUNITY MENTORS

A renewed partnership between Northwestern University and Mather High School will bring nearly 100 elementary and secondary school students to campus for immersive learning and mentorship experiences. Funded by a $175,000 ASPIRE grant from AT&T, the new Science Explorers Summer Camp pilot initiative at Mather — a Chicago Public School located on the city's North Side — will take place during consecutive summers (2020-21). "Relationship-building is core to our work, and this happens not only between Northwestern mentors and Mather students, but also between teachers and staff," says Michael Kennedy, **Science in Society** director.

HOW THE MICROBIOME MAY REACT ON MARS

During his yearlong stay on the International Space Station (ISS), astronaut Scott Kelly experienced a shift in the ratio of two major categories of bacteria in his gut microbiome. The diversity of bacteria in his microbiome, however, did not change during spaceflight, which the research team, led by **Fred Turek** and **Martha Vitaterna** of **Northwestern's Center for Sleep and Circadian Biology,** found encouraging.

Gut health affects digestion, metabolism and immunity; and, more recently, changes in the microbiome have been linked to changes in bones, muscles, and the brain.

The study's finding could help physicians and researchers pinpoint and implement ways to protect astronauts' and space tourists' microbiomes during long bouts of space travel, such as during the much-anticipated mission to Mars.

Vitaterna and Turek were recently awarded additional funding from NASA to study "Martian-level gravity in conjunction with a Martian-length day." A day on Mars is about 41 minutes longer than one on Earth. The conditions will be replicated aboard the ISS using mice.

A FLUID SITUATION

Sera Young

To address the complex global problem of water insecurity, the National Science Foundation recently awarded a $500,000 grant to several members of the Household Water Insecurity (HWISE) Consortium to develop the HWISE Research Coordination Network. The five-year project is being co-led by **Sera Young**, anthropology and a faculty fellow with the University's **Institute for Policy Research, Water Research Center,** and **Program of African Studies**. Spanning four continents, data collection is ongoing at nearly 30 study sites.

"Many experts in the field were already collaborating virtually, but that's not enough. We need to have a critical mass of individuals come together to explore a project."

Mayda Velasco, founder and director of the **Colegio De Fisica Fundamental E Interdiciplinaria De Las Americas** (COFI), which brings together particle theorists and computational and experimental experts from across the globe to Puerto Rico to discuss their work and identify opportunities for collaboration

A ROAD MAP TO MENTAL HEALTH, EARLIER

Mental disorders are the predominant chronic diseases of youth, and a wealth of evidence demonstrates that the neurodevelopmental roots of common mental health problems are present in early childhood. In an article published March 27 in the *Journal of Clinical Child & Adolescent Psychology*, faculty at Northwestern's **Institute for Innovations in Developmental Sciences** (DevSci) proposed a translational "Mental Health, Earlier" roadmap as a key direction for prevention of mental disorders. DevSci faculty utilized interdisciplinary collaboration for the Mental Health, Earlier strategy that rests on the "science of when to worry," a concrete methodology for addressing these issues and transforming clinical outlooks. These Mental Health, Earlier strategies hold promise for transforming clinical outlooks and ensuring young children's mental health and wellbeing in a manner that reverberates throughout the lifespan.

117

More than 100 departments are represented within Northwestern URICs. "The University has created a research ecosystem that nurtures team science and collaboration across disciplinary boundaries," says Fruma Yehiely, associate vice president for research. "One of the places where such investigations occur is in our URICs, knowledge hubs that, by design, attract talent to pursue discoveries that often reside at the intersection of different fields."

Photo by Shane Collins

"It's abundantly clear that we need completely new methods to try to shut down cancer proliferation. We're very excited that our work could pave the way for new types of treatments for brain, breast, and other very resistant cancers."

Thomas O'Halloran, the Charles E. and Emma H. Morrison Professor in Chemistry and Molecular Biosciences, founding director of the **Chemistry of Life Processes Institute,** and director of the **Center for Developmental Therapeutics,** on new research using arsenic — in low doses — to fight cancer.

SUPERCRYSTAL FLOWER

In collaboration with the Museum of Science and Industry, the city of Chicago, and the Chicago Public Library, Northwestern's **Materials Research Center** (MRC) has launched the next iteration of its Materials Science Exhibit at the Harold Washington Library in downtown Chicago. The newly updated exhibit is located in the Grand Promenade on the third floor and will be open to the general public through January 30, 2020. While the original exhibit featured galleries on ubiquitous (ceramics, plastics, and metals) and frontier (silicon, carbon, and magnets) materials, the current iteration also features a microscopy gallery, highlighting the intersection of art and science. Pictured above is "Supercrystal Flower" by Taegon Oh, a graduate student, in the lab of Chad Mirkin, chemistry.

"Core facilities act as hubs where users from diverse backgrounds can come together and create wonderful multidisciplinary research initiatives that are a hallmark of Northwestern."

Vinayak Dravid

Vinayak Dravid, director of **NUANCE** and the Soft and Hybrid Nanotechnology Experimental (SHyNE) Resource

NEW KAPLAN FELLOWS

Originally launched in 2016 with generous funding from Richard and Barbara Franke, the **Alice Kaplan Institute for the Humanities** awards exclusive Franke Fellowships to the most promising undergraduate seniors and graduate students in fields across the humanities. Following a rigorous selection process, 2019-20 winners include undergrads Malia Bowers, Arturo Chang, Jayme Collins, and Bradley Dubos, as well as graduate students Melia Agudelo, Meghan Clare Considine, and Nicholas Liou.

URICA'S PATRICK RECOGNIZED FOR 'BRIDGE BUILDING,' MENTORSHIP

Brittany Patrick's resume doesn't list experience as an architect or engineer, but the senior research administrator's ability to design innovative solutions and build lasting relationships was recognized as she was named spring's OR STAR, a quarterly staff recognition. Patrick has worked in research administration for nearly a decade. Prior to joining the University Research Institute and Centers Administration (URICA) team, she worked in the Feinberg School of Medicine's Basic Science Administration unit, where she supported a variety of complex and large-scale research projects from proposal through close-out.

Brittany Patrick

17

Northwestern's Research Development team supported 17 complex team science and young investigator funding proposals in 2018. Ten of those proposals — totaling $52 million over the lifetime of the grants — were funded.

> "The faculty and staff within University Research Institutes and Centers never fail to impress me with their ambition and innovation. From reducing wires attached to monitoring equipment so parents can bond with premature infants to reducing the HIV-risk through social science, the scope of discovery is amazing."

Joseph Boes

Joseph Boes, senior director of administration and operations for University Research Institutes and Centers. For his efforts in leading the URICs Administration team, Boes was named Northwestern's 2019 Employee of the Year.

QUANTUM SCIENCE INITIATIVE LAUNCHED

Northwestern University has launched a new interdisciplinary initiative to integrate and advance its strengths in quantum science, a field that promises to transform communications, security, metrology, sensing, and computing. **The Initiative at Northwestern for Quantum Information Research and Engineering** (INQUIRE) is designed to bridge multiple academic domains, bringing together faculty from the University's top-ranked departments, including Chemistry and Materials Science & Engineering, as well as Physics & Astronomy, Electrical & Computer Engineering, and Computer Science. Additional efforts anchored in some of Northwestern's University Research Institutes and Centers, cross-disciplinary knowledge hubs, are an integral part of the Initiative. In May, Northwestern joined the Chicago Quantum Exchange, a multi-institutional hub for quantum science that currently includes University of Chicago, University of Illinois, University of Wisconsin, Argonne National Laboratory, and Fermi National Accelerator Laboratory. "Collaborative science is at the heart of Northwestern's research success," said **Jay Walsh**, vice president for research. "We have created an ecosystem that encourages cross-disciplinary discovery, while ensuring that deep fundamental research continues within individual domains. Initiatives such as INQUIRE help to galvanize our talent and enable Northwestern to extend its research impact by engaging with colleagues beyond the University, regionally, nationally, and internationally."

GOLDEN OPPORTUNITY

The Block Museum's Caravans of Gold has provided wonderful visuals, and the content complements many of the **Institute for the Study of Islamic Thought in Africa's** (ISITA) core interests, such as Africa's interconnectedness with other parts of the world, the multi-directional flows of Islamic knowledge, and the importance of the Arabic language and script in Africa. The collaborative dimension of the exhibit's planning and execution has been exemplary; ISITA and its partners have built creative programming around the exhibit, including a conference on "Saharan Futures" and the launch of a new Arts of Islam in Africa initiative.

854

University Research Institutes and Centers cultivate talent, collaboration, and innovation at the intersections of traditional disciplines. Last year, 854 faculty members participated in research associated with at least one URIC.

IPR at 50

A LOOK AT 10 DISCOVERIES THAT EXEMPLIFY EFFORTS TO TRANSFORM THE SOCIAL POLICY LANDSCAPE

Northwestern's Institute for Policy Research (IPR) was born as the Center for Urban Affairs in 1968, a time of urban violence, turmoil, and fear. From its earliest years, IPR was a dynamic research hub, bringing together scholars from many disciplines to tackle vital issues of community — including crime, poverty, social welfare, discrimination, education, and family life.

Over the decades, IPR's research focus developed to include national policy issues beyond urban affairs, reflected in its name change to IPR in 1996, and drew upon the increasing availability of large surveys and data sets. But the commitment to interdisciplinary research that addresses policy changes to improve people's lives did not change.

Today, IPR is nationally known as the home of renowned social science researchers in both subject and methodology — and as a resource for policymakers at all levels.

"Our researchers are harnessing big data sets, integrating different disciplines, and deploying increasingly sophisticated research methods to compile a body of visionary research with growing policy impact," says economist **Diane Whitmore Schanzenbach,** IPR's seventh director.

These new tools and methods enable IPR researchers to uncover surprising connections and offer new ideas that can lead to a fundamental rethinking of how we view — and solve — persistent social issues. Seminal studies published in highly influential journals by IPR faculty researchers over the last decade, such as the 10 that follow, exemplify how their research is transforming the social policy landscape.

Can Cash Payments Cut Deforestation?


Seema Jayachandran

Deforestation accounts for an estimated 9 percent of human-induced carbon emissions. A two-year randomized control trial in 121 Ugandan villages, led by an IPR economist, found that paying people to conserve their trees could be a highly cost-effective way to reduce both deforestation, and therefore carbon emissions. Published in *Science*, 2017

Partisanship and Public Opinion


James Druckman

What can we do to bridge political party divisions? Three IPR researchers tested how individuals interpret information through the lens of their political party via their motivations, informational sources, and information processing. When partisanship was the key motivator, participants were more likely to endorse their party's policy. But for those who knew a position had bipartisan support and were expected to explain their opinion, their "partisan-motivated reasoning" completely disappeared. Published in *Political Behavior*, 2014

School Spending Matters


Kirabo Jackson

For decades, policymakers have cut education budgets, pointing to research that finds school spending does not affect education outcomes. A study led by an IPR economist found differently. In tracking states' education spending and student outcomes before and after the Great Recession, the researchers discovered that a 10 percent increase in spending per pupil across all 12 years of public school led to better outcomes: They spent more time in school and earned more as adults. In particular, increased spending was especially beneficial to schoolchildren from low-income families. Published in *The Quarterly Journal of Economics*, 2016

Can Your Kindergarten Class Affect Your Earnings?


Diane Whitmore Schanzenbach

In the 1980s, Tennessee undertook an innovative experiment to randomly assign nearly 12,000 kindergartners to third graders to small classrooms. An IPR economist and her colleagues used tax data to link these students' kindergarten classroom quality to their adult outcomes. The researchers showed that those who were randomly assigned to a higher-quality kindergarten classroom earned more as 27 year olds. As adults, they were also more likely to own a home, be married, and have retirement savings than their schoolmates in lower quality classrooms. Published in *The Quarterly Journal of Economics*, 2011

Using Identity to Motivate Students


Mesmin Destin

Boys and low-income children typically find it harder to succeed in school and college when compared with their more affluent peers. An IPR psychologist developed an "identity-based motivation" intervention to help schoolchildren to visualize their past, present, and future success. The study shows how seemingly small interventions based on identity can have large effects on students' behaviors and education. Published in *The Counseling Psychologist*, 2010

How Your Adult Body 'Remembers' Your Infancy

An interdisciplinary group of IPR faculty has been instrumental in bringing together the social, life, and biomedical sciences to explore how disparities affect human health and development. In one experiment, two IPR anthropologists and an IPR health psychologist reveal how an infant's physical environment, as measured by nutritional, microbial, and psychosocial exposures, can predict inflammation — an important risk factor for a wide range of diseases — when they become adults. The researchers explain how our bodies "remember" our experiences in infancy, and how these, in turn, can have an impact on adult health. Published in *PNAS*, 2017


Thomas McDade

How Neighborhoods Affect Health

An interdisciplinary team of researchers that included an IPR psychobiologist and anthropologist studied nearly 4,500 low-income families with children in five US cities, some of whom were randomly assigned housing vouchers. Those moving into lower-poverty neighborhoods showed long-term health improvements, with modest reductions in cases of diabetes and extreme obesity. The findings highlight the link between disadvantaged communities and their residents' poor health. Published in *The New England Journal of Medicine*, 2011


Emma Adam

Facing Uncertainty in Policy and Implications for Gun Laws

Do gun laws, such as those for right to carry (RTC), curb or contribute to crime? An IPR economist and his colleague examined annual crime rates in three states with RTC laws over more than 30 years. Their conclusion: There is no simple answer; it depends on which theories or assumptions are combined with the data. They propose that researchers offer more flexible assumptions to improve policymaking — even if these do not yield the black-and-white statements, such as "more guns, less crime," that policymakers and the public typically crave. Published in *The Review of Economics and Statistics*, 2018


Charles Manski

Meta-Analysis and What It Can Reveal

Meta-analysis is a statistical technique that permits researchers to consolidate findings across different studies. Two IPR faculty, statistician Larry Hedges and psychologist Alice Eagly, have made fundamental contributions in the area in several fields, including management, psychology, education, and statistics. In a key article, Hedges and his co-authors provide guidance to researchers on when they should use a fixed- or random-effects model. Hedges, who recently won the Yidan Prize for his work in this area, has also worked with other IPR faculty, who are using the technique to investigate critical issues, such as racial discrimination in hiring. Published in *Research Synthesis Methods*, 2010


Larry Hedges

Why Female Leaders Are Seen As Less Qualified

Alice Eagly has used meta-analysis to conduct groundbreaking studies of gender and leadership. In one recent study, she and her colleagues show how the public largely considers leadership stereotypes as masculine, although this perception has somewhat decreased over the last 30 years. According to the study, most view female leaders as being less qualified or less natural than men, and when women adopt culturally masculine behaviors, they are seen as inappropriate or presumptuous. Published in *Psychological Bulletin*, 2011


Alice Eagly

REFLECTING GREATNESS

Having come to Northwestern because of its prestige, Presidential Fellows now contribute to the University's reputation

Northwestern's Presidential Fellowship is the most esteemed award available to graduate students at the University. Students who receive the fellowship — funded by the president and awarded by The Graduate School — are nominated for representing a combination of intellectual and creative ability, as well as demonstrating the capacity to play an important leadership role not only in the Society of Fellows, but also in their respective disciplines and beyond. *NRM* asked a few of these graduate students to reflect on what brought them to Northwestern, and how mentors are helping to inspire their careers.

1 CHELSEA FRAZIER
African American Studies

I spend the majority of my time thinking, reading, and writing at the intersection of black feminist theory and theories of ecology. The moment I knew Northwestern was for me was actually sometime after I'd arrived on campus. After a couple of informal gatherings with my cohort members, we decided to start preparing for our seminars together. In these informal meetings we studied, summarized, dissected, and debated various texts we were reading in our courses. In addition to feeling more prepared for each of my seminars, I felt grateful that I'd found a group of young, slightly nervous, yet passionate people with whom I could safely exchange ideas.


2

2 PAUL OHNO
Chemistry

I knew Northwestern was the place to be when I visited campus and saw how much collaborative science was taking place within the Department of Chemistry. Solving the grand challenges of today requires researchers with complementary expertise working together, and the collaborations present within the department and beyond exemplify that. Much of science is asking the right questions, and while at Northwestern my adviser has taught me how to ask the important questions that will make an impact on both science and society.


5


9
6
4
1
8
7
3

❸ JASON ROSENHOLTZ-WITT

Music

I worked as a professional double bassist for a number of years, but as I became more and more interested in the history of the music I was playing, I began considering a career in academia. Northwestern's Musicology Department is truly invested in interdisciplinary study — one of the reasons I was drawn here — and my adviser has helped me approach music history more broadly, as a historian of culture.

❹ BONNIE ETHERINGTON

English

I have been interested in stories and how stories shape the way we see the world ever since I was a small child. I am a non-Indigenous person from New Zealand who grew up in West Papua and I saw in both countries how limited colonial narratives of Indigenous peoples have very real and violent consequences. I knew I wanted to study Indigenous protest literatures after a graduate seminar I took with Kelly Wisecup, who is now my adviser.

❺ MARCOS LEITAO DE ALMEIDA

History

A professor from the University Texas-Austin told me that Northwestern was the best place in the US to be trained in African history, particularly early African history. I knew Northwestern was one of the most important centers for African studies in the country, but I didn't realize it was a place one could conduct research on the early periods of the continent.

❻ MOLLIE MCQUILLAN

Human Development and Social Policy

When I came across the HDSP program at Northwestern, it looked like the perfect way to merge my experience within the K-12 school system with research related to social stress and health in adolescence. When I visited as a prospective student this enthusiasm for the program grew — and intensified even further as I took classes and started pursuing my own research agenda. I have felt very supported at Northwestern, especially around the work I am doing related to LGBTQ youth.

❼ DANIEL GARCIA

Chemical Engineering

When I entered graduate school, I had no knowledge of mathematical modeling and optimization, but I did have a passion for biofuels, sustainability, and clean energy. One of my advisers helped me leverage the tools of modeling and optimization to both see sustainable energy in a new light and learn how to practically advance its implementation. Another adviser, Jian Cao, opened my eyes to the world of advanced manufacturing, and we applied my background to give a novel twist to the design of sustainable manufacturing systems.

❽ KRITISH RAJBHANDARI

Comparative Literary Studies

What appealed to me about Northwestern and specifically about the CompLit program was the focus on interdisciplinary research. There are so many resources and platforms for cross-disciplinary conversations, such as the interdisciplinary clusters, the Kaplan Humanities program, black arts initiative, and so on. The very idea of studying the literatures of South Asia and Africa in relation to each other was quite new, and my adviser helped me think of new ways of approaching literature, and doing literary and cultural history beyond national or linguistic boundaries.

❾ ANNE D'AQUINO

Biological Sciences

My experience in the Summer Research Opportunity Program as a part of Heather Pinkett's lab was incredible and inspired me to continue my education and training in the biological sciences. Five years later, I am mentoring my own undergraduate trainees, in the hopes of similarly inspiring younger students to pursue graduate studies in the sciences.

2019 PRESIDENTIAL FELLOWS

Luis Fernando Amaya Muñoz, Music

Angel Escamilla Garcia, Sociology

Hannah Getachew-Smith, Media, Technology, and Society

Heather McCambly, Human Development and Social Policy

Lea Richardson, Plant Biology and Conservation

Lindsay Zimmerman, Health Sciences Integrated PhD Program

‘ORGANIC INTERACTIONS’ GROW INTO NEW DISCOVERIES

Global researchers form lasting collaboration at the Simpson Querrey Institute

When **Evangelos Kiskinis,** neurology and physiology, joined the Northwestern faculty in 2015, he had heard of **Samuel Stupp** but never worked with him.

An international leader in self-assembling materials and supramolecular chemistry who was born in Costa Rica, Stupp, director of Northwestern’s **Simpson Querrey Institute** (SQI), had never even met the Greek-born Kiskinis. That all changed about two years ago thanks to another relationship that began taking shape in Spain.

Zaida Alvarez-Pinto and **J. Alberto Ortega** were pursuing their PhDs when they met at the University of Barcelona in 2009. The pair shared a passion for traveling, food, and a career in research. Today, as postdoctoral fellows at Northwestern — and husband and wife — Alvarez-Pinto, who works in the Stupp lab, and Ortega, who works in the Kiskinis lab, have helped forge a connection between the two principal investigators.

“Because we have common scientific interests and we love our jobs, we constantly share what we do in the lab, and discuss how the other might answer questions we want to address,” says Ortega. “One Saturday, Zaida returned home from a Stupp lab meeting, and we began to discuss some of the problems when culturing induced pluripotent stem cell (iPSC)-derived neurons.”

IPSCs originate from skin or blood cells that have been reprogrammed into an embryonic-like state. These stem cells can then mature into any type of human cell — a neuron for instance.

The initial problem Ortega described was that human neurons cultured alone for long periods of time tend to aggregate and look terribly unhealthy and immature.

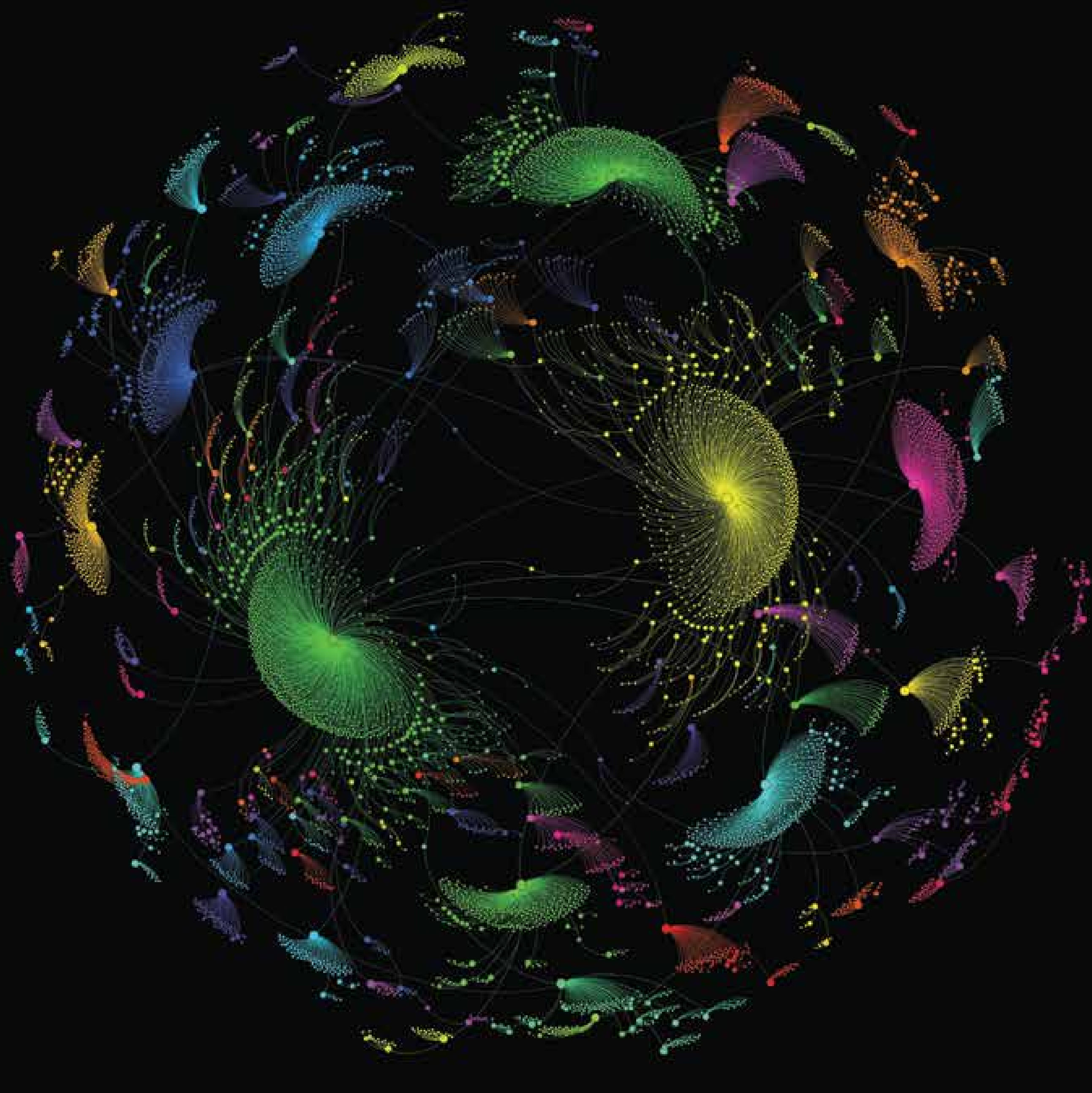
“Zaida pointed out that neurons, and especially human neurons, have a very low capacity to produce extracellular matrix, so the lack of a supportive environment produces all these problems,” Ortega recalls.

Zaida Alvarez-Pinto and J. Alberto Ortega

In her research, Alvarez-Pinto uses peptide amphiphiles, self-assembled molecules commonly utilized in the Stupp lab, that resemble the extracellular matrix.

Ortega wondered if the material might make the iPSC-derived neurons used in the Kiskinis lab look more physiologically sound. Each postdoc proposed the idea to their respective PIs and after agreement about 18 months ago, the labs began rapidly testing the concept. As of today, two publications have resulted, the first of which highlighted the discovery of a supramolecular nanostructure that mimics a brain-derived neurotrophic factor.

“The partnership is a natural fit between a stem cell lab interested in developing models of disease and discovering therapeutics and Sam’s lab that develops regenerative and therapeutic materials,” says Kiskinis, now a member of SQI whose most recent publication with Stupp explored Peptide–siRNA Supramolecular Particles for Neural Cell Transfection. “Our story nicely demonstrates how organic interactions bring about the best kind of collaboration under the umbrella of the Simpson Querrey Institute.”
— Roger Anderson



A network graph — called a “minimum spanning tree” — shows thousands of predicted table compounds from the Open Quantum Materials Database when it launched in 2014. Since this image was completed, the number of compounds predicted has increased to more than 55,000. Chris Wolverton’s research group created the database to take some of the guesswork out of designing new materials.

POWER THEORY

Engineer Chris Wolverton uses computation to improve materials for energy storage and conversion

Machines are changing how engineers think about materials. Using powerful computation, **Chris Wolverton,** the Jerome B. Cohen Professor at the McCormick School of Engineering, can achieve in hours or days what once may have been impossible in a physical lab. At Northwestern, Wolverton leads a research group that studies the application of computational tools to predict and optimize the properties of materials and help solve energy storage and conversion challenges. *Northwestern Research Magazine* spoke to the **International Institute for Nanotechnology**-affiliated researcher about his materials modelling, how it is used in research, and its larger implications for spurring future innovation.

NRM: What is computational materials science?
CW: We don't have a laboratory. The idea is that these computational techniques eventually connect a material — a chemical composition and maybe an atomic or crystal structure — with the material's properties. So given a material (real or hypothetical), a chemical composition, and an arrangement of atoms, we can calculate what the properties of that material should be.

Several years ago we wondered if we could just do calculations for all known inorganic solids and store them in a large database. Depending on your definition, there are between 50,000 and 150,000 known, inorganic solids; so, the question is, could you do that many fundamental physics-based calculations, quantum mechanical calculations? The answer is yes you can. But it takes a long time. We started that process years ago and now have this large-scale archive that we call the Open Quantum Materials Database (OQMD). Because the calculations are fundamental, and thus highly predictive, this means we can calculate the properties of a material and it doesn't really matter whether or not this material has been synthesized inside a laboratory.

NRM: What kinds of material are you looking for?
CW: We are quite interested in materials problems that have to do with energy and sustainability. A lot of my group's work tries to find materials for next-generation batteries. Thermoelectric materials are interesting because they can turn heat into electricity or vice versa. There is a lot of interesting work in this area to try and use these materials to capture waste heat. If we could capture a fraction of the world's waste heat and use it to produce electricity, this would be a fantastic improvement in energy efficiency.

NRM: Can you discuss your collaboration with IIN Director Chad Mirkin?
CW: In Mirkin's group they have fantastic new tools for growing huge libraries of nanoparticles, and are especially interested in what happens when you grow these nanoparticles consisting of a large number of different elements. So not just a single element, not just silver, or platinum or whatever. But what happens when you make a nanoparticle with platinum and silver and copper and cobalt all together? What he's found is that these nanoparticles tend to segregate into different phases or compounds. Looking in our database, to a large extent we could accurately predict which phases should form in these nanoparticles. At this point, we've mostly done these calculations retroactively, where Mirkin's group grows a particle of a given composition and says "this is what we find." Then we go to the database and say: "yeah, we could have told you that."

The idea is that now you have a tool that is actually predictive. So you could start scanning through this database, through the trillions of possible combinations


Chris Wolverton

of these elements, and look for the combinations that are likely to form phases that you might find desirable.

This collaboration between Mirkin and myself is going to be a very powerful combination — computing, then experimenting — because my lab can do these computations in a "high-throughput" manner, making tens or even hundreds of thousands of calculations. The Mirkin group can analogously grow a large number — thousands or millions of nanoparticles. Combining these two methods is potentially a game-changer and could dramatically accelerate the rate at which we discover new materials.

NRM: Given this kind of collaboration, what might the future hold?
CW: Different parts of the story are easier or harder to deal with. The OQMD already exists. It's free, it's online, it's open. You could go there now type in six-component chemical compositions and learn within seconds what phases should form. Other parts of the problem are ongoing. Calculating the interfacial properties between phases and the ultimate arrangement of phases in a particle, that's not done. We don't have a giant database of interfacial energies yet, so we can't just look up the answer. We have to do the calculations and those could take a while.

We've developed this new computational framework for predicting nanoparticles, now we need data. Once we have data, then we can do these calculations relatively quickly. Part of that problem we can solve right now because of the work with Mirkin. Now it's a matter of grinding through and doing the calculations. That will take a while, but it will be well worth it. — *Aaron Dorman, Medill graduate student*

Photo by Eileen Molony

MANUFACTURING A FUTURE… BEYOND THE ASSEMBLY LINE

"I think of the new manufacturing as a kind of integration platform, one that includes a focus on being smart, sustainable, and safe," says **Jian Cao,** the Cardiss Collins Professor of Mechanical Engineering at Northwestern's McCormick School. An expert in cutting-edge manufacturing processes and systems, Cao serves as an associate vice president for research and is director of the **Northwestern Initiative for Manufacturing Science and Innovation** (NIMSI), whose efforts advance cyber-physical distributed and also personalized manufacturing systems.

Cao's fundamental research contributions have earned her numerous distinctions, including being named a 2019 Vannevar Bush Faculty Fellow by the US Department of Defense and elected a 2018 fellow of the American Association for the Advancement of Science. In 2016, she was the first woman to earn the Frederick W. Taylor Research Medal, the highest honor given by SME for research excellence in the manufacturing field.

Cao sees manufacturing developing in ways that draw upon a distributed model — local level connections — but still integrated with a global network to ensure flexibility and quality control. This model will require a new approach to workforce training. "STEM education is very much needed," she says. "Manufacturing involves materials science, chemistry, and many different disciplines, in addition to mechanical engineering. It's not just moving the assembly line: You need to know programming and have a heart for the well-being of people and the environment." — *Matt Golosinski*"

By measuring the ratio of different masses of the atoms of calcium in shells, which vary in response to ocean acidification, Ben Linzmeier can evaluate what their environmental conditions were at specific points in their lifetime. Photos by Julianne Beck

ANCIENT ANALOGS

Northwestern postdoc studies the past as a proxy for modern-day ocean acidification

Shells — even those some 66 million years old — can tell us a lot about climate change, says **Ben Linzmeier.**

Linzmeier studies bivalves, aquatic mollusks that include oysters, clams, mussels, and scallops that lived through the extinction of the dinosaurs. Because these creatures use chemicals from their environments as building blocks for their shells, studying the chemical composition of those remains can suggest what the environment was like when these animals were alive. Such insights, in turn, tell researchers more about the earth's history and about how the environment may change in the future.

Linzmeier has pursued this research since joining Northwestern's Earth and Planetary Sciences Department as a postdoctoral fellow in 2017. The investigations expand on dissertation work he completed at the University of Wisconsin–Madison, where he studied new ways to determine the biology and behavior of ancient cephalopods (e.g. squids). His current research is supported by the

Ubben Program for Climate and Carbon Science, which focuses on developing interdisciplinary approaches to study climate system dynamics and develop solutions for climate adaptation and mitigation.

Using an extremely accurate form of chemical measurement developed by Northwestern Professor **Andrew Jacobson,** Linzmeier measures the ratio of different masses of calcium in the samples. These different masses of the same element are known as isotopes. They help scientists learn more about environmental conditions, like temperature or ocean pH, during Earth's distant past.

"The work is extremely painstaking, given the focus on quality over quantity," says Jacobson, Earth and planetary sciences, director of Northwestern's Environmental Sciences Program, and one of Linzmeier's advisers. "It's not the kind of research that can be completed quickly. Each sample is processed through a manual procedure to get it ready for analysis."

To measure the calcium's isotope ratio, Linzmeier uses a tool called a thermal ionization mass spectrometer. First, he isolates the calcium in a metal-free clean lab and puts it on a filament. Then the machine heats the filament, causing ionization. Calcium is accelerated away from the hot filament and then flies through a magnetic field in the mass spectrometer, which separates heavy from light isotopes using the same forces that are felt when driving around curves. Beams of atoms then crash into cups creating electrical signals used to measure the number of atoms of each mass.

Knowing the calcium isotope ratio of shells at given points in time allows Linzmeier to study changes in ocean pH, thus giving him a proxy record, an indication of the environmental conditions that contributed to the most recent mass extinction.

Between February and October 2018 Linzmeier painstakingly analyzed about 40 fossilized shells from Seymour Island, an uninhabited land mass off the coast of Antarctica.

"We're looking at resiliency over generational timescales," Linzmeier says. These timescales are thousands of years in "deep time" — the 500,000 years before the dinosaurs went extinct and the 500,000 years after, when the Deccan Traps volcanoes (in modern-day India) erupted frequently.

Understanding how proxy records preserve environmental characteristics and figuring out how ocean acidification records work in deep time guides researchers' understanding of similar trends happening today.


Ben Linzmeier

"The changes that happened then might be similar magnitude to what's happening today, but now it's happening a lot faster," Linzmeier says. "Understanding how bivalves can respond — or not — to acidification, is not insignificant."

Bivalves are economically important — the market value of their fisheries is an estimated $23 billion, but their full economic value is much higher due to profits from secondary products and services like shucking and packaging houses. Studying bivalves' responses to environmental stimuli is not only integral to the immediate impact on fisheries, but also their impact on the oceanic ecosystem as a whole.

Linzmeier's research is made possible by the Ubben Program for Climate and Carbon Science, a part of the **Institute for Sustainability and Energy at Northwestern** (ISEN). The Ubben Program was established in 2017 through a $5.5 million gift from Jeff (KSM '87) and Laurie Ubben. Jeff is also a member of Northwestern's Board of Trustees. The Ubben Program aims to improve understanding of global climate system dynamics and evaluate low- and zero-carbon alternatives to fossil fuels.

"It's really great because the Ubben Program is supporting basic science, like my research," says Linzmeier. "It's helping support my professional development as a scientist, working on very different problems than I was thinking about before, and learning new techniques."

Linzmeier intends to submit his research to the journal *Geology* later this year and his co-authors — including Earth and planetary sciences faculty Jacobson, **Matthew Hurtgen,** and **Brad Sageman,** as well as research associate **Meagan Ankney** — are reviewing a final draft of the results.
— Valerie Nikolas, Medill graduate student

FACULTY *Excellence*

Neha Kamat,
biomedical engineering

Richard D'Aquila,
medicine: infectious diseases

Lincoln Quillian,
sociology

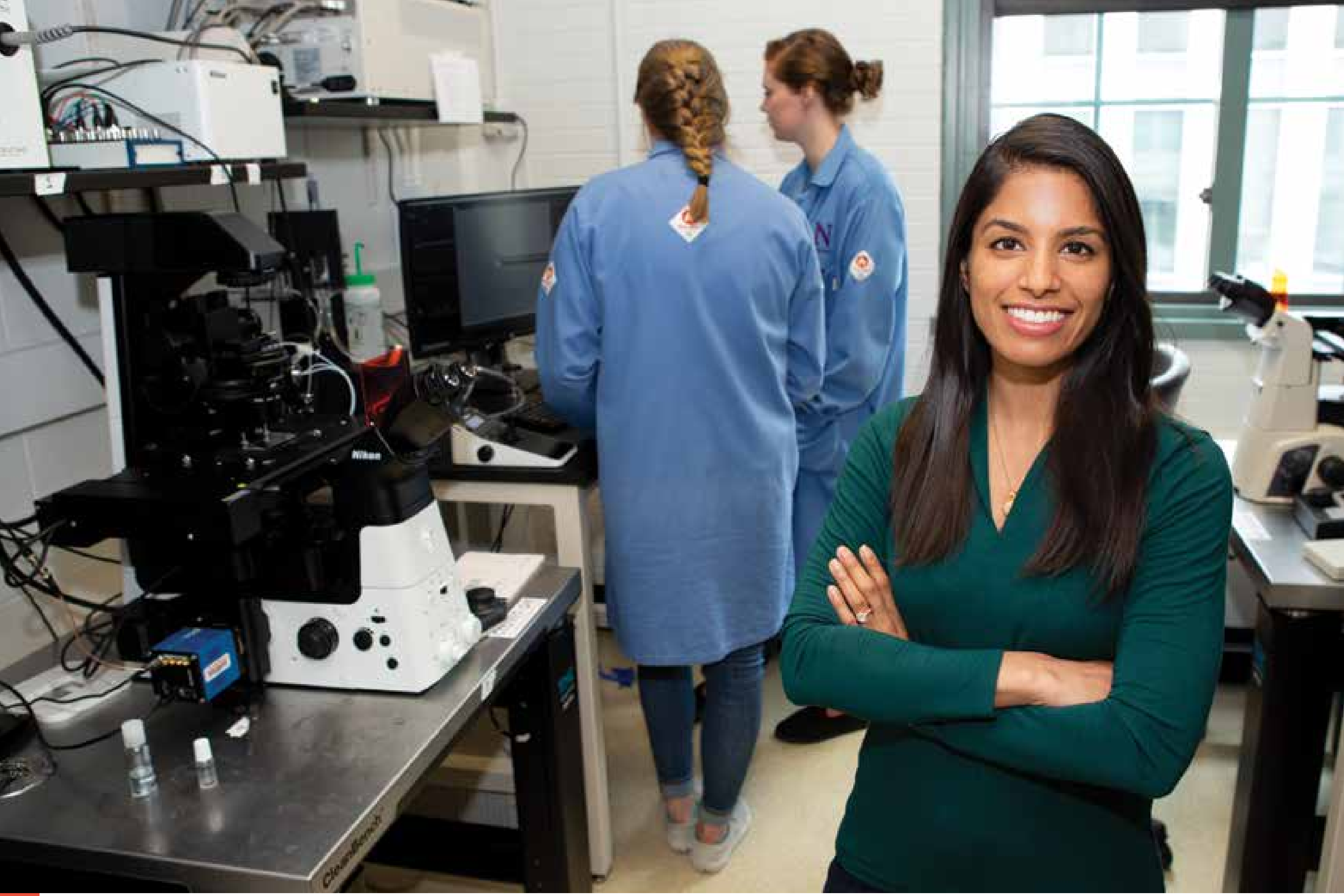
Photos by Eileen Molony

Outstanding faculty are the heart of an exemplary research university like Northwestern. These thought leaders make breakthrough discoveries — in the laboratory, the classroom, and in the field — that advance their academic disciplines while also helping educate the next generation of scholars and scientists.

Northwestern's mission is to create knowledge with transformative social impact, and this dynamic relationship between research and teaching allows the University to flourish as it continues to make important contributions in an array of fields — from the biological sciences to the social sciences; from engineering to the arts and humanities.

Innovative thinking across every discipline and program is a hallmark of Northwestern research excellence. Here, bold discovery often combines expertise that's at the intersection of different fields to seek answers to some of humanity's most urgent questions and find solutions to the most pressing challenges.

In the following pages, we highlight a few of the many Northwestern faculty members who are pursuing extraordinary discovery. Their accomplishments offer testimony to their individual talent and effort, while highlighting the importance of the University's unique research ecosystem that helps nurture such achievements.



Graduate students Miranda L. Jacobs and Margrethe Boyd (background) discuss a research project in the lab of principal investigator Neha Kamat. Photo by Eileen Molony

CELL MAKER

Neha Kamat is using synthetic biology to develop real solutions

Josh Leonard remembers the recruitment event where he met **Neha Kamat.** He already knew about her work on artificial cells, most notably as a NASA Postdoctoral Fellow at Jack Szostak's lab at Harvard.

"Neha's accomplishments coming into this position were already extremely impressive," says Leonard, the director of the biotechnology training program at the **Center for Synthetic Biology** and an associate professor of chemical and biological engineering.

Then came the interview. Leonard recalls his silence as Kamat presented her work, the energy and passion she exuded as she explained how synthetic cell membranes could be used as biosensors or someday deliver drug protocols. "The work is very compelling, but more than that was the way Neha presented it," Leonard says. "You immediately start thinking about new ideas you want to pursue. I think all of us who met with Neha had a similar impression."

It's how many describe Kamat, an assistant professor of biomedical engineering at McCormick and member of the Center for Synthetic Biology since December 2017. They use words like "creative" and "dynamic" and talk about her ability to enhance any collaboration. They talk about the implications of her work, which focuses on creating artificial cells that can mimic cellular behavior. Her current research into how cell membranes respond to different types of energy won her the 2019 Young Investigator Research Program Award from the US Air Force Office of Scientific Research.

But Kamat? She says she's the lucky one.

"I ended up at my dream school," she says. "I knew this was a space I wanted to move into to pursue really creative ideas. You have to work with people who know the other components a lot better than you and interact with them daily to come up with 'wacky' new ideas."

But Kamat's path to Northwestern wasn't a straight one. She grew up the daughter of a Notre Dame professor and software developer in South Bend, Indiana. Hoping not to run into them on campus, Kamat studied bioengineering at Rice University in Houston under Jennifer West, a noted biomaterials and nanotech researcher. "That's where my love of research began," she says.

But it was at the University of Pennsylvania with Daniel Hammer where she discovered her love for artificial cells. It came the first time she made a cell membrane out of synthetic polymers. She looked at them under the microscope and was amazed.

"I saw these perfect circles dancing around and it was beautiful," she recalls "I thought 'Well, this is something I could stare at for a long time.'"

Kamat tempers that zeal with a similar passion for engineering. "Cells already perform such complex functions," she says. "By trying to reconstruct them, we can learn how they work and put the parts back together in new ways."

Kamat finished her doctorate in 2012 but still felt she had gaps in her knowledge. While she understood how to build cell membranes, she wondered if they could interact with their environments and make decisions, much like cells do.

"Something you learn as a scientist is to identify the gap in your knowledge bank that you need to seal to do what you actually want to do," she says.

That led her to the postdoctoral program at Harvard University and Szostak, who won the 2009 Nobel Prize as part the team that discovered telomeres, the caps on the end of DNA strands that prevent cellular decay. His lab at Massachusetts General was working on genetic polymers that could rewire parts of a cell. "I thought, 'That's the field I need to move into,'" she says.

Kamat spent four years in Boston studying RNA, a crucial polymer in forming cellular life, and using membranes to study how the two components may have worked together to form primitive cells. Her studies on how RNA behaves inside membranes — led to her eventual arrival in Evanston and quest to build synthetic cells.

Since joining the Center for Synthetic Biology, she's started several projects, including one funded by a National Science Foundation grant with Leonard to graft biological sensors onto synthetic cells. A second project with **Danielle Tullman-Ercek,** who runs the master's biotech program, is looking into the role of micro-compartmentalization in biochemical systems.

"She has this vision that she can implement extremely quickly, says Tullamn-Ercek, an associate professor in chemical and biological engineering. "We tend to come up with something creative and if that doesn't pan out, we come up with something else creative, but there's already a path for it. She's able to pivot and come up with a new direction on the spot."

While she enjoys working and collaborating with her colleagues, Kamat knows she's still near the beginning of a lifelong journey to understanding cell membranes — from how they form to how they respond to environmental signals— to the point where she can reverse-engineer them synthetically for different applications.

"This basic question of how cell membranes work will lead to the development of sensors and drug delivery tools," she says, "but right now I'm focused on the fundamental question of how the lipids and proteins work together to accomplish specific tasks." — *Glenn Jeffers*

FACULTY EXCELLENCE

FOUND IN TRANSLATION

Physician-scientist Richard D'Aquila has spent three decades advancing solutions for those infected by HIV

The deaths were palpable.

Just six years after the start of a medical career he envisioned would be filled with helping patients heal, **Richard D'Aquila,** instead, found himself at the forefront of the AIDS epidemic. What he did next continues to alter the lives of those living with the disease and its precursor, the human immunodeficiency virus (HIV).

"I decided that instead of going to more funerals, I would return to the lab and pursue additional research training," says D'Aquila, director of Northwestern's HIV Translational Research Center and the Howard Taylor Ricketts Professor of Medicine. "I was fortunate enough to connect with virologists at Yale in 1985 with ties to scientists who had actively worked to uncover the cause of AIDS."

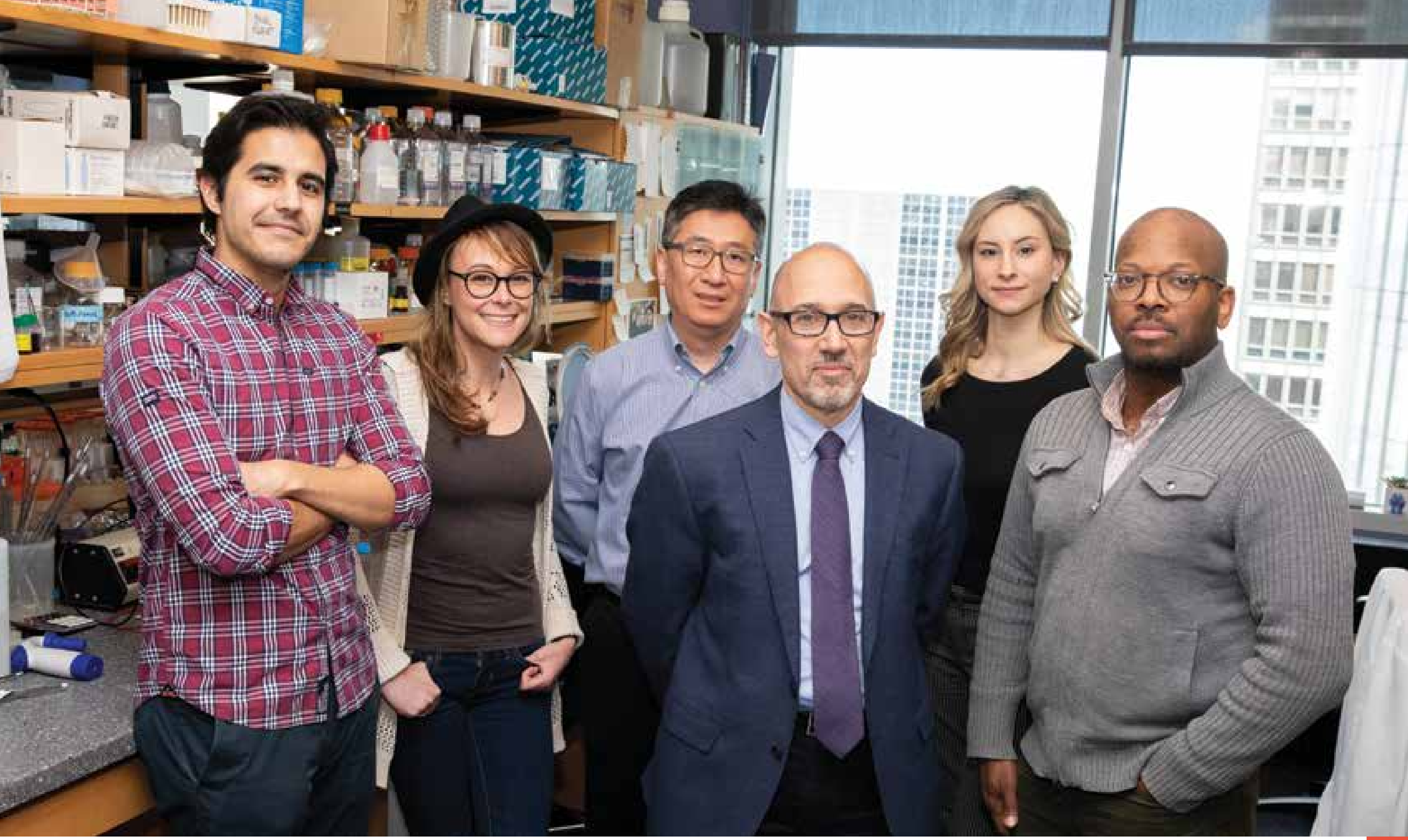
That answer was revealed with the 1984 discovery of HIV.

Following a research fellowship at Yale, D'Aquila joined the faculty in New Haven, about 30 miles from where he grew up in New Britain, Connecticut. His persistent interest in developing new drugs — he nearly pursued a PhD in pharmacology before obtaining an MD at Albert Einstein College of Medicine — and his clinical background in infectious diseases, led to his recruitment by Massachusetts General Hospital and Harvard Medical School, where he was able to take leadership roles in some of the earliest clinical trials and related clinical virology research for what was still considered a largely untreatable disease.

Today, more people than ever before are finding they can manage HIV more effectively as a direct result of improved antiretroviral treatment, which is often as straightforward as taking one pill daily. In the early 1990s, D'Aquila was instrumental in moving a novel "drug cocktail" — a combination of three antiretrovirals that for the first time effectively suppressed the virus — from the laboratory into the clinic. Since then, the number of pills needed to suppress the diseases, as well as their efficacy, has steadily improved. And very recently, there is evidence that having the amount of virus in the blood consistently suppressed to "undetectable" levels can also stop transmission to others; this offers a hopeful strategy for ending the epidemic.

"The memories of what it was like in the earliest days when all that we could offer was comfort haven't faded, but we're living in a different world in terms of what we can now do for patients," says D'Aquila, who is also director of the Third Coast Center for AIDS Research (CFAR), a National Institutes of Health-funded program operated collaboratively with the University of Chicago and various community partners. "We have medications that really work, and in turn that allows my lab, and many others, to concentrate on working toward solutions to the remaining problems faced by people living with HIV: finding a 'cure' and avoiding common health problems that decrease the quality of life but are not life-threatening."

D'Aquila prefers to discuss "the sustained remission of HIV after antiretroviral medications are stopped," rather than a cure in the traditional sense. That's because scientists are closer to slowing the virus from returning after stopping the medications than completely eliminating the virus from the body. While people living in developed nations on HIV treatment now do not suffer from the life-threatening opportunistic infections and cancers that accompanied AIDS previously, they experience more frequent and earlier disorders associated with aging. These include heart diseases and cancers that are common among those not infected with HIV. So while lifespan is beginning to approach actuarial standards, the "healthspan" is still shorter than those not infected, a challenge researchers continue to address and hope to ameliorate.



From left: Graduate student Gaël Scholtès, postdoctoral fellow Isabelle Clerc, research assistant professor of medicine Chisu Song, principal investigator Richard D'Aquila, graduate student Nina Calantone, and research assistant professor of medicine Harry Taylor Photo by Eileen Molony

During a short elevator ride to his Feinberg School of Medicine office overlooking Michigan Avenue, the passion D'Aquila maintains for research is evident. Although he sees patients less, they still guide almost everything he does.

"We have a couple of ongoing projects in the HIV Translational Research Center where we are seeing astonishing results," he says, noting that he couldn't possibly shoulder the workload being carried out by medical school faculty **Chisu Song** and **Harry Taylor,** graduate students, and a postdoctoral fellow. "One of the most exciting parts in any day is learning new things from them and determining how to push different ideas forward with them."

Research efforts focus on novel drug therapies to boost a defensive cell protein in HIV virions abbreviated as A3s and to decrease a cell's ability to replicate HIV. The goal is to achieve sustained HIV remission after antiretrovirals are stopped and decrease the persistent inflammation that can contribute to disorders associated with aging.

In another of his multiple roles, D'Aquila is director of the **Clinical and Translational Sciences Institute's** (NUCATS) Center for Clinical Research, and in 2017, he was named an associate vice president of research, which positions him as a connecting point between Northwestern administration and the directors of four University Research Institutes and Centers.

In his roles with CFAR and NUCATS, D'Aquila sees himself as a catalyst for team-based approaches to clinical investigation.

"I work in a world of similar priorities for NUCATS, CFAR, and Northwestern's Institute for Public Health and Medicine," says D'Aquila. "Development and implementation of new interventions so they become routine medical practice and benefit society relies on community participation."

D'Aquila also is committed to helping early-career investigators establish their careers: "Making sure that young researchers own the advances in which they play a central role is a critical step in establishing future generations of investigators who will help solve problems that today seem unsolvable." — *Roger Anderson*

DISCRIMINATING MIND

IPR's Lincoln Quillian explores ways prejudice, economics, segregation shape societies

Lincoln Quillian was not surprised at the findings. Saddened, maybe. But not surprised.

Quillian, a professor of sociology and chair of the **Institute of Policy Research's Program on Urban Policy and Community Development,** had pulled together two dozen studies examining discrimination between black and white job candidates. Many of the studies included field experiments where investigators sent out actors of different ethnicities to apply for the same job, complete with similar fake resumes.

After examining them, Quillian and longtime collaborator and Harvard sociologist Devah Pager found no change in rates of discrimination between 1990 and 2015. "There were other things that maybe suggested more optimism," says Quillian. "Answers to survey questions that asked about traditional measures of prejudice had shown some signs of decline. But the lack of change was clear in the data."

What did surprise Quillian, however, was how much he enjoyed this meta-analytical approach to examining results from various studies and then combining them. And it's opened a new avenue of research for Quillian, an IPR fellow who is considered a leading scholar on racial inequality and social stratification.

"It's not something where you have this complicated statistical model," he says. "Here, you get this nice form of relative transparency."

It's a departure from Quillian's typical work. He's known more for his statistical rigor as a social demographer, most notably in his 2012 paper "Segregation and Poverty Concentration: The Role of Three Segregations," in which he won the American Sociological Association's Jane Addams Award in 2014. There, Quillian revised sociologists Douglas Massey and Nancy Denton's argument in *American Apartheid* (Harvard University Press, 1998) that racial segregation, race-based gaps in poverty and segregation based on poverty within race has created a pernicious, concentrated levels of poverty within black and Latino communities.

Instead, Quillian examined Massey and Denton's data and argued that a third segregation hadn't been accounted for: the segregation of high- and medium-income members of other groups from blacks and Latinos.

"It didn't model that black families or non-white families that live in white neighborhoods tend to be more affluent than the non-white neighbors that live in less-white neighborhoods. And likewise, white people that live in more heavily minority communities may have lower income than white people that live elsewhere," Quillian says. "It didn't completely change Massey's simulation, but it added some complexities to it."

That attention is key when trying to understand what Quillian calls "an important social problem," an interest he's held since his undergraduate days at the University of Chicago. Living in Hyde Park, Quillian saw a racial dynamic that was unfamiliar to him despite growing up near "Little Saigon," a large Vietnamese community that stretches across three cities in Orange County, California.

"There was a stark, racial inequality that was in your face," he says. "Then there was the White-Asian thing that I grew up with where there was racial diversity, but it was different. That caught my attention."

At Chicago, Quillian studied while surrounded by faculty such as Massey and famed sociologist William Julius Wilson. There, he started writing about migration and segregation. His dissertation tracked migration patterns and the development of poverty in US neighborhoods.

Quillian then headed to the University of Wisconsin-Madison, where he spent eight years before coming to Northwestern in 2005. While he was in Madison, Quillian advised a young doctoral student named Devah Pager whose work also focused on racial stratification. She proposed putting together an audit study where she would hire actors, give them resumes that included a criminal record, and see if they got callbacks on job interviews.

"So many people were coming out of prison because of mass incarceration and it was an important subgroup to look into," Quillian recalls. "It was a really bold idea. Yeah, her dissertation ended up being quite famous."

So began a decades-long partnership with Pager where the two collaborated on several papers, including the 2017 meta-analysis piece on hiring discrimination. Each brought something unique to the union, Quillian says. Devah's clear thinking and "people skills" complemented Quillian's statistical prowess. However, the relationship ended when Pager passed away of pancreatic cancer in November 2018. "There's another paper of ours that I'm still trying to get published," Quillian says.

Since then, Quillian has expanded on his new approach. Currently, he's compiling a database of similar studies from around the world, particularly in Europe. "Lincoln is very generous," says Arnfinn Haagensen Midtbøen, a senior research fellow at The Institute for Social Research in Oslo, Norway, and a co-author on the 2017 paper. "I sometimes find American academics to be overly strategic and not too interested in collaborating with scholars from the Northern corner of Europe. Lincoln, by contrast, made me confident that my contributions were much appreciated."

With renewed focus, Quillian hopes to continue the work he and Pager started — just on a more global scale — and find more answers to this social dilemma.

"You don't understand the reason why employers do what they do, but you get a very clear measure of discrimination," Quillian says. "And the simplicity of the experimental design and results is a very appealing thing." — *Glenn Jeffers*

Graduate students Antonio Nanni and John Lee (background) discuss a research project they are conducting with adviser Lincoln Quillian. Photo by Eileen Molony

VIEWFIN

Early career researchers at the Center for Interdisciplinary Exploration and Research in Astrophysics are changing the way we see the cosmos

When the ultra-dense cores of dead stars collide in some distant galaxy billions of miles away, **Wen-fai Fong** gets a text message.

Sometimes, the message comes from NASA's Swift satellite, a telescope launched in 2004 designed specifically to track gamma-ray bursts. Other times, it's from the Laser Interferometer Gravitational Wave Observatory (or LIGO), where high-powered lasers bounce down miles-long tunnels and collide, creating an "interference pattern" that can detect measurements 1/10,000th the size of a proton.

Whatever the source, it likely means that Fong — and those around the world who study transient phenomena that are included in an auto-generated group text — will be up all night, tracking the events. An astrophysicist and assistant professor at Northwestern, Fong studies these collisions and the gamma-ray bursts they emit to understand the forces that drive these celestial bodies. Those gamma-rays — "the highest energy form of light we can detect," says Fong — may contain the secrets of the universe, from detecting the gravitational waves that bend and curve spacetime to understanding how dead stars form, feed, and grow.

"It's a very exciting time to start a PhD or to start research in this field," Fong says.

It may be more exciting for Northwestern's **Center for Interdisciplinary Exploration and Research in Astrophysics** (CIERA), where Fong and her team study this phenomenon. Fong is one of a young group of researchers whose work has helped solidify CIERA as a world-leading hub for astrophysics.

Earlier this year, CIERA astrophysicist and assistant professor **Raffaella Margutti** presented her research on AT2018cow, otherwise known as "The Cow," a bright anomaly that flared up 200 million light years away in the Hercules constellation that was captured by two radio telescopes in Hawaii. After compiling various imagining sources, Margutti and her team theorized that the telescopes had caught a star collapsing under its own gravity, transforming either into a neutron star or a black hole.

"There was instant excitement all over the world," Margutti says. Her team collaborated with researchers across the globe to verify her findings. "Our access to the telescopes gave us an edge."

For her efforts, Margutti was named a 2019 Sloan Research Fellow by the Albert P. Sloan Foundation, which recognizes early-career researchers. Like Fong, Margutti tracks the electromagnetic spectrum (from gamma-rays to radio) to study the most violent events in our universe, including stellar explosions, black holes, and neutron star collisions, which generate the gravitational waves LIGO detects.

Margutti also studies supernova explosions, rare transients (like "The Cow"), and massive stellar eruptions. She considers the neutron star mergers that LIGO can now see as a prominent core to her research.

NDERS

“I helped lead an effort that resulted in the characterization of the first neutron star merger seen with gravitational waves across the spectrum and I published several papers — one being the most cited paper in 2018 — about the event,” Margutti says.

Another CIERA assistant professor, **Alexander "Sasha" Tchekhovskoy,** focuses on revealing how black holes and neutron stars interact with their environment. They can devour each other, "spaghettify" (stretch) unlucky stars that wander too close, and enrich the Universe with heavy elements like gold and platinum. They manage to shoot out relativistic beams of gamma rays that allow us to peer billions of years into the past and watch the Universe when it was a toddler, much younger than the young adult it is today.

Or, as he says, “I study how black holes eat their food, and the burp that comes next.”

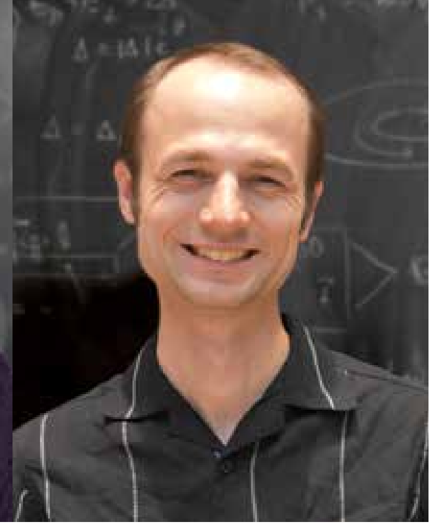
It’s a little more involved than that. A computational astrophysicist, Tchekhovskoy develops computer simulations that reveal what happens “under the hood” of stellar collisions. The simulations make the job of his observer colleagues easier by predicting what the telescopes would see. Using the simulations as a template can help observers better locate collapsing stars and interpret the observations.

Like the others, Tchekhovskoy’s work as been recognized. Last December, Tchekhovskoy received the 2019 Innovative and Novel Computational Impact on Theory and Experiment (INCITE) Award for his proposal, “Simulating Neutron Star Binary

A Boeing Delta II rocket propels NASA's Swift satellite into orbit on November 20, 2004. Swift was designed to solve the 35-year-old mystery of the origin of gamma-ray bursts, and the satellite has helped aid in numerous discoveries at Northwestern’s Center for Interdisciplinary Exploration and Research in Astrophysics.
Photo by NASA/Kennedy Space Center

Wen-fai Fong

Raffaella Margutti



Sasha Tchekhovskoy

Merger Remnant Disks and Tilted Thin Disks." But the award is more than a plaque; it grants him access to 850,000 node-hours with Summit, the world's fastest supercomputer. Based in Oak Ridge, Tennessee, Summit can perform up to 200,000 trillion calculations per second.

"It is not trivial to convert codes to run black hole simulations on graphics processing units, a type of graphics card that is the heart of Summit. In fact, our group is the only one in the world who can use such graphics cards for black hole simulations right now," Tchekhovskoy says. "We are no longer limited by computational resources, which allows us to ask bigger questions than ever before and tackle problems previously deemed too difficult to solve."

Which makes the INCITE award that much more important to both Tchekhovskoy and CIERA. Tchekhovskoy said he plans to use the allocation to carry out high resolutions simulations of the neutron star binary mergers that both Fong and Margutti have observed in hopes of solving two mysteries that have challenged astrophysicists: how neutron star collisions produce heavy elements, and how black holes digest red-hot disks of gas.

Together, the three researchers are taking what's known as a "multi-messenger" approach to astrophysics, the idea that combining different information from different types of signals will allow scientists to better understand how astrophysical systems evolve and change.

This kind of work can be seen in Margutti's research on "The Cow." Instead of studying the luminous phenomenon using optical telescopes, the team used x-rays, hard x-rays, gamma rays, and radio waves, then put them together to create a clearer picture.

Another technique allows researchers to see the previously unseen. "It's what we call stacking. We add all of the exposures together to create an ultra-sensitive image," says Fong, who was named a 2018 Kavli Fellow by the National Academy of Sciences. The fellowship is the society's premiere way to distinguish young scientists. Fong uses the stacking technique in her research on neutron star collisions to "bring out the features in the galaxy and the location of the neutron star merger that we couldn't see before."

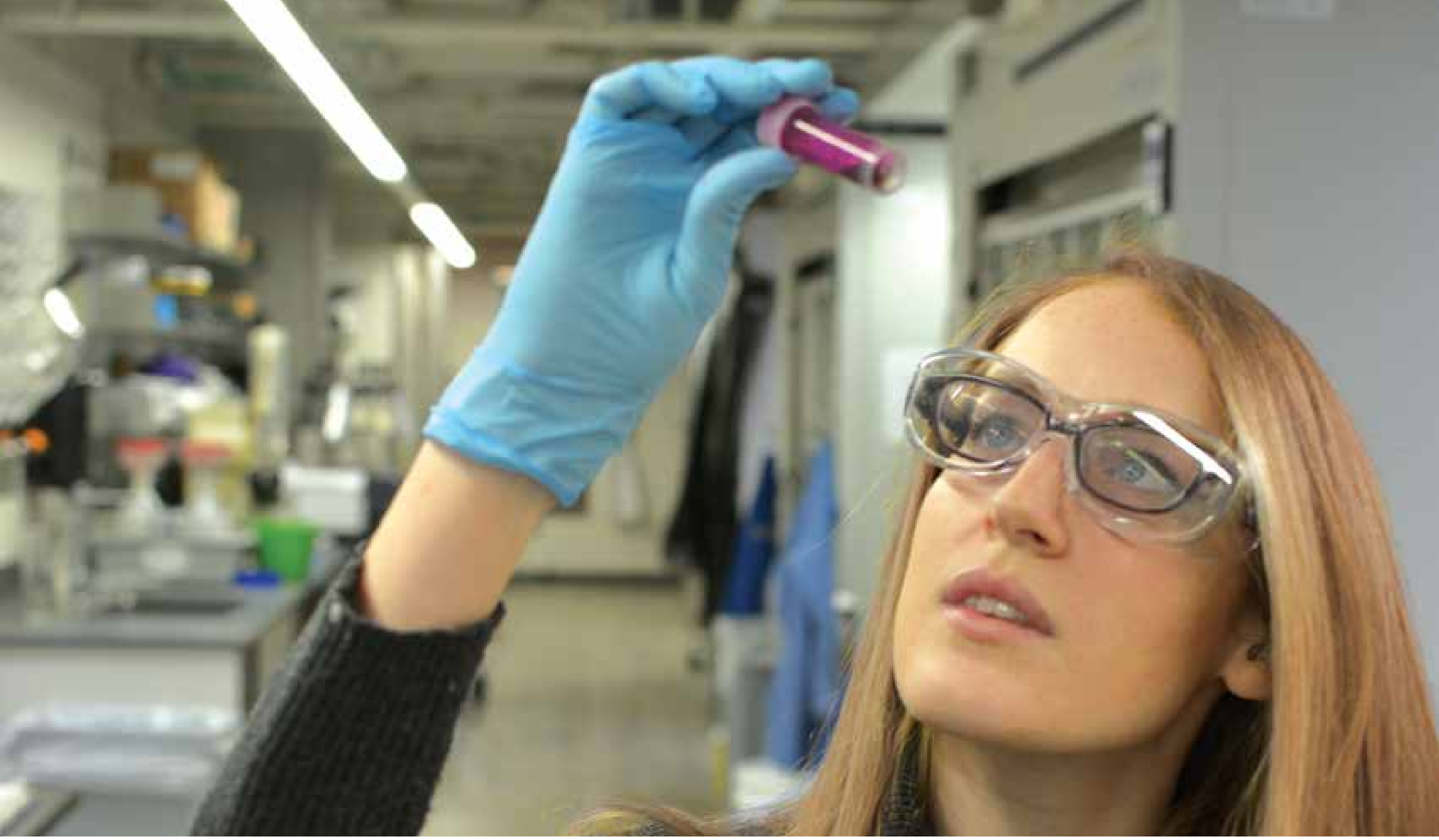
But that kind of collaboration is part of why Fong says she enjoys working at Northwestern. "One of the major benefits is the synergy with the other groups," she says. "I'm an observational astronomer. I study these events and it's amazing to be in the same department as other early career investigators who are world-class in their knowledge of observations and computations. Being able to collaborate with other faculty and their groups has been really fruitful for me as a young professor."

The other fun thing? The telescope access, Fong says. CIERA recently signed contracts to secure institutional access to the Multiple Mirror Telescope in Arizona and the W. M. Keck Observatory in Hawaii.

Northwestern researchers, including Fong and Margutti, have special access to these observational facilities, while Margutti's research team has also been successful in applying for time at the SoAR telescope in Chile.

When she can, Fong likes travel to Keck and spend the night staring at galaxies millions of light years away. That is, when the sulfur and ash from the nearby volcanoes don't get in the way.

"It can definitely affect the skies," she says. "But being there and looking up; it's amazing." — *Glenn Jeffers*



Postdoctoral fellow Andrea Carlini is first author on a recently published paper that demonstrated a novel way to deliver a bioactivated, biodegradable, regenerative substance to the heart through a noninvasive catheter. Photos by Roger Anderson

EXPLORING NEW WAYS TO FIX A BROKEN HEART

Northwestern chemist's novel strategy and dynamic material could heal damage from myocardial infarction

Scientists have designed a minimally invasive platform that turns the body's inflammatory response into a signal to heal, rather than a means of scarring the heart following myocardial infarction.

Although tissue engineering strategies to replace or supplement degrading extracellular matrix (ECM) following heart attack are not new, researchers led by co-principal investigators **Nathan Gianneschi,** chemistry, biomedical engineering and materials science and engineering, and Karen Christman at the University of California, San Diego, have demonstrated a novel way to deliver a bioactivated, biodegradable, regenerative substance through a noninvasive catheter. The research was published April 15 in *Nature Communications*.

"We sought to create a peptide-based approach because the compounds form nanofibers that look and mechanically act very similar to native ECM; they are also biodegradable and

Nathan Gianneschi and Andrea Carlini

biocompatible," says **Andrea Carlini**, a postdoctoral fellow in the lab of John Rogers, director of the Center for Bio-integrated Electronics. Carlini was a graduate student in Gianneschi's lab when this research was conducted and is the paper's first author. "Most preclinical strategies have relied on direct injections into the heart, but because this is not a feasible option for humans, we sought to develop a platform that could be delivered via intracoronary or transendocardial catheter."

Peptides are short chains of amino acids instrumental for healing. The team's approach relies on a catheter to deliver self-assembling peptides (SAP) — and a therapeutic — to the heart following myocardial infarction.

"What we've created is a targeting-and-response type material. We inject a self-assembling peptide solution that seeks out a target — the damaged ECM — and is then activated by the inflammatory environment itself," says Gianneschi, a member of Northwestern's **Simpson Querrey Institute** as well as its **International Institute of Nanotechnology.** "The key is to have the material create a self-assembling framework, which mimics the natural scaffold that holds cells and tissues together."

When a person has a heart attack, the matrix is stripped away and scar tissue often forms in its place, decreasing the heart's functionality. Because of this, most heart attack survivors have some degree of heart disease, the largest killer in America.

The team's preclinical research was conducted in rats and segmented into two proof of concept tests. The first test established that the material could be fed through a catheter without clogging and without interacting with human blood. The second determined whether the SAPs could find their way to the damaged tissue, bypassing healthy heart tissue. Researchers created a fluorescent tag for the SAPs to carry and then imaged the heart to see where the peptides eventually settled.

"In previous work with responsive nanoparticles, we produced speckled fluorescence in the infarct region, but in this case, we were able to see large continuous hydrogel assemblies throughout the tissue," says Carlini.

Researchers now know that when they remove the florescent tag and replace it with a drug, the SAP will locate to the affected area of the heart. One hurdle is that catheter delivery in a rodent model is far more complicated — because of the animal's much smaller body — than the same procedure in a human. This is one aspect where Christman's lab at UC-San Diego has immense knowledge.

If the team can prove the approach to be efficacious, there is then "a fairly clear path" in terms of progressing toward a clinical trial, says Gianneschi. The process, however, would take several years.

"We started working on this chemistry in 2012, and it took immense effort to produce a modular and synthetically simple platform that would reliably gel in response to the inflammatory environment," says Carlini. "A major breakthrough occurred when we developed sterically constrained cyclic peptides, which flow freely during delivery and then rapidly assemble into hydrogels when they come in contact with disease-associated enzymes."

By programming in a spring-like switch, Carlini was able to unfurl these naturally circular compounds to create a flat substance with much more surface area and greater stickiness. The process creates conditions for the peptides to better self-assemble, or stack, atop one another and form the scaffold that so closely resembles the native ECM.

Having demonstrated the platform's ability to activate in the presence of specific disease-associated enzymes, Gianneschi's lab has also validated analogous approaches in peripheral artery disease and in metastatic cancer, each of which produce similar chemical and biological inflammatory responses. — *Roger Anderson*

HERE TO HELP **YOU** DISCOVER.

Northwestern | RESEARCH

Office for Research
633 Clark Street
Evanston, IL 60208-1108

ELEMENTS OF SUCCESS

‘Periodic Table’ of Northwestern URICs

Our University Research Institutes and Centers (URICs) are interdisciplinary knowledge hubs that harness faculty talent from across Northwestern schools to pursue transformative discovery.

By deepening our understanding of the physical world, the biological world, and the human world, URIC-affiliated researchers are dedicated to helping society overcome its greatest challenges. From discovering next-generation energy sources, to seeking better cancer diagnostics and treatments, these researchers are passionate about advancing fundamental science and finding real-world solutions in a broad range of fields.

Whether by exploring the farthest reaches of the cosmos or the smallest realm of nanoscience; whether through improving health, strengthening public policy, or inspiring human creativity and imagination, this extraordinary URICs ecosystem is helping to redefine the parameters of the possible.

2019
INQUIRE
Initiative at Northwestern for Quantum Information Research and Engineering

2000
SQI
Simpson Querrey Institute for Bionanotechnology

2009
CIERA
Center for Interdisciplinary Exploration and Research in Astrophysics

2016
COFI
Instituto de Cosmologia y Fisica de las Americas

2016
CBIE
Center for Bio-Inspired Electronics

On the 150th anniversary of Dmitri Mendeleev’s publication of his Periodic Table of Chemical Elements, we honor and are inspired by this milestone scientific achievement in our own depiction of Northwestern’s robust URICs network.

2007
SIS
Science in Society

2017
CAPST
Center for Applied Physics and Superconducting Technologies

1991
NSRC
Northwestern Synchrotron Research Center

1959
MRC
Materials Reseach Center

2000
ISITA
Institute for the Study of Islamic Thought in Africa

1948
PAS
Program of African Studies

2006
SILC
Spatial Intellligence and Learning Center

1968
IPR
Institute for Policy Research