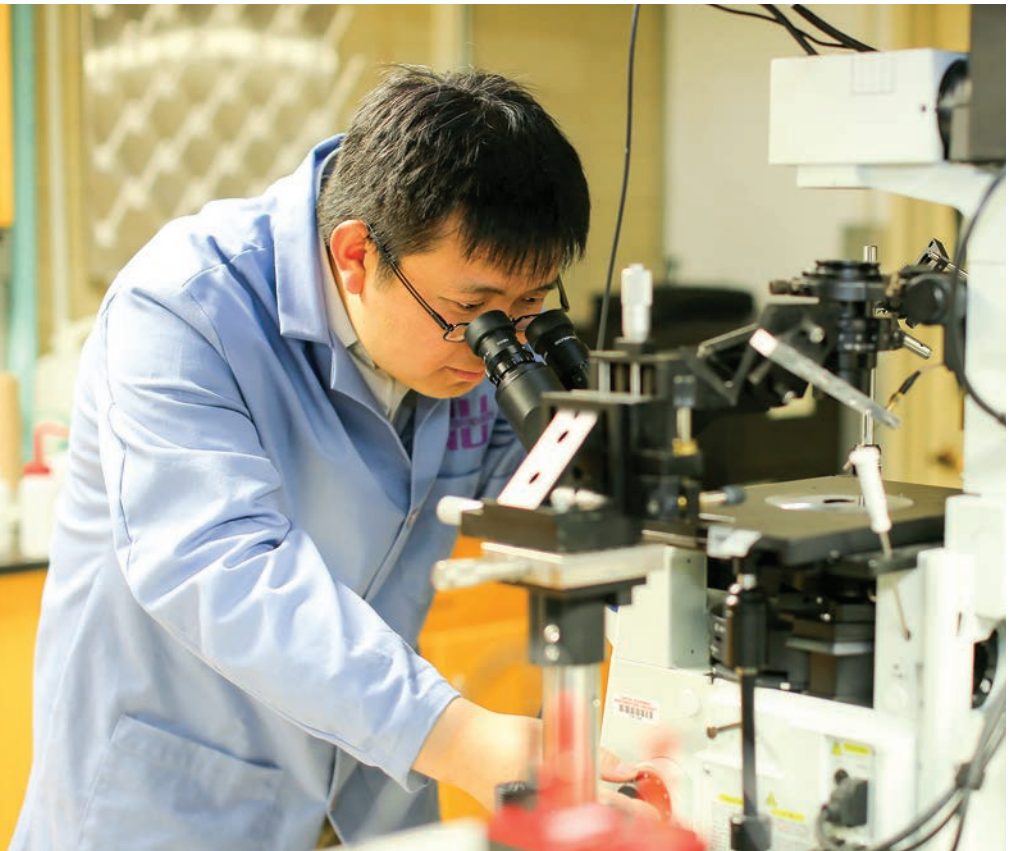
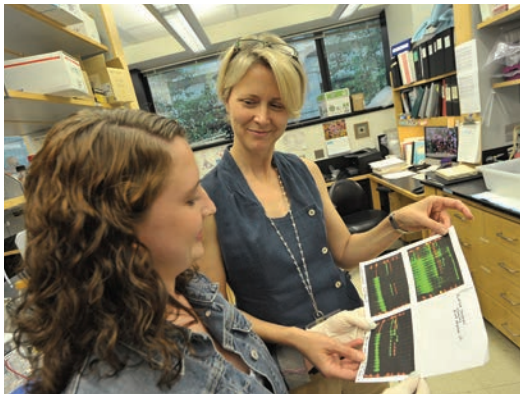
NORTHWESTERN UNIVERSITY
RESEARCH

ANNUAL REPORT 2014

CREATING NEW KNOWLEDGE





Front cover images, left to right, beginning at the top:

Kirabo Jackson, associate professor of human development and social policy, conducts research on the relationship between increased school spending and improved student outcomes. Read more about Jackson's work on page 39.

Jelena Radulovic, MD/PhD, Dunbar Professor of Bipolar Disease, studies how memories of aversive events become a gateway to anxiety and depression. Read more about her work on page 48.

Hao Zhang, associate professor of biomedical engineering, ophthalmology, works at the interface of engineering and medicine to develop tools that help prevent vision loss. Read more about his work on Page 55.

Cara Gottardi, associate professor of medicine: pulmonary and critical care, conducts research on a protein complex that projects from the cell surface, acting as a structural "Velcro" to hold cells to one another. Read more about Gottardi on page 36.

Khaled Hroub teaches Middle Eastern studies and Arab media studies at Northwestern University in Qatar. His research explores the spontaneous integration between broadcasting and social media during the Arab Spring, beginning in 2010-11. Read more about Hroub's work on page 37.

Managing Editors
Meg McDonald
Joan T. Naper

Writers
Joan T. Naper
Roger Anderson
Laura Hayes

Designer
Jeanine Shimer

Award and Proposal Data Management and Coordination
Kimberly Griffin, Sara Krentz,
Office for Sponsored Research

Benchmark Data
Paul Schatz,
Office of the Vice President for Administration and Planning

Expenditure Data
Office of Financial Operations and Treasurer

Metrics
Emilie Kahle, Office for Research
Anne C. Martin, Office for Research

Citation Data
Ruth Allee, Office of Human Resources

Published annually by the Office for Research
Jay Walsh, Vice President
Meg McDonald, Senior Executive Director
Joan T. Naper, Director of Research Communications

Address correspondence to
Office for Research
Northwestern University
Rebecca Crown Center, 2-574
633 Clark Street
Evanston, Illinois 60208-1108

E-mail: research@northwestern.edu
www.research.northwestern.edu

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NORTHWESTERN
UNIVERSITY

NORTHWESTERN UNIVERSITY
RESEARCH
Creating New Knowledge™

ANNUAL REPORT 2014

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Photo by Earl Richardson

Dear Colleagues,

Northwestern was the focus of the world's attention on October 2 when President Obama spoke on campus. The president deliberately chose Northwestern, with a focus on students in the Kellogg School of Management. "There's a reason I came to a business school instead of a school of government," he said. "I believe that capitalism is the greatest force for prosperity and opportunity the world has ever known. I believe that private enterprise—not government, but the innovators and risk takers and makers and doers—should be the driving force of job creation."

President Obama also recognized the groundbreaking research done by our own "innovators and risk takers and makers and doers." He discussed the International Institute of Nanotechnology in terms of the economic benefits it brings: startups, products, and jobs. He mentioned the work of the Solar Fuels Institute to turn sunlight into liquid fuel. And he recognized our participation in the Chicago-area digital manufacturing consortium, led by University-Industry (UI) Labs, which will help position Chicago as a national hub for digital manufacturing and unite Northwestern engineering faculty, students, and postdoctoral fellows with academic-, industry-, and government-based colleagues conducting cutting-edge research and bringing innovations to market.

It is notable that he recognized those collaborations that are tackling the bigger problems facing our society. Our partnerships—with each other and with other institutions—are what leverage our strengths to produce some of the most significant outcomes.

"I BELIEVE THAT PRIVATE ENTERPRISE—NOT GOVERNMENT, BUT THE INNOVATORS AND RISK TAKERS AND MAKERS AND DOERS—SHOULD BE THE DRIVING FORCE OF JOB CREATION."

— PRESIDENT OBAMA

For example, the Center for Hierarchical Materials Design, a National Institute of Standards and Technology–sponsored center of excellence for advanced materials research, focuses on developing the next generation of computational tools, databases, and experimental techniques. By leveraging the strengths of the Northwestern-Argonne Institute for Science and Engineering (NAISE), Northwestern faculty are leading this Chicago-based consortium—which includes colleagues from the University of Chicago and Argonne National Laboratory—to enable the accelerated design of novel materials and their integration into industry, one of the primary goals of the Obama administration's Materials Genome Initiative.

Another program in which Northwestern played a role this year is the Young African Leaders Initiative (YALI). An impressive 50,000 young Africans applied to the program, which develops African leaders, strengthens partnerships between the United States and Africa, and promotes democratic governance via programs at 20 universities across the United States. Only 1 percent were admitted, and of those, we were honored to host 25 truly impressive participants last summer for a six-week, on-campus program in entrepreneurship and business led by Northwestern's Program of African Studies in a terrific collaboration with the Farley Center for Entrepreneurship and Innovation.

President Obama and his administration continue to rely on Northwestern faculty and leaders as frequent advisers in Washington.

Photo by Jim Prisching

Photo courtesy of the White House

Kate Klein, associate director of the Program of African Studies and current ASPPH/CDC Allan Rosenfield Global Health Fellow at the Centers for Disease Control and Prevention, stands with President Barack Obama at the Young African Leaders Summit in Washington, D.C.

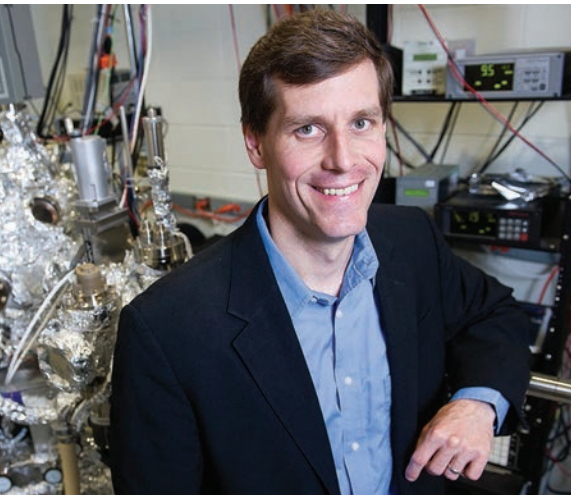


Photo by Jason Brown

Mark Hersam

Photo by Jocelyn Augustino

Darlene Clark Hine

International Institute of Nanotechnology director **Chad Mirkin,** chemistry and biomedical engineering, is a familiar face at the White House as a member of the President's Council of Advisors on Science and Technology. Further, in July the US Department of Defense selected Professor Mirkin for an unprecedented second time to be one of its National Security Science and Engineering Faculty Fellows.

President Obama met with President **Morton Schapiro** in January 2014 when he participated in the first White House College Opportunity Summit, which discussed university programs to increase access to college among low-income and underserved students.

In March, **Fay Lomax Cook,** human development and social policy and former longtime director of our Institute for Policy Research (IPR), was named assistant director of the National Science Foundation and head of its Directorate for Social, Behavioral and Economic Sciences.

Also in March, the White House recognized **Tahera Ahmad,** Northwestern's associate chaplain, as a leading US Muslim female. But this wasn't Ahmad's first trip to the White House, as she previously attended a Ramadan dinner hosted by President Obama. And in the last two years, she has also visited four cities in Afghanistan and worked with Secretary of State John Kerry on the State Department's Office of Faith-Based Community Initiatives.

In May, the Institute for Policy Research held its annual policy research briefing on Capitol Hill. IPR director and fellow **David Figlio,** education and social policy, moderated the briefing on "College Access and Success." IPR fellow **James Rosenbaum,** education and social policy and sociology, was one of the panelists.

Finally, a discussion of White House connections would not be complete without recognizing **Darlene Clark Hine,** who teaches both African American studies and history and received a 2013 National Humanities Medal in July for her efforts in enriching the understanding of the African American experience. She was one of 10 recipients of the award, which recognizes work in history, cultural studies, filmmaking, cultural commentary, and historic preservation.

Members of our faculty could also be found testifying before Congress throughout the legislative year:

Materials Research Center director **Mark Hersam,** materials science and engineering—a 2014 MacArthur Fellowship ("genius grant") recipient—testified in May to push for federal funding for nanotechnology research and development because of its potential for "unanticipated breakthroughs."

Kemi Jona, director of the Office for STEM Education Partnerships, shared his expertise on university-industry partnerships for STEM (science, technology, engineering, and mathematics) in January 2014. Jona is also launching MetaMedia, a new STEAM (science, technology, engineering, art/design, and mathematics) education program for underserved middle school students at Evanston's McGaw YMCA that was highlighted in a White House report at the second White House College Opportunity Summit on December 4.

Photo by Jim Prisching

Members of the DuPont-Northwestern-Dow Collaborative Access Team and Life Sciences Collaborative Access Team, the two groups run by the Northwestern Synchrotron Research Center at the Advanced Photon Source.

Nina Kraus, communication studies and disorders, testified in May on the biological benefits of music education.

Megan McHugh, director of the Program in Health Policy and Implementation at the Feinberg School of Medicine's Center for Healthcare Studies, testified in July at the hearing "Telemedicine: A Prescription for Small Medical Practices?"

Milan Mrksich, biomedical engineering, testified in August on future directions for nanotechnology and the importance of federal funding for nanotechnology research.

Our additional partnerships with the federal government include close relationships with two of the Department of Energy's national laboratories: Argonne National Laboratory and Fermi National Accelerator Laboratory. I sit on the governing boards of both labs and in the past two years have served on the search committees for their new directors: Nigel Lockyer, who began his tenure as Fermi's director in September 2013, and Peter Littlewood, who took over as Argonne's director in March 2014. I and others at Northwestern have been working closely with both directors and their staffs this year on a number of projects.

More broadly, Northwestern researchers collaborate with Argonne in fields ranging from solar-cell development to high-performance computing. Almost 20 paid faculty members hold joint appointments at Argonne and Northwestern. In addition, we oversee management of two sectors at Argonne's Advanced Photon Source (APS), a synchrotron that produces intense x-rays vital for imaging and characterization of both soft (e.g., biological) and hard (e.g., Northwestern-developed nanoparticles) materials; more than 280 Northwestern researchers applied for APS beam time in 2013.

Our joint ventures with Argonne include the Center for Hierarchical Materials Design, mentioned above, as well as the Joint Center for Energy Storage Research, which is developing the next generation of batteries.

A new biomedical research building on the Chicago campus is expected to double the medical school's research enterprise and provide critical space for investigators working in the areas of cancer, heart disease, neurodegenerative disorders, diabetes, and more. Construction will take place over two to three phases with the building ultimately standing more than 25 stories.

Rendering by Perkins

Last summer we received the welcome news from the Department of Energy of two Energy Frontier Research Center (EFRC) renewals: the Argonne-Northwestern Solar Energy Research Center and the Northwestern University Center for Bio-Inspired Energy Science. Northwestern is one of only two academic institutions (the other is MIT) to serve as the lead institution on two EFRCs. Further, our faculty and their laboratories play significant roles as researchers in four other EFRCs. The impact of Northwestern researchers in the energy area is strong and clear.

A significant enabling component of any major research endeavor is the space where the work is done. On the north end of the Evanston campus, construction continues on the new Kellogg School of Management building; the anticipated completion date is late 2016. The Garage™, a space for student-led entrepreneurial activity, will open this calendar year in the new north-campus parking structure. Wonderful new space for nanotechnology and energy research is close to completion as an expansion of Tech. And finally, on the south campus the beautiful new Music and Communication Building—with glorious views across Lake Michigan to downtown Chicago—is nearing completion, with occupancy projected for this fall.

On the Chicago campus, we expect to break ground this spring for the new medical research building. This will house laboratories for Feinberg School of Medicine faculty and allow the Stanley Manne Children's Research Institute (the research arm of the Ann and Robert H. Lurie Children's Hospital of Chicago) to move from Lincoln Park to the Streeterville campus. Completion of the initial phase is scheduled for 2018. Further, the School of Law's expansion at the interfaces of its main buildings (Levy Mayer, McCormick, and Rubloff) continues on schedule, with completion expected this year.

Finally, in Qatar, the construction of our spectacular new building in Doha's Education City is progressing wonderfully. Expected to be ready in 2016, the new building will allow our program to move into space specially designed for work in journalism and communication.

The University's impact on society is demonstrated in many ways; in the

Photo by Alyssa Schukar

From left, Mary J.C. Hendrix, president and scientific director of the Stanley Manne Children's Research Institute, Pat Magoon, president and CEO of Ann and Robert H. Lurie Children's Hospital of Chicago, and Stanley Manne, chairman of the Manne Family Foundation, met on June 3 to announce the renaming of the Stanley Manne Children's Research Institute.

Excellence in Research section on the pages that follow, you will see that impact clearly. These faculty research articles feature, for the first time this year, two faculty members from the growing research enterprise at Northwestern University in Qatar (NU-Q). This fall I enjoyed a productive visit with NU-Q associate dean for research **Klaus Schoenbach** and several NU-Q faculty to discuss research opportunities and associated challenges in Qatar and, more broadly, the Middle East.

Naturally this is the time of year when we reflect on the year's accomplishments. As you will read in the following pages, it's been a very good year. Our award numbers continue to grow, which—because federal research funds are generally distributed following peer review—means that our peer institutions' faculty recognize the importance of the work under way at Northwestern and the great promise of the work our faculty have proposed. I reflect too on the hard work of everyone involved in the process of creating new knowledge—the process we call research. Without the commitment of the faculty, students, and staff to this endeavor, the results and impact of our discoveries would be much diminished. Their dedication creates the new knowledge that will change the lives of this and future generations.

All the best,

J. T. Walsh

Jay Walsh

Vice President for Research

AWARDS AND RECOGNITION

The strength of Northwestern's reputation is based on its faculty. Our faculty members provide intellectual rigor in both teaching and research. They educate students, introducing them to their fields of expertise in the classroom and lab. They involve students in hands-on experience through their research. They prepare their students for the careers of the future that will find new solutions to the problems that beset society.

MEMBERS OF NATIONAL ACADEMIES AND SOCIETIES

The distinction of Northwestern's faculty is recognized through their membership in prestigious national academies and societies, awards from the most preeminent grant and fellowships programs, their contributions to academic journals, and other recognitions and honors.

This report presents a view of individual faculty accomplishments over the past year as well as the financial measures of research excellence—awards for sponsored projects, expenditures, and submitted proposals. For the first time, we are using a new cohort for comparisons with other universities: drawn from the American Association of Universities (AAU), a select group of the nation's top universities, admissible by invitation only. These universities are considered outstanding because of their research and education programs. Northwestern has been an AAU member since 1917.

NATIONAL ACADEMY OF SCIENCES MEMBERS

	2009	2010	2011	2012	2013	2014	
Institution	Total	Total	Total	Total	Total	New	Total
Harvard University	165	164	166	162	159	10	175
Stanford University	125	126	131	133	134	2	144
Massachusetts Institute of Technology	144	116	117	119	114	3	117
Yale University	59	60	61	62	61	3	62
Columbia University	45	46	46	50	48	3	54
University of Chicago	40	40	40	41	40	4	44
Cornell University	39	37	37	35	34	1	39
New York University			28	30	29	0	35
Johns Hopkins University	19	23	23	26	26	2	27
University of Pennsylvania	29	29	28	30	27	2	27
Duke University	22	21	22	23	22	0	24
Northwestern University	**16**	**18**	**19**	**20**	**20**	**1**	**21**
Washington University	16	15	17	16	16	0	18
University of Rochester	8	8	9	8	8	1	8
Boston University					7	1	8
Vanderbilt University			5	7	7	0	7
University of Pittsburgh			3	6	6	1	6
Case Western Reserve University			3	3	3	0	3

Source: National Academy of Sciences (http://www.nasonline.org/)
Notes: Including only living members: members, emeriti, and foreign associates; Harvard includes: Harvard University, Harvard-Smithsonian Center for Astrophysics, and Dana-Farber Harvard Cancer Center; Cornell includes Weill Cornell Medical College

NATIONAL ACADEMY OF ENGINEERING MEMBERS

	2009	2010	2011	2012	2013	2014	
Institution	Total	Total	Total	Total	Total	New	Total
Massachusetts Institute of Technology	110	112	108	111	114	2	112
Stanford University	90	91	92	93	95	1	97
Cornell University	24	25	26	26	25	1	26
Harvard University	19	20	19	23	23	0	23
Columbia University	16	16	16	17	18	0	19
Northwestern University	**19**	**18**	**18**	**19**	**19**	**0**	**18**
University of Pennsylvania	9	10	9	10	12	0	11
Case Western Reserve University			7	7	8	0	8
New York University			5	5	9	0	8
Yale University	7	7	6	7	7	0	7
University of Chicago	1	2	4	4	6	0	6
Duke University	3	3	3	4	5	0	6
Johns Hopkins University	11	9	5	6	6	0	6
University of Rochester	5	5	5	6	6	0	6
Boston University					3	0	4
Vanderbilt University			3	3	3	0	3
Washington University	2	2	2	2	2	0	2
University of Pittsburgh			3	2	2	0	2

Source: National Academy of Engineering (http://www.nae.edu/)
Notes: Includes emeriti; Harvard includes Harvard Business School, Harvard Medical School, Harvard University, and Harvard/MIT Medical School; MIT includes MIT, MIT Lincoln Lab, and Harvard/MIT Medical School; Cornell includes Cornell NYC Tech

One of the highest honors for faculty members is election to prestigious national academies and societies, such as the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The national academies bring together committees of excellence in all areas of scientific, humanistic, and technological endeavor. These experts serve pro bono to address critical national issues and give advice to the federal government and the public. Those elected in 2014 are:

Timothy Earl, anthropology: member, American Academy of Arts and Sciences

Katherine T. Faber, materials science and engineering: member, American Academy of Arts and Sciences

Edward Muir Jr., history: member, American Academy of Arts and Sciences

Amy Rosenzweig, molecular biosciences: member, American Academy of Arts and Sciences

Richard Silverman, chemistry: member, American Academy of Arts and Sciences

James Spillane, learning and organizational change: member, National Academy of Education

J. Fraser Stoddart, chemistry: member, National Academy of Sciences

INSTITUTE OF MEDICINE MEMBERS

	2009	2010	2011	2012	2013	2014	
Institution	Total	Total	Total	Total	Total	New	Total
Harvard University	133	140	145	113	118	7	125
Stanford University	61	68	71	64	65	3	68
University of Pennsylvania	50	62	66	59	65	1	66
Columbia University	47	59	60	56	56	3	59
Johns Hopkins University	53	68	70	56	56	2	58
Yale University	39	52	52	41	40	1	41
Duke University	33	38	38	32	33	1	34
Massachusetts Institute of Technology	29	36	38	32	30	1	31
Washington University	33	32	32	25	26	1	27
Vanderbilt University		16	17	19	22	2	24
University of Pittsburgh		22	24	23	24	0	23
Cornell University	9	11	19	16	18	2	20
University of Chicago	11	17	17	14	13	0	13
University of Rochester	14	17	17	13	12	0	12
New York University		14	14	10	12	0	12
Boston University			8	8	8	0	7
Case Western Reserve University		9	10	5	4	2	6
Northwestern University	**3**	**5**	**5**	**4**	**4**	**0**	**3**

Source: Institute of Medicine (http://www.iom.edu/)
Notes: 2013: Members only, excludes committee members and staff; 2013: Harvard includes Dana-Faber Harvard Cancer Center; 2013: MIT includes MIT/Harvard Medical; 2013: Yale includes Yale-New Haven Hospital

CAREER AWARDS

Institution	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Massachusetts Institute of Technology	16	8	12	4	10	13	102
Cornell University	14	6	10	6	7	10	85
Stanford University	10	4	9	7	10	9	78
Columbia University	12	6	6	6	5	8	64
Yale University	5	9	1	6	6	5	53
Northwestern University	**12**	**5**	**7**	**2**	**2**	**5**	**51**
Duke University	7	4	1	4	4	4	45
University of Pennsylvania	4	7	6	5	4	6	45
Boston University	2	4	2	6	8	4	44
Johns Hopkins University	6	4	2	2	5	4	42
Harvard University	8	6	4	3	4	4	42
Pittsburgh University	6	4	2	3	5	0	39
New York University	4	5	1	2	1	5	36
Washington University	3	3	4	2	5	2	35
University of Chicago	2	2	3	6	5	3	35
Vanderbilt University	4	4	6	4	1	2	35
University of Rochester	3	3	1	3	1	2	24
Case Western Reserve University	4	3	1	2	3	0	17

Source: National Science Foundation (http://www.nsf.gov/awardsearch)
Years based on calendar years, not Northwestern fiscal year

CAREER AWARDS FROM THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation's most prestigious award program for new faculty members is the Faculty Early Career Development Program (CAREER). The CAREER Award recognizes and supports the early career-development activities of those teacher-scholars who are most likely to become the academic leaders of the 21st century. The award went to two Northwestern faculty members in 2013 and five in 2014.

Lori Beaman (2013), economics, Institute for Policy Research

Giuseppe Buscarnera (2013), civil and environmental engineering

Douglas Downey (2014), electrical engineering and computer science

T. David Harris (2014), chemistry, Chemistry of Life Processes Institute

Kateryna Juschenko (2014), mathematics

Yoram Lithwick (2014), physics and astronomy

Toru Shiozaki (2014), chemistry

CITATIONS

The following list of Northwestern faculty whose published work has achieved the greatest impact has been determined using the Scopus (Elsevier) database. Scopus covers a much broader set of publications than other sources; one limitation, however, is that Scopus only collects citations as recent as 1996. Thus, faculty members whose publications have appeared primarily since 1996 in a wide set of disciplines are well represented.

Zdeněk P. Bažant, Civil and Environmental Engineering

Al B. Benson III, Medicine, Hematology/Oncology

Robert O. Bonow, Medicine, Cardiology

William J. Catalona, Urology

David Cella, Medical Social Sciences

Alfred L. George Jr., Pharmacology

Mihai Gheorghiade, Medicine, Cardiology

Francis Joseph Giles, Medicine, Hematology/Oncology

Robert Goldman, Cell and Molecular Biology

Jordan Henry Grafman, Physical Medicine and Rehabilitation

Philip Greenland, Preventive Medicine

Stephen B. Hanauer, Medicine, Gastroenterology

Mary J. C. Hendrix, Oncology

Brian M. Hoffman, Chemistry

Yonggang Huang, Civil and Environmental Engineering

Joseph T. Hupp, Chemistry

Peter J. Kahrilas, Medicine, Gastroenterology

Mercouri Kanatzidis, Chemistry

Robert A. Lamb, Molecular Biosciences

Wing K. Liu, Mechanical Engineering

Kiang Liu, Preventive Medicine

Donald M. Lloyd-Jones, Preventive Medicine

Tobin Jay Marks, Chemistry

Patrick M. McCarthy, Surgery, Cardiac Surgery

Herbert Y. Meltzer, Psychiatry and Behavioral Sciences

Marek-Marsel Mesulam, Neurology

Richard J. Miller, Pharmacology

Stephen D. Miller, Microbiology-Immunology

Chad A. Mirkin, Chemistry

Richard I. Morimoto, Molecular Biosciences

Milan Mrksich, Biomedical Engineering

Eric G. Neilson, Medicine: Nephrology

SonBinh Nguyen, Chemistry

Marcus Ernst Peter, Medicine, Hematology/Oncology

Alfred W. Rademaker, Preventive Medicine

Mark A. Ratner, Chemistry

Janardan K. Reddy, Pathology

George C. Schatz, Chemistry

Robert P. Schleimer, Medicine, Allergy

Michael H. Schmitt, Physics and Astronomy

J. Fraser Stoddart, Chemistry

Samuel Isaac Stupp, Materials Science and Engineering, Chemistry, Medicine

Dalton James Surmeier, Jr., Physiology

James David Thomas, Medicine, Cardiology

Richard P. Van Duyne, Chemistry

Michael R. Wasielewski, Chemistry

Steven M. Wolinsky, Medicine, Infectious Diseases

Clyde W. Yancy, Medicine, Cardiology

2014 FACULTY RECOGNITION AND HONORS

Northwestern's Office of Administration and Planning, in conjunction with the faculty honors committee, compiles a comprehensive list of faculty awards and honors. The faculty honors committee then selects those faculty members with the most prestigious honors for University recognition. At this year's faculty recognition dinner hosted by President **Morton Schapiro** and Provost **Daniel Linzer** on November 24, the following faculty members were honored for work that has brought particular distinction to Northwestern.

Jan Achenbach, civil and environmental engineering, engineering sciences and applied mathematics, mechanical engineering: medal named in his honor by the International Workshop on Structural Health Monitoring; honorary professor, Beijing Institute of Technology

Erik Andersen, molecular biosciences: Pew Scholar in the Biomedical Sciences, Pew Charitable Trusts

Torben Andersen, finance: highly cited researcher, Thomson Reuters Corporation

Bruce Ankenman, industrial engineering and management sciences: Outstanding Simulation Publication Award, Institute for Operations Research and the Management Sciences

Nir Avni, mathematics: research fellowship, Alfred P. Sloan Foundation

Mira Balberg, religious studies: fellowship, Frankel Institute for Advanced Judaic Studies, University of Michigan

Melika Bass, radio/television/film: artist fellowship, Illinois Arts Council

Randall Berry, electrical engineering and computer science: fellow, Institute of Electrical and Electronics Engineers

Eileen Bigio, pathology: highly cited researcher, Thomson Reuters Corporation

Karl Bilimoria, surgery, surgical oncology division: Young Investigator Award, National Comprehensive Cancer Network Foundation

Robert Bonow, cardiology: highly cited researcher, Thomson Reuters Corporation

L. Catherine Brinson, mechanical engineering: fellow, American Academy of Mechanics; Nadai Medal for Distinguished Contributions to Materials Engineering, American Society of Mechanical Engineers

Gregory Budinger, medicine, pulmonary division: member, American Society for Clinical Investigation

Giuseppe Buscarnera, civil and environmental engineering: CAREER Award, National Science Foundation

Geraldo Cadava, history: Frederick Jackson Turner Award, Organization of American Historians

Francesco Calegari, mathematics: fellow, American Mathematical Society

Jian Cao, mechanical engineering and associate vice president for research: Outstanding Service Award, Manufacturing Engineering Division, American Society of Mechanical Engineers

David Cella, Medical Social Sciences: John Ware and Alvin Tarlov Career Achievement Prize, International Society of Quality of Health Care Conference

Joshua Chambers-Letson, performance studies: Outstanding Book Award, Association for Theatre in Higher Education

S. Hollis Clayson, art history: Chevalier, Ordre des Palmes Académiques (France)

Jasmine Cobb, communication studies: American Fellowship, American Association of University Women

Deborah Cohen, history: one of the year's best nonfiction books, Public Books; best book of the year, T*he Spectator, Sunday Times,* and *Times* Literary Supplement (U.K.)

J. Edward Colgate, mechanical engineering: fellow, Institute of Electrical and Electronics Engineers

Noshir Contractor, industrial engineering and management sciences, behavioral sciences: Distinguished Scholar Award, National Communication Association

Eric Dahl, physics and astronomy: Early Career Research Award, US Department of Energy

Isaac Daniel, civil and environmental engineering, mechanical engineering: honorary doctorate, Democritus University of Thrace (Greece); C. E. Taylor Award, Society for Experimental Mechanics

Erin Delaney, law: Fulbright Scholar, Fulbright Program

Robert Dodson, Center for Genetic Medicine: highly cited researcher, Thomson Reuters Corporation

Douglas Downey, electrical engineering and computer science: CAREER Award, National Science Foundation

James Druckman, political science: highly cited researcher, Thomson Reuters Corporation

Jeanne Dunning, art theory and practice: Art Journal Award, College Art Association

Stuart Dybek, English: Peter Lisagor Award for Best Sports Story in a Nondaily Publication, Chicago Headline Club; Harold Washington Literary Award, Near South Planning Board (Chicago)

Alice Eagly, psychology: Lifetime Achievement Award, International Leadership Association; Eminent Leadership Scholar Award, Academy of Management

Timothy Earle, anthropology: member, American Academy of Arts and Sciences

Martin Eichenbaum, economics: highly cited researcher, Thomson Reuters Corporation

Wendy Espeland, sociology: fellow, Wissenschaftskolleg du Berlin

Antonio Facchetti, chemistry: highly cited researcher, Thomson Reuters Corporation

Omar Farha, Chemistry; Highly Cited Researcher, Thomson Reuters

Gary Fine, sociology: fellowship, School of Social Science, Institute for Advanced Study

Caitlin Fitz, history: fellowship, American Council of Learned Societies

Danna Freedman, chemistry: Young Investigator Research Program, US Air Force Office of Scientific Research

Elizabeth Gerber, mechanical engineering, computer science and engineering: Undergraduate Teaching Award, Institute of Electrical and Electronics Engineers Computer Society

Jonathon Glassman, history: fellowship, National Humanities Center

Paul Goerss, mathematics: fellow, American Mathematical Society

Goldie Goldbloom, creative writing: fellowship, National Endowment for the Arts; Hunger Mountain Creative Nonfiction Prize, Vermont College of Fine Arts

Edward Gong, urology: Individual Biomedical Research Award, Hartwell Foundation

Robert Gordon, economics: distinguished fellow, American Economic Association

Nina Gourianova, Slavic languages and literatures: Outstanding Book in Literary/Cultural Studies, American Association of Teachers of Slavic and East European Languages

Philip Greenland, preventive medicine: highly cited researcher, Thomson Reuters Corporation

Itai Gurvich, managerial economics and decision sciences: first prize, Best Paper Competition, College of Healthcare Operations Management, Production and Operations Management Society

Stephen Hanauer, gastroenterology and hepatology: highly cited researcher, Thomson Reuters Corporation

Elad Harel, chemistry: Fellowship for Science and Engineering, David and Lucile Packard Foundation

T. David Harris, chemistry: CAREER Award, National Science Foundation; Young Investigator Award, US Army Research Office

Todd Hasak-Lowy, School of Professional Studies: Risa Domb/Porjes Translation Prize, Jewish Book Council (U.K.)

Larry Hedges, statistics and education: Statistician of the Year, Chicago Chapter, American Statistical Association; Presidential Citation, American Education Research Association

Walter Herbst, director, Master of Product Development Program: Gold Award for Industrial Design, Computer and Entertainment Category, Edison Awards

Mark Hersam, materials science and engineering: MacArthur Fellowship, John D. and Catherine T. MacArthur Foundation

Darlene Clark Hines, African American studies: National Humanities Medal, National Endowment for the Humanities

Joel Horowitz, economics: honorary doctorate, Humboldt University of Berlin

Jiaxing Huang, materials science and engineering: Guggenheim Fellow, John Simon Guggenheim Memorial Foundation; highly cited researcher, Thomson Reuters Corporation

Yonggang Huang, civil and environmental engineering, mechanical engineering: highly cited researcher, Thomson Reuters Corporation

Joseph Hupp, chemistry: fellow, Royal Society of Chemistry (U.K.); Stephanie L. Kwolek Award, Royal Society of Chemistry (U.K.); highly cited researcher, Thomson Reuters Corporation

Steven Jacobsen, Earth and planetary sciences: Friedrich Wilhelm Bessel Research Award, Alexander von Humboldt Foundation

Ravi Jagannathan, finance: Graham & Dodd, Murray, Greenwald Prize for Value Investing, Gabelli Funds

E. Patrick Johnson, African American studies, performance studies: Otto René Castillo Award for Political Theatre, Castillo Theatre (New York City)

Kateryna Juschenko, mathematics: CAREER Award, National Science Foundation

Mercouri Kanatzidis, chemistry: Outstanding Achievement Award, International Thermoelectric Society; Einstein Professor, Chinese Academy of Sciences

Leon Keer, civil and environmental engineering, mechanical engineering: fellow, Engineering Mechanics Institute, American Society of Civil Engineers

Neil Kelleher, molecular biosciences: Allen Distinguished Investigator Award, Paul G. Allen Family Foundation

Philip Kotler, marketing: Officier, Ordre des Palmes Académiques (France); Management Hall of Fame, Thinkers50; honorary doctorate, Plekhanov Russian University of Economics

Jörg Kreienbrock, German: Humboldt Research Fellowship, Alexander von Humboldt Foundation

Phyllis Lassner, Writing Program: Diamond Jubilee International Visiting Fellowship, Southampton University (U.K.)

Angela Lee, marketing: Hall of Honor Award, University of Hawaii at Mānoa

Carol Lee, education and social policy, learning sciences: Dogon Award, DuSable Museum of African American History

Yoram Lithwick, physics and astronomy: CAREER Award, National Science Foundation

Wing Kam Liu, mechanical engineering: highly cited researcher, Thomson Reuters Corporation

Donald Lloyd-Jones, preventive medicine: highly cited researcher, Thomson Reuters Corporation

Erik Luijten, engineering sciences and applied mathematics, materials science and engineering: fellow, American Physical Society

D. Soyini Madison, performance studies: Lilla A. Heston Award for Outstanding Scholarship in Interpretation and Performance Studies, National Communication Association

Charles Manski, economics: Corresponding Fellow, British Academy

Laurence Marks, materials science and engineering: B. Warren Award, American Crystallographic Association

Tobin Marks, chemistry: Sir Geoffrey Wilkinson Award, Royal Society of Chemistry (U.K.); highly cited researcher, Thomson Reuters Corporation

Kate Masur, history: fellowship, W. E. B. DuBois Research Institute, Harvard University

Dan McAdams, psychology, human development and social policy: Master Lecturer, American Psychological Association

Douglas Medin, psychology, education: William James Lifetime Achievement Award for Basic Research, Association for Psychological Science

Marek-Marsel Mesulam, neurology director, Cognitive Neurological Alzheimer's Disease Center: Potamkin Prize, American Academy of Neurology and American Brain Foundation

Chad Mirkin, chemistry, biomedical engineering: fellow, National Academy of Inventors; Vittorio de Nora Award, Electrochemical Society; Citation Laureate, Thomson Reuters Corporation; National Security Science and Engineering Faculty Fellow, US Department of Defense; Distinguished Medical Science Award, Friends of the National Library of Medicine

Richard Morimoto, molecular biosciences: Feodor Lynen Medal, German Society for Biochemistry and Molecular Biology

Adilson Motter, physics and astronomy: fellow, American Physical Society

Edward Muir Jr., history: member, American Academy of Arts and Sciences; Senior Scholar Citation, Society of Italian Historical Studies

Aaron Naber, mathematics: research fellowship, Alfred P. Sloan Foundation

Barry Nelson, industrial engineering and management sciences: Outstanding Simulation Publication Award, Institute for Operations Research and the Management Sciences

Aviv Nevo, economics: fellow, Econometric Society

SonBinh Nguyen, chemistry: highly cited researcher, Thomson Reuters Corporation

Teri Odom, chemistry: Carol Tyler Award for Distinguished Achievement, International Precious Metals Institute

Puneet Opal, neurology, cell and molecular biology: member, American Society for Clinical Investigation

Ann Orloff, sociology: fellowship, Center for Advanced Study in the Behavioral Sciences, Stanford University

Dimitris Papanikolaou, finance: Amundi Smith Breeden Prize, American Finance Association

Susan Pearson, history: fellowship, American Council of Learned Societies

Christian Petersen, molecular biosciences: New Innovator Award, National Institutes of Health

Mitchell Petersen, finance: highly cited researcher, Thomson Reuters Corporation

Frank Petriello, physics and astronomy: fellow, American Physical Society

Miriam Petty, radio/television/film: Career Enhancement Fellowship, Woodrow Wilson National Fellowship Foundation

Monica Prasad, sociology: Distinguished Book Award, American Sociological Association

Indira Raman, neurobiology: Javits Neuroscience Investigator Award, National Institute of Neurological Disorders and Stroke

Mark Ratner, chemistry and interim dean, Weinberg College of Arts and Sciences: Weizmann Memorial Lecturer, Weizmann Institute of Science (Israel)

Manijeh Razeghi, electrical engineering and computer science: Faculty Award, IBM

Brian Reiser, learning sciences: highly cited researcher, Thomson Reuters Corporation

Ramón Rivera-Servera, performance studies: Outstanding Publication in Dance Research, Congress on Research in Dance; José Rollins de la Torre Bueno Prize, Society of Dance History Scholars

Todd Rosenthal, theatre: Outstanding Set Design (Resident Production), Helen Hayes Awards

Amy Rosenzweig, molecular biosciences: member, American Academy of Arts and Sciences; Joseph Chatt Award, Royal Society of Chemistry (U.K.)

John Rudnicki, mechanical engineering: Engineering Science Medal, Society of Engineering Science

Alice Salzman, physical therapy and human movement sciences: Ronnie Leavitt Award for the Promotion of Social Responsibility in Physical Therapy, Global Health Special Interest Group, Section on Health Policy and Administration American Physical Therapy Association,

Paola Sapienza, finance: highly cited researcher, Thomson Reuters Corporation

Mark Satterthwaite, hospital and health services management strategy: Robert F. Lanzillotti Prize, Industrial Organization Society

John Schafer, classics: fellowship, Loeb Classical Library Foundation

Diane Schanzenbach, human development and social policy: Raymond Vernon Memorial Prize for Best Research Article, Association for Public Policy Analysis and Management

George Schatz, chemistry: Joseph O. Hirschfelder Prize in Theoretical Chemistry, Theoretical Chemistry Institute, University of Wisconsin; highly cited researcher, Thomson Reuters Corporation

Joseph Schofer, civil and environmental engineering: Deen Distinguished Lectureship Award, Transportation Research Board

Toru Shiozaki, chemistry: CAREER Award, National Science Foundation; Young Investigator Research Program, US Air Force Office of Scientific Research

David Shyovitz, history: Visiting Fellowship in Jewish Studies, Yad Hanadiv and the Beracha Foundation

Richard Silverman, chemistry: member, American Academy of Arts and Sciences; iCON Innovator Award, iBIO Institute; Excellence in Medicinal Chemistry Prize, Israel Chemical Society

Christine Sneed, director (academic), School of Professional Studies: Award for Adult Fiction, Society of Midland Authors

Randall Snurr, chemical and biological engineering: highly cited researcher, Thomson Reuters Corporation

Scott Sowerby, history: Whitfield Book Prize, Royal Historical Society (U.K.)

Lynn Spigel, radio/television/film: Guggenheim Fellow, John Simon Guggenheim Memorial Foundation

James Spillane, learning and organizational change: member, National Academy of Education

Jeremiah Stamler, preventive medicine: Eugene Braunwald Academic Mentorship Award, American Heart Association

Jeremy Staum, industrial engineering and management sciences: Outstanding Simulation Publication Award, Institute for Operations Research and the Management Sciences

Seth Stein, Earth and planetary sciences: Price Medal, Royal Astronomical Society (U.K.); Humboldt Research Award, Alexander von Humboldt Foundation

Nathaniel Stern, physics and astronomy: Early Career Research Program, US Department of Energy; highly cited researcher, Thomson Reuters Corporation

J. Fraser Stoddart, chemistry: member, National Academy of Sciences; IChem Awards in North America Chemical Engineering Project of the Year, Institution of Chemical Engineers; Centenary Prize, Royal Society of Chemistry (U.K.); highly cited researcher, Thomson Reuters Corporation

Neil Stone, cardiology: Physician of the Year, American Heart Association

Samuel Stupp, materials science and engineering: SPSJ International Award, Society of Polymer Science, Japan; highly cited researcher, Thomson Reuters Corporation

Hans Thomalla, composition, music technology: fellow, Wissenchaftskolleg zu Berlin

Krista Thompson, art history: Writers Grant, Creative Capital/Andy Warhol Foundation for the Visual Arts

Helen Tilley, history: Ludwig Fleck Prize for Best Book in Science and Technology Studies, Society for Social Studies of Science

David Tolchinsky, radio/television/film: artist fellowship, Illinois Arts Council

Keith Tyo, chemical and biological engineering: Transformative Research Award, National Institutes of Health

David Uttal, psychology, education: president, Cognitive Development Society; George A. Miller Award for an Outstanding Recent Article on General Psychology, Society for General Psychology, American Psychological Association

Richard Van Duyne, chemistry: E. Bright Wilson Award in Spectroscopy, American Chemical Society; fellow, Society of Applied Spectroscopy; Charles Mann Award for Applied Raman Spectroscopy, Federation of Analytical Chemistry and Spectroscopy Societies; highly cited researcher, Thomson Reuters Corporation

Jan Van Mieghem, managerial economics and decision sciences: first prize, Best Paper Competition, College of Healthcare Operations Management, Production and Operations Management Society

Kari Vilonen, mathematics: Fellow in Mathematics, Simons Foundation

Manu Vora, School of Professional Studies: Harrington/Ishikawa Medal, Asia Pacific Quality Organization

Julia Weertman, materials science and engineering: John Fritz Medal, American Association of Engineering Sciences

Bruce Wessels, materials science and engineering: fellow, Optical Society of America

Myles Wolf, nephrology: Young Investigator Award, American Society of Nephrology

Teresa Woodruff, obstetrics and gynecology: Beacon Award, Board of Scientific Counselors, Frontiers in Reproduction Research Program, Marine Biological Laboratory

Clyde Yancy, cardiology, medical social sciences: Gold Heart Award, American Heart Association; highly cited researcher, Thomson Reuters Corporation

Steven Zelditch, mathematics: Stefan Bergman Prize, American Mathematical Society

Mary Zimmerman, performance studies: Outstanding Director (Large Theater), Elliot Norton Awards

Laurie Zoloth, religious studies: President, American Academy of Religion

RESEARCH FELLOWSHIPS

With 29 US Fulbright grant recipients, Northwestern most likely ranks among the top 10 Fulbright-producing schools for academic year 2013–14 (the Fulbright/International Institute of Educate program has delayed its announcement of rankings until February 2015). This would be Northwestern's ninth straight year in the top 10.

The 29 Fulbright awardees were chosen from 115 applicants supported by Northwestern's Office of Fellowships, a yield of 25.2 percent. From that initial pool, 57 applicants—almost half—made the first cut. Because of the delayed announcement of 2014 data, it is not yet possible to know the national success average, but in the previous cycle the rate was 17 percent. Although the 2014–15 Fulbright application cycle has not yet concluded, Northwestern has already put forward 125 applicants.

Northwestern students also do well in the National Science Foundation Graduate Research Fellowship program. The NSF no longer lists the students' expected graduate institutions, so only the undergraduate listing is available for 2014. In 2014, among the American Association of Universities (AAU) cohort, Northwestern placed 11th in the NSF fellowship program.

NSF GRADUATE RESEARCH FELLOWSHIPS

Institution	2007	2008	2009	2010	2011	2012	2013	2014
Cornell University	23	22	24	49	40	41	29	48
MIT	35	44	56	66	54	59	58	47
Harvard University	26	29	41	45	45	44	40	40
Stanford University	35	31	37	60	41	36	30	36
Yale University	22	21	23	33	27	28	23	23
Duke University	14	7	11	22	21	19	16	20
Columbia University	8	12	14	16	30	19	21	19
Washington University	10	7	12	19	14	11	18	16
University of Rochester	2	2	8	10	17	11	10	15
University of Pittsburgh	2	3	6	14	14	13	16	12
Johns Hopkins University	8	7	12	14	10	17	8	11
Boston University	0	0	13	7	7	6	10	11
University of Chicago	13	12	17	22	20	20	20	10
Case Western Reserve University	2	9	0	10	8	5	10	9
University of Pennsylvania	8	5	10	19	11	16	21	8
Vanderbilt University	6	4	4	10	10	10	13	8
Northwestern University	**11**	**5**	**11**	**19**	**19**	**15**	**18**	**7**
New York University	5	2	6	10	14	9	5	7

Souce: National Science Foundation (https://www.fastlane.nsf.gov/grfp/Login.do)

Roberta Buffett Elliott Makes Transformative Gift to Northwestern

Alumna **Roberta Buffett Elliott** has donated more than $100 million to create the Roberta Buffett Institute for Global Studies, President Morton Schapiro announced on January 28, 2015. Her generous donation is the largest single gift in the University's history. Mrs. Elliott is a 1954 Northwestern graduate.

Mrs. Elliott's gift is part of **We Will. The Campaign for Northwestern,** the University's $3.75 billion fundraising campaign, and increases her total giving to the Campaign to approximately $110 million.

Roberta Buffett Elliott with Brian Hanson and Bruce Carruthers of the Buffett Center at the January 28, 2015 event announcing her transformative gift. Photo by Bruce Powell

"Bertie's extraordinary commitment and her unprecedented generosity to Northwestern will fundamentally transform every corner of the University's global programming," said President Schapiro. "In our conversations over the past several months, Bertie and her husband, David, expressed their appreciation for what Northwestern has already been doing in terms of its global outreach, while recognizing that the University could have a much greater impact on the world with expanded and new programs. She is a truly visionary philanthropist and we are honored to have her trust."

The Buffett Institute will take a multidisciplinary, problem-solving approach to advancing important global issues such as the spread of democratic political systems, economic development in impoverished regions of the world, immigration policies and forced migrations, the impact of cultural exchanges on societies, global religious movements, and global communications, media and technology.

Photo by Bruce Powell

Warren Buffett, Roberta Buffett Elliot, and David Elliott pose with the large antique map of the world given to Mrs. Elliott to commemorate her historic and visionary gift.

The Institute will conduct and facilitate research, coordinate campus-wide discussions with visiting experts about pressing global challenges confronting society and provide collaborative funding to academic departments and programs throughout the University.

Mrs. Elliott's historic gift will have broad impact, providing support for:

- Adding interdisciplinary professorships. The gift will enable Northwestern to hire new faculty members focused on international areas, with joint appointments at the Institute and a number of academic departments.
- Funding interdisciplinary research. The gift will provide resources for faculty-led research projects with the potential for incubating solutions to critical global issues.
- Hiring a renowned expert in global affairs to direct the University-wide Buffett Institute. The new director is expected to be someone with high-level experience in government and/or academia who will provide overall direction for the Institute and work with Northwestern's provost, deans, and other academic leaders.
- Providing scholarships for international students. Up to $20 million of the gift could be used as a matching challenge grant to donors who will endow scholarships benefitting international students.
- Expanding a visiting scholars program that brings distinguished international scholars to Northwestern for the academic year. Drawn primarily from the social sciences, each cohort of visiting scholars will build academic relationships with Northwestern faculty, graduate students, and each other.
- Providing travel grants for students. The additional funding for travel will enable more students who receive financial aid to participate in study abroad and other international travel programs.
- Providing funding for graduate student fellowships. Graduate students will work closely with faculty members on research projects and with undergraduates in the classroom.
- Creating a postdoctoral fellows program. Fellowships will allow scholars early in their careers to work on individual and collaborative research projects and to teach undergraduate courses on topics relevant to the Institute's core areas.

Mrs. Elliott has been a major supporter of international studies at Northwestern for many years. Her earlier gifts enabled the University to expand the Center for International and Comparative Studies, now called the Buffett Center. The Center supports 33 research centers, programs, working groups, and funded projects across the University and has 218 affiliated faculty representing all of Northwestern's schools. The Center sponsors or co-sponsors nearly 10 conferences annually, hosts 12-15 visiting scholars per year and enables approximately 30-40 graduate students to conduct research abroad during the summer.

GESI student Claire Hunt (SESP '12) during her community development internship in Uganda.

Photos used courtesy of The Buffet Center

The Buffett Center's Global Reach

Northwestern's hub for international scholarship and global engagement will be transformed by Roberta Buffett Elliott's 2015 gift. The existing center, which opened in November 1994 as the Center for International and Comparative Studies, was renamed the Roberta Buffett Center for International and Comparative Studies to recognize Mrs. Elliott's gift in 2007.

Researchers cite the Buffett Center's dynamic, collaborative atmosphere as a key element in their work on global issues. Students are grateful for global engagement opportunities that not only help build their careers but also give them new perspectives and enthusiasm for tackling global challenges. The Northwestern community appreciates having an inclusive space on campus for international learning, dialogue, and debate.

"The Buffett Center is successful because we play a unique role on campus, bringing together people from across schools and disciplines to engage with critical issues facing our world today," says Buffett Center Director **Bruce Carruthers.** "Whether you're an undergraduate student learning about international development, a graduate student looking for research support, or a faculty member researching warlords or international law, this is a place where you will feel welcomed, challenged, and encouraged.

During Homecoming Weekend 2014, the Buffett Center hosted a panel of young alumni who reflected on how the Center's student-driven initiatives impacted their lives and helped shape their careers after graduation. From left to right: Buffett Center Director of Programs and Research Brian Hanson, GESI co-founder Jonathan Marino (SESP '06), Megha Agrawal (SESP '10), Heidi Dessecker (WCAS '10), and Ayanna Legros (WCAS '13).

The Buffett Center is the home of several of the University's prominent interdisciplinary research groups and centers, including the Center for Forced Migration Studies, Equality Development and Globalization Studies, the Deportation Research Clinic, the International Organizations and International Law working group, Comparative-Historical Social Science, and the Keyman Family Program in Modern Turkish Studies.

Over the past five years, more than a thousand undergraduate students have been involved in Buffett Center programs. The center is the home to some of Northwestern's most popular student groups, including GlobeMed, the Northwestern University Community on Human Rights, and the Global Engagement Summit. The Buffett Center's student-founded study abroad program, the Global Engagement Studies Institute, teaches undergraduates international development in Uganda, India, Bolivia, South Africa, Nicaragua, the Dominican Republic, and Kenya.

Global Studies in Action

Of the many vast and varied global issues addressed at the Buffett Center, these two recent and powerful examples help illustrate what the center is all about.

Learning Where the Shoe Pinches: Undergraduate Research and Engagement in Uganda

When **Nathaniel Whittemore** (WCAS '06) and **John Marino** (SESP '06) rolled out the Buffett Center's study abroad program—the Global Engagement Studies Institute (GESI)—in 2007, Jinja, Uganda, was chosen as its first location. Since then, the GESI program has exploded in size and popularity—almost 400 students have completed more than 100 international development projects in eight different countries on four continents. Students work as interns in an annually changing lineup of local grassroots organizations. One

Photo left: the Budondo Savings and Credit Cooperative Organization in Uganda. Photo right: GESI student Jenna Pugrant (WCAS '14) discusses her team's ginger farming initiative with a local women's group in Jinja, Uganda.

The 2014-2015 Arryman Fellows and Scholars, from left to right: Luthfi Adam, Gde Metera, Yoes Kenawas, Sabina Puspita, Najmu Sopian, Wara Urwasi, Hipo Ringgi, Dhika Utama, and Muhammad Fajar.

Uganda nongovernmental organization, however, has remained a Northwestern partner since 2007: Jinja's Organization for Rural Development (ORUDE).

Founded in 1997, ORUDE trains rural women in financial literacy and prepares them to obtain credit. The organization's original mission was to link farmers with outside microfinance institutions, but it soon became apparent that many of these institutions were not helping the people who needed loans most. Like traditional banks, microfinance institutions do not always offer credit to poor rural farmers (and especially women). To make matters worse, the high interest rates attached to these microloans were taking money out of the local economy.

When GESI students arrived in 2007, ORUDE—hoping to offer an alternative to these microfinance institutions—was embarking on a plan to start its own Savings and Credit Cooperative Organizations, which would be owned, governed, and managed by members of the local community.

As ORUDE program director **Justine Ojambo** explains, "There is a saying in our local language, 'He who puts on the shoe knows where it pinches most.' That is very important, that the people who come to work here listen to what the local people are saying, value what they know, and add on to what they know. And this is exactly what this [Northwestern] program is all about."

Based on community needs and feedback over the years, GESI students have helped introduce new, more lucrative crops such as ginger and coffee as well as assisting in teaching best practices for raising livestock.

Bringing International Scholarship to a Postcolonial World

Despite boasting Southeast Asia's largest economy and a society that greatly values education, Indonesia has a major education challenge. According to data from the World Bank, less than 20 percent of its citizens who are of age enroll in higher education, and just 7 percent of Indonesian academic staff hold a PhD. And even for those Indonesians with a PhD, it is extremely difficult for them to thrive as scholars producing scholarship. These are just a few of the reasons why for the past several years Indonesia's higher education system has finished at the very bottom of the U21 Ranking of National Higher Education Systems.

On the other side of the world, the Buffett Center's Arryman Program is collaborating with Indonesian and American scholars to rectify this problem. Designed by Northwestern faculty member **Jeffrey Winters,** political science, and launched in 2012, the Arryman Program works in partnership with education and research institutions in Indonesia to bring Indonesian PhD students to study in the social sciences at Northwestern. The Arryman Program is administered in Evanston by the Buffett Center's Equality Development and Globalization Studies (EDGS) program, a globally-focused intellectual and research hub for the Northwestern community.

Named for **Arif Arryman,** a well-respected Indonesian education advocate and intellectual figure, the Arryman Program seeks to cultivate a new generation of first-rate scholars for Indonesia. Each year the Indonesian Scholarship and Research Support Foundation (ISRSF) selects candidates to pursue doctoral studies in Evanston. After an initial research year as Arryman Fellows, they

become Arryman Scholars when they are accepted into their desired Northwestern PhD program.

Arryman's vision was a school of public policy and social sciences that would set a new standard of research, scholarship, and teaching in Indonesia. The Arryman Scholars here at Northwestern will eventually become core faculty in that new school. The first cohort should obtain their PhD degrees in 2019, by which time a new institute in Jakarta called "Transformasi" will be evolving into the new Indonesian School for Public Policy and Social Sciences. Currently there are nine Arryman students at Northwestern, a number that will reach a goal of 20 scholars over the next three years.

Upon arriving at Northwestern, Arryman Fellows—hailing from a wide range of social science disciplines— are welcomed and guided by Buffett Center staff and Northwestern faculty.

"It would not be an overstatement to say that my academic life here so far has been challenging yet also very exciting," says **Sabina Puspita,** a 2014 Arryman Fellow studying comparative politics. "The responsiveness of the faculty and staff is inspiring. I am grateful to be in an environment that is conducive to an enjoyable learning and research-crafting experience."

"The educational investment the Indonesian donors to the Arryman Program are making demands a unique kind of vision because there will be no instant gratification, no problems immediately solved, no social pain instantly alleviated," says Winters. "Cultivating scholars and scholarship for Indonesia will have an immeasurable impact in the years and decades ahead."

— Laura Hayes

A WORLD OF SUPPORT

Roberta Buffett Elliott

The Buffett Center is grateful for significant support from Northwestern alumna **Roberta Buffett Elliott** '54, for whom the center is named.

"I'm very pleased to be able to support the important work that Northwestern does in international studies," Mrs. Elliott said. "A better understanding of the world is critical in an increasingly global society, and the Institute's research and support of academic programs will help reach that goal."

Generous gifts from alumni donors such as Mrs. Elliott and University Trustee **Bonnie Daniels** '69 and her husband **Mike Daniels** '68, '69 MA, have funded a number of individual programs, such as the Global Engagement Studies Institute, to provide robust need-based scholarships for undergraduates who want to learn how to make change in their world. Due to these initiatives, more than $500,000 in need-based GESI scholarships has been awarded since 2010.

As Bonnie Daniels explains, "It is important for students to be afforded the opportunity to get overseas field experience on a merit basis regardless of their economic or financial situation. An early experience in a developing country can have a lasting impact, not only in career selection but in terms of overall world perspective."

The Arryman Fellows Program (see preceding article) is funded by leading Indonesian corporations and foundations. Donors include prominent Indonesian alumni **Victor Hartono** '98 and **Ario Rachmat** '95. The Arryman program is overseen by the Equality Development and Globalization Studies program, funded by a gift from **Peter Sondakh** through the Rajawali Foundation in Indonesia.

Generous gifts from University Trustee **Melih Keyman** and his wife **Zeynep Keyman** have created and strengthen the University's Keyman Family Program in Modern Turkish Studies, housed in the Buffett Center. This program was designed to increase knowledge about Turkey and its importance in the world.

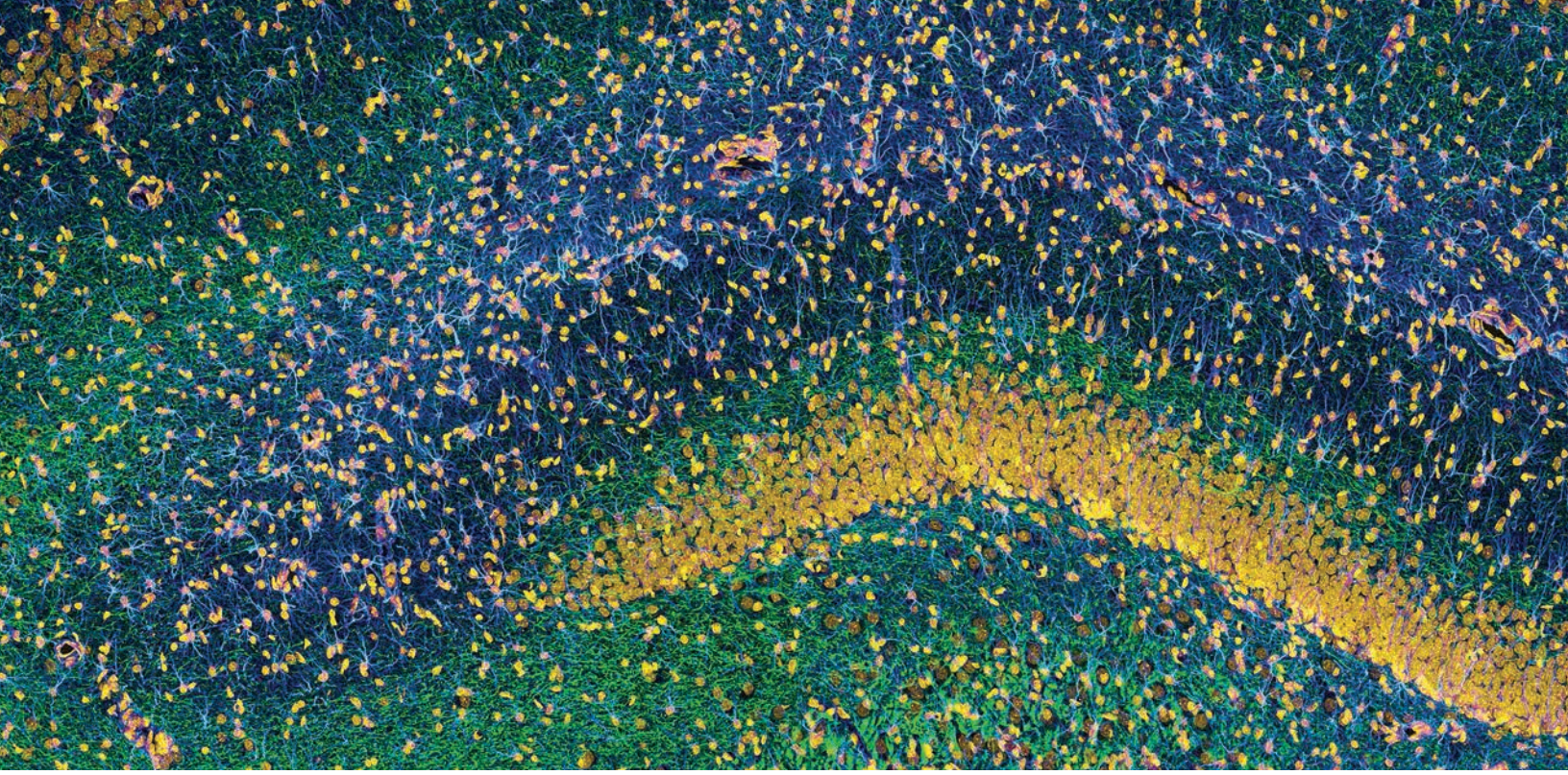


Photo by National Center for Microscopy and Imaging Research

Putting Memory under the Microscope

RESEARCHERS TAKE DIVERSE APPROACHES TO EXPLORING THE MIND

The human brain contains an estimated 86 billion neurons—and if you remember that fact, a series of cellular events has just occurred.

"We know that the building of declarative memories—recollections of facts and knowledge—starts with the hippocampus," says **John Disterhoft,** Ernest J. and Hattie H. Magerstadt Memorial Research Professor of Physiology. "Assuming that the brain is mediating the learning, there have to be places in it changing when or just before the memory is formed. Our goal is to continue to unravel this mystery and characterize the way neurons in those locations store new information at the cellular level."

Disterhoft uses models of associative learning to explore the aging brain and Alzheimer's disease, relying on in vivo (electrodes placed in a living animal) and in vitro (postmortem brain slice) techniques. In the classic example of associative learning, Ivan Pavlov's dogs would salivate at the ringing of a bell in anticipation of the learned connection between that sound and food. Similarly, Disterhoft uses stimuli, such as tones, before administering an air puff to elicit eye blinking; when animals learn the connection, they blink when the tone occurs, in anticipation of the puff.

The hippocampus is the starting point for building declarative memories—recollections of facts and knowledge. The above image shows a rat's hippocampus under ultra-widefield high-speed multiphoton laser microscopy. The tissue was stained to reveal the organization of non-neuronal cells (cyan), the neurofilaments found in neurons (green), and DNA (yellow).

Photo by Roger Anderson

John Disterhoft

Monitoring Cellular Connections

What Disterhoft has observed is a set of interesting changes in the output neurons of the hippocampus. In animals that have learned a conditioned response, a large percentage of those neurons show increased excitability.

This shift in volatility is marked by a reduction in calcium-activated potassium current, a fundamental regulator of neuronal excitability. In normal aging these currents naturally increase, and the output neurons, known as pyramidal cells, become less excitable. The combination makes it more difficult for the hippocampus to be involved in forming new associations or memories, a finding that may help explain why older individuals take more time to learn new tasks.

If the effects of aging can be offset, the brain would be better equipped to protect itself from degeneration. "When we use a specific calcium-channel blocker, and give it systemically to old animals, they are able to learn as fast as their younger counterparts," says Disterhoft. "Because aging is a major risk factor for Alzheimer's and other neurodegenerative diseases, understanding what is going on in normal aging may well allow us to get a handle on why aging cells are so much more sensitive to mechanistic changes that lead to disease."

Researchers know that different types of memories form in different ways and are stored in different parts of the brain. Factual memories, for instance, are created or encoded in the hippocampus but are stored in the temporal cortex and elsewhere. And even the simplest organisms, like single-cell bacteria, can make memories, recalling where they've been in an effort to avoid certain death. In humans the brain's neurons form complex networks as part of a system that relies on trillions of cellular combinations. Individual cells communicate across tiny gaps known as synapses. As synapses strengthen, partially as a result of excitability changes, memories are formed.

Jelena Radulovic

Photo by Steven Gross

Cellular/Molecular Basis of Emotion

For **Jelena Radulovic, MD/PhD,** pharmacology, it's the addition of emotions and their connection to memory that's especially intriguing. Researchers in her laboratory are working to reveal how stressful events leave lasting memories and how those memories come to trigger fear or anxiety. "It's really a big puzzle," says Radulovic, psychiatry and behavioral sciences and pharmacology. "If a trauma is too intense, some people will develop posttraumatic stress disorder in conjunction with permanent flashbacks. Others might experience dissociation, where they can't remember a thing."

What triggers the repression or rehearsal and recollection of a memory is still unknown, but when fear and anxiety arise in the face of real or perceived danger, the stress sometimes becomes overwhelming. When it does, the emotional reaction can be excessive and lead to various psychiatric disorders.

"We're continuing to learn about the cellular pathways to memories, and we've had some success identifying what is needed to form and extinguish these stress-inducing recollections in our animal models," says Radulovic who is also featured on page 48. "But we still don't know what the essence of a memory is, or whether all memories of averse events are created equal."

One of the biggest mysteries of psychiatric illness is that even after death the dissected brain shows no defining characteristics. In contrast, scientists' ability to explore the brains of those stricken with Alzheimer's disease and other forms of dementia has provided insight into what occurs to those brains before death. Without any identifiable features tied to psychiatric disorders, producing effective pharmacological interventions is difficult.

Radulovic's long-term goal is to determine the mechanisms linking cognitive and emotional processes in an effort to identify novel targets for treating anxiety and depression. Her work pursues the hypothesis that disruption of molecular signaling within the hippocampus results in abnormal fear of threatening environments. If the disruptions can be identified, the brain can be manipulated to block or eliminate those fears.

Strengthening, Eliminating Memories

If you are to recall the number of neurons in the human brain—86 billion—then the mind first has to encode, consolidate, and store that fact.

To explore the role of memory consolidation—the process between acquisition and storage—**Laura Shanahan,** a student in the Northwestern University interdepartmental neuroscience PhD program, plans to use magnetic resonance imaging (MRI). The project will involve pairing a sensory cue (odor) with learning and then delivering that same cue during deep sleep. MRI, which records the blood flow in the brain as an indirect measure of neuronal activity, will allow her to observe what changes occur when odors are administered.

"Multiple studies have shown that this technique can improve memory for the learned task upon waking, but the mechanisms underlying the targeted memory consolidation remain unclear," says Shanahan, who will conduct her work in the olfaction laboratory of **Jay Gottfried,** neurology. "In theory, targeted memory reactivation could be used to enhance consolidation of important memories or reduce the effect of fearful ones."

What Shanahan is doing with odor, **Ken Paller,** psychology, has explored with sound. His laboratory's research has shown that sound can penetrate deep sleep and be used to guide rehearsal of specific information, pushing the consolidation of memories in one direction over another.

"While asleep, people are thought to process the events of the day," says Paller. "But we decided which memories our volunteers would activate, guiding them to rehearse some of what they had learned an hour earlier."

The growing body of evidence suggests that humans don't ever completely shut down their brains. Instead, they use what is considered rest to process memories, review recently acquired information, and integrate it with other knowledge.

Another way that Northwestern researchers are exploring memory is through the use of noninvasive electrical currents. **Joel Voss,** medical social sciences, is investigating ways to augment memory and cognition through transcranial magnetic stimulation (TMS). Voss and his colleagues recently demonstrated that this technique could specifically change memory functions of adult brains without surgery or drugs. The members of his laboratory measure brain function while people think and act in order to determine how

Photo by Roger Anderson

Laura Shanahan

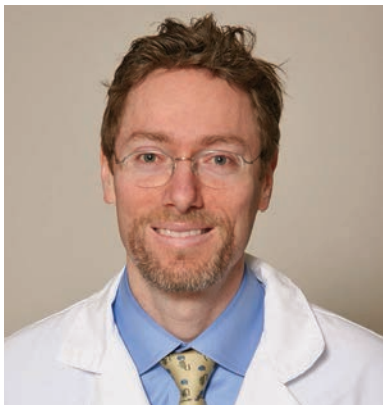


Photo courtesy of Feinberg School of Medicine

Jay Gottfried

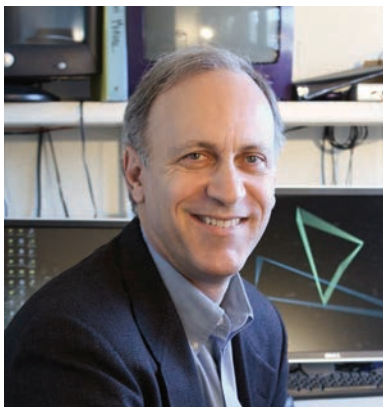


Photo courtesy of Weinberg College of Arts and Sciences

Ken Paller

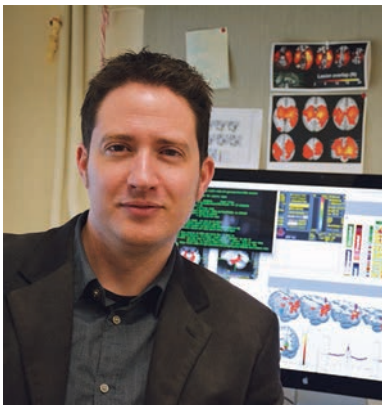


Photo by Roger Anderson

Joel Voss

different parts of the brain contribute to the ability to learn, decide, act, and adapt. "Brain regions important for cognitive abilities such as memory do not act alone. Instead, brain networks—collections of these interacting areas—work together to support cognition," says Voss, who is also featured on page 53. "Disruption of the hippocampal network occurs in many brain disorders, including Alzheimer's disease, traumatic brain injury, stroke, and psychiatric conditions such as schizophrenia and PTSD."

By indirectly stimulating the hippocampal network, Voss showed that memory could be improved. Although years of research are needed to determine whether the approach is safe or effective for patients with Alzheimer's disease and similar memory disorders, Voss says that "it opens up a whole new area for treatment studies in which we will try to see if we can improve function in people who really need it."

— Roger Anderson

©iStock by Getty Images

Computer-generated image of excited neurons.

The Brain's GPS

PLACE CELLS PROVIDE THE MEMORIES OF WHERE WE'VE BEEN

Have you ever felt like your car just drove itself to work, or realized how little thought it takes to get a cup of coffee?

These seemingly mindless tasks rely on the brain's ability to continually map its surrounding environment. Place cells—first discovered in 1971, a finding that earned John O'Keefe the 2014 Nobel Prize in physiology—act as the brain's global positioning system.

"When you look across the hundreds of thousands of cells in the hippocampus, you find that different place cells fire when the body is in different locations. The prevailing thought is that these cells are the internal representation of space," says **Daniel Dombeck,** neurobiology. "What we wanted to do was investigate a range of individual cells and their dendrites in a living model."

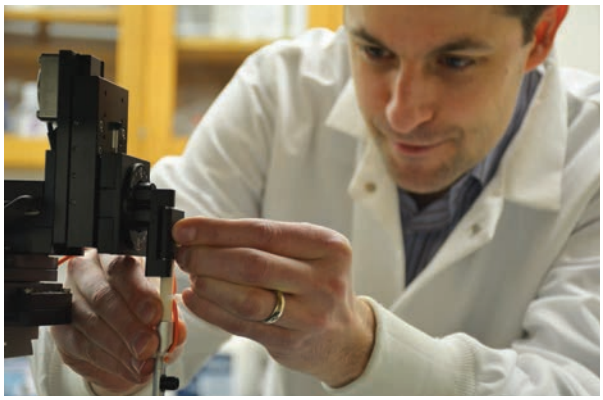


Photo by Roger Anderson

Daniel Dombeck

To do so, Dombeck and his lab had to design and build a first-of-its-kind, high-powered digital microscope. He also had to combine the microscope with a way of simulating free-range motion and a protocol to stabilize the brain for viewing.

"Part of the excitement was in developing a technique that people had been seeking for decades," he says. "By looking at the activity of the cell body in relation to that of the dendrites in behaving mice, we were able to change the way neuroscientists think of these neurons."

Dombeck and **Mark Sheffield,** a postdoctoral fellow in his lab, found that contrary to current thought, the activity of a neuron's cell body and its dendrites (the nerve cell's tree-like extensions) can differ.

Their testing was a confluence of new and old methodologies that produced stunning visuals of place-cell neurons in near real time. The researchers found that when cell bodies were activated but dendrites were not, lasting memories were less likely to be formed. The discovery suggests that cell bodies seem to represent ongoing experiences, while dendrites help to store a given experience as a memory.

To observe the living brain, Dombeck and Sheffield placed a mouse on a free-floating ball in a virtual reality environment. As the animal ran back and forth down a virtual corridor, the researchers were able to observe the action of neurons and dendrites through the microscope. As each cell fired, it activated a fluorescent highlight that had been added to the place cells to make them more visible. The team confirmed that the activation of specific place cells coincides with the animal's location, a finding Dombeck believes translates to the human brain as well.

Once the memory of a unique location is formed—like each turn on your walk to the train—the same place cells will fire whenever that journey is experienced or even visualized. This spatial navigation represents one of the most striking examples of behavioral correlation in the mammalian brain.

"One of the nice things about imaging is that no one has to blindly trust my research. I can show them the proof; an image says a thousand words," says Dombeck. "When I realized that this experiment would work, I began to shift my mindset to look for the next 'impossible' problem. Neuroscience is driven by techniques, and the engineering of solutions is where my passion lies."

— Roger Anderson

MEMORY INTENSIFIER

The hormone oxytocin appears to be the reason why stressful social situations, perhaps being bullied at school, reverberate long past the event and can continue to trigger fear and anxiety. That's because, as Jelena Radulovic discovered, the hormone actually strengthens social memory in one specific region of the brain. If a social experience is negative or stressful, the hormone activates a part of the brain that intensifies the memory. Oxytocin also increases susceptibility to feeling fearful and anxious during subsequent stressful events.

Sarki Abba Abdulkadir, MD

John T. Grayhack, MD,
Professor of Urological Research

FEINBERG SCHOOL OF MEDICINE

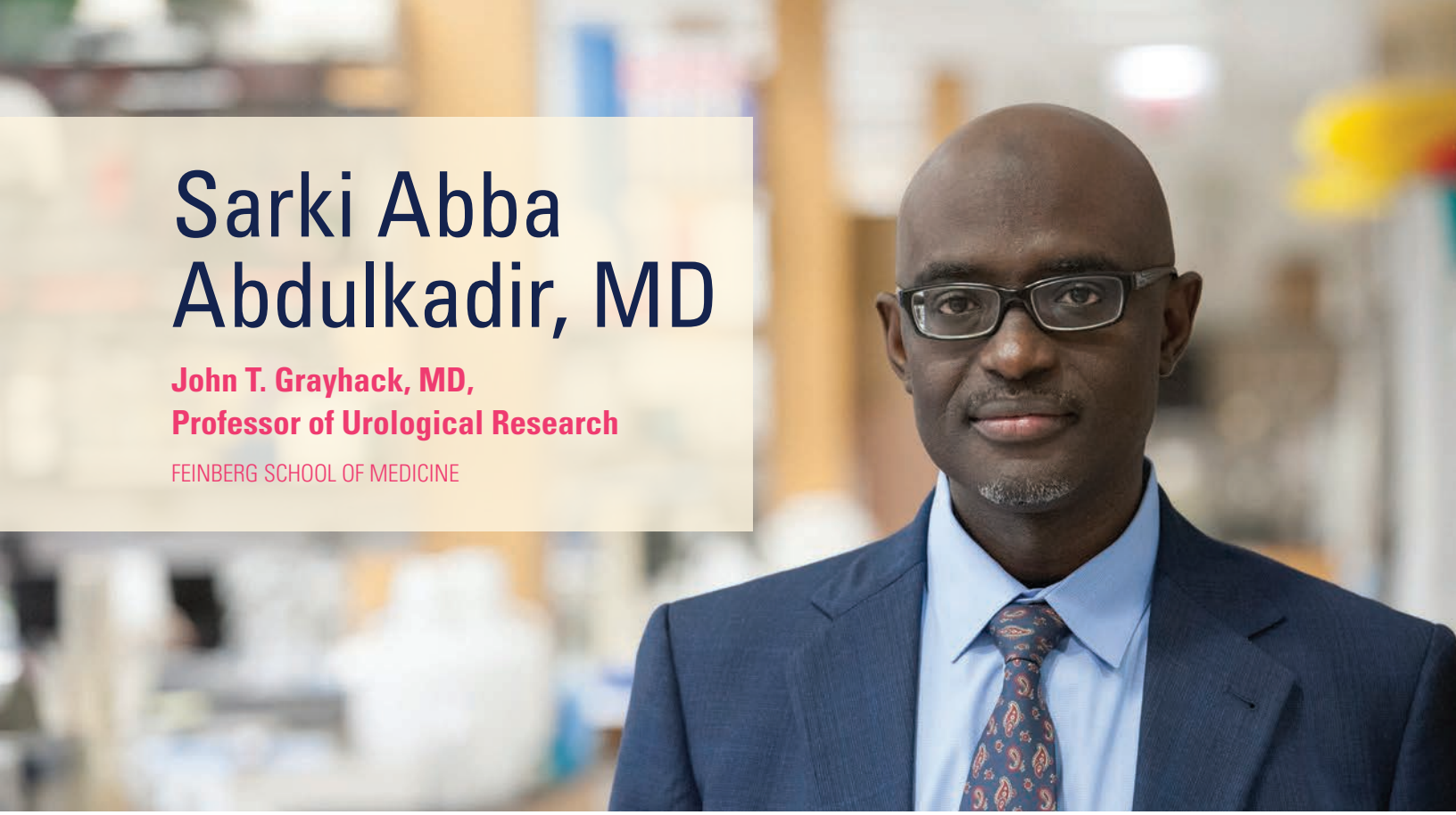
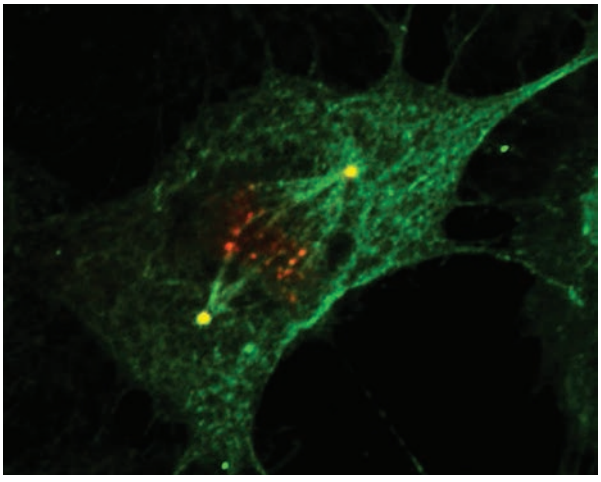


Photo by Steven Gross

Inhibiting Prostate Cancer Tumors

Sarki Abba Abdulkadir, urology and pathology, and his research group are working to understand the mechanisms by which prostate cancers initiate, progress, and recur after therapy. Their approach involves selecting cancer genes that are commonly altered in human tumors. They then model these changes as closely as possible in animal models.

One of these cancer genes—MYC—is implicated in up to 70 percent of all human cancers. High levels of MYC in cancer cells drive cancer growth and spread. Yet, despite the importance of this gene in human cancers, there are no cancer-treating drugs available to inhibit it; indeed, MYC is widely regarded as an "undruggable" target. Over the years, Abdulkadir and his colleagues' studies of how common genetic alterations transform normal prostate cells into prostate cancer have led them to a possible indirect way to therapeutically target MYC.



The image shows the location of PIM1 (green) in a dividing cell. PIM1 localizes to the polar ends of the cell (yellow dots), which are important for cell division.

They discovered that another protein, PIM1, cooperates dramatically with MYC in promoting prostate cancer development. PIM1 is a kinase—an enzyme that adds phosphate groups to proteins to modulate their function. It cooperates with MYC by modifying several proteins, including MYC itself as well as chromatin around MYC-binding sites. When researchers inactivated the kinase function of PIM1, its capacity for cooperating with MYC in promoting cancer was completely lost. Because PIM1 is a "druggable" target, this gave them the idea that inhibiting the kinase function of PIM1 with a drug may inhibit MYC-driven tumors. In a recent study in press at the *Journal of the National Cancer Institute,* they show that an orally administered small-molecule inhibitor of PIM1 kinase severely inhibits MYC-driven prostate cancers in animal models.

The work was funded by the National Cancer Institute.

Collateral and the Democratization of Credit

Collateral—property pledged by a borrower to secure the interests of the lender—is of central importance in credit markets. In particular, collateral allows the creditor to recover, at least partially, a loan made to a debtor. The ability to seize and sell collateral is one of the defining characteristics of debt financing. Both the theory and the practice of finance rely heavily on the notion of collateral for the theoretical design of debt contracts and the practical functioning of credit markets.

Efraim Benmelech, finance, has recently studied a 2004 credit reform in Brazil that simplified the sale of repossessed cars used as collateral for auto loans. In the paper "Repossession and the Democratization of Credit," published in the *Review of Financial Studies* in 2014, Benmelech and his Brazilian coauthors show that the reform—which enabled banks to sell repossessed assets more quickly—led banks to expand credit to self-employed individuals and borrowers with lower credit scores who purchased newer and more expensive cars.

The legal change has also led to larger loans with lower interest rates and longer maturities. As a whole, the results shed light on the consequences of a credit reform and highlight the crucial role that collateral and repossession play in the liberalization and democratization of credit.

The evidence in the study suggests that the ability to resell collateral enables banks to expand credit, mitigates financial shortfalls, and brings about a "democratization of credit" enabling riskier, lower-income borrowers to obtain loans at a lower cost. Although the study is based on data from one large Brazilian bank, the results suggest a broader link not limited to that one bank or to Brazil at large. The ability to repossess and resell collateral facilitates credit provision, in particular to borrowers who would otherwise be left out of credit markets.

This study was funded by a National Science Foundation CAREER Award.

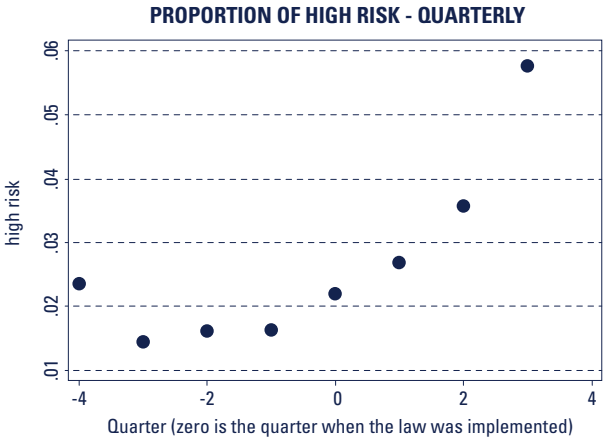
Efraim Benmelech

Harold L. Stuart Professor of Finance

Director of the Guthrie Center for Real Estate Research

KELLOGG SCHOOL OF MANAGEMENT

Photo by Veronica Hinojosa



Bruce S. Bochner, MD

Samuel M. Feinberg Professor in the Division of Allergy-Immunology

FEINBERG SCHOOL OF MEDICINE

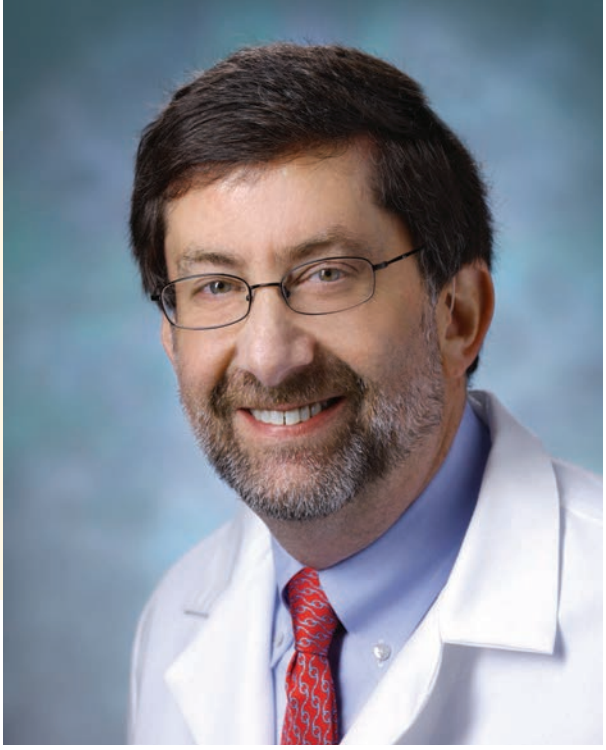


Photo courtesy of Bruce Bochner

To Kill an Eosinophil

Bruce S. Bochner, MD, allergy-immunology, studies the eosinophil, a normal but uncommon white blood cell. Its main function is to fight off parasitic infections, a benefit to the immune system. But sometimes there are too many eosinophils, or too many of them end up in the wrong organs and get activated, as in asthma and certain allergic gastrointestinal disorders. When this happens, havoc can ensue.

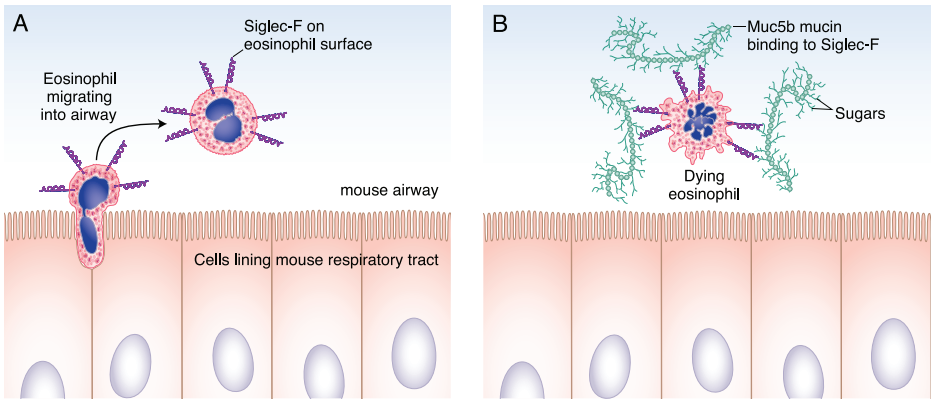
Bochner was recruited to Northwestern in August 2013 after spending 28 years at the Johns Hopkins University School of Medicine, the last 10 as chief of the division of allergy and clinical immunology. One of the few physicians in the world specializing in the diagnosis and treatment of eosinophilic disorders, he is committed to finding newer and better treatments for these conditions.

In the late 1990s, his efforts contributed to the issuing of several patents related to Siglec-8, a molecule he codiscovered that selectively marks eosinophils. What is particularly exciting is that when a specific antibody or sugar structure engages Siglec-8 on an eosinophil, it causes these cells to die, providing a potentially ideal method for getting rid of them.

His most recent work studies Siglec-F—the closest counterpart to Siglec-8 in mice. Bochner and his colleagues found that a certain type of airway mucus, the mucin Muc5b, carries just the right sugars to bind to Siglec-F and kill mouse eosinophils. This Siglec-F mucin-mediated elimination of eosinophils occurs normally in mice; mice without Muc5b, or those whose Muc5b sugars have been altered such that they can't bind to Siglec-F, develop an exaggerated accumulation of eosinophils in their airways in an asthma-like allergic lung response.

Buoyed by these and other findings, Bochner and his longstanding colleague and collaborator Robert P. Schleimer, chief of Northwestern's division of allergy-immunology, hope that Siglec-8 could someday be targeted as a treatment for eosinophil-related diseases.

This work is funded by grants from the National Institutes of Health.



Pathways for control of eosinophilic lung inflammation via sugars found on the mucin Muc5b. Eosinophils (expressing Siglec-F) are preferentially recruited into the airways during many forms of asthma and other eosinophilic lung diseases (panel A). Once in the airways, selective binding to Siglec-F of specific sugars displayed on Muc5b triggers eosinophil death, helping to eliminate these troublesome cells from the airway (panel B).

Illustration by Jacqueline Schaffer

Moran Cerf

Donald P. Jacobs Assistant Professor

KELLOGG SCHOOL OF MANAGEMENT
AND NEUROSCIENCE PROGRAM

Behavior from Deep Down in the Brain

Moran Cerf, marketing and neuroscience, studies the neural basis of our behavior: how the brain shapes our motivations, choices, memories, emotions, and consciousness.

Cerf uses a variety of tools ranging from EEG readouts from the scalp, eye tracking, biometrics and genetic markers, and fMRI, which uses magnetic fields to study the inside of the brain, and invasive methods, such as placing electrodes deep inside the brains of patients undergoing surgery. This then allows him to access the activity of individual nerve cells as the patients engage in typical behaviors such as freely making decisions, recounting events from the past, or imagining. Cerf uses the electrodes to eavesdrop on cell activity indicating the choice a patient is going to make prior to the conscious awareness of it, or to see how memories are being formed, modified, and retrieved.

This innovative method of studying the brain has enabled some groundbreaking results from Cerf's lab. For example, in looking at the internal imagination process in action to see how humans use their imaginations to override external inputs, he has effectively projected their imagined thoughts onto a screen in front of their eyes.

At Kellogg, Cerf is pioneering the new field of neuromarketing—the use of neuroscience to study consumer behavior. Businesses are increasingly interested in accessing the thought processes of the customer: to learn how purchasing decisions are being made, help predict successful products, identify the mechanisms that are used to evaluate risk in financial decisions, and understand the reasoning behind irrational economic choices. Cerf's work looks at people's thought process as they go through those actions and offers new ways to understand consumer psychology.

In one study, partnering with Hollywood studios to help measure engagement in content, Cerf measured the correlation across viewers' brains as they watched movies. This allows for sales predictions based on viewing patterns alongside neural metrics. Cerf is able to predict what content would register in viewers' memory or prompt an emotional response, ultimately allowing him to determine what makes for successful content—whether in film, TV or print ads, political campaigns, or any other type of messaging.

Photo by Evanston Photographic Studios

Photo by Moran Cerf

As published in the journal *Nature,* Cerf's work shows an ability to tap into people's thoughts by looking deep inside the brain, using electrodes implanted in patients undergoing neurosurgery for clinical purposes. His work shows how subjects' internal thoughts can be projected on a screen in front of them, helping them learn to override thoughts by sheer will.

Cynthia Coburn

Professor of Education and Social Policy

SCHOOL OF EDUCATION AND SOCIAL POLICY

Photo courtesy of Cynthia Coburn

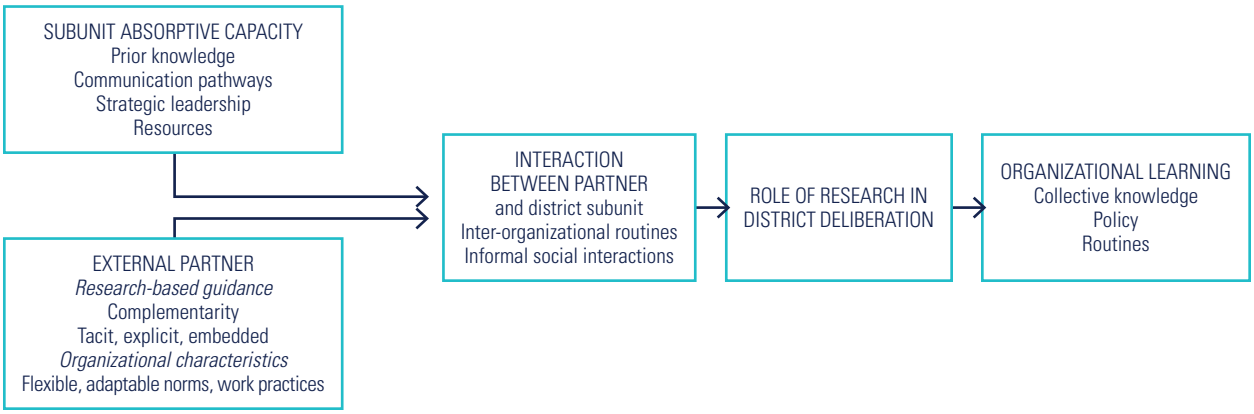
How Schools Use Research and Information

The leaders of urban school districts are tasked with providing high-quality education to students with a wide range of needs in a climate of reduced resources and increased accountability. School districts increasingly are reaching out to a range of external providers for assistance. When and under what conditions are they able to make productive use of this guidance in their decision making?

Cynthia Coburn, education and social policy, and her research group are investigating the conditions that facilitate and impede research use by school district leaders. While policy makers seeking to increase districts' use of research have focused on improving the quality of research or creating new pathways to bring research into schools and districts, Coburn's group found that organizational conditions within school districts greatly affect their ability to use external research sources. To investigate this issue, she and her colleagues drew on the concept of absorptive capacity: an organization's ability to recognize the value of new information, assimilate it, transform it, and apply it in productive ways.

Coburn and her associates have identified organizational qualities that foster urban school districts' absorptive capacity, including relevant prior knowledge, dense communication pathways, leadership, and adequate resources for engaging with external research sources. In a longitudinal study of two urban school districts, they are currently studying how variation in these organizational conditions influences the role of research in district leaders' deliberations and problem solving about mathematics instruction, and how that deliberation influences district policy and practices.

Coburn's group observed district decision makers as they grappled with how to implement the Common Core State Standards in mathematics, set new district policies on mathematics, design and provide training to teachers, and make decisions about adopting new materials. In so doing, the researchers were able to trace how a district's absorptive capacity and its interaction with external partners influenced the degree to which research ideas and approaches played an important role in its decision making about mathematics. Their work has implications for school district leaders as well as for researchers who want their work to be useful and usable.



Ancient Pigments, African Papermaking, and New Initiatives for Conservation

Two Northwestern conservators developed a research agenda that emerged from assessing the condition of Northwestern's collection of Arabic manuscripts, produced in Nigeria in the late 19th and early 20th century. Combining elements of materials science, bibliographic history, and African studies, the project led to presentations at national and international conferences and represents a significant expansion of the Library's preservation program beyond the repair and stabilization of books and other materials.

Scott W. Devine and Tonia E. Grafakos conducted research on how and when specific papers and inks were produced. This research contributes to a fuller understanding of the spread of Islam in West Africa as well as trade and economic developments in early 20th-century Nigeria.

Employing innovative analytical techniques, Devine and Grafakos collaborated with scientists at the McCormick School of Engineering and Applied Science as well as experts worldwide to identify the chemistry and material composition of the inks and papers used to produce these unique manuscripts. At the recent Tenth Islamic Manuscript Conference in Cambridge, England, they presented a paper discussing their research on Northwestern's 'Umar Falke Collection, the largest of four Arabic manuscript collections held by the Herskovits Library of African Studies. Consisting of more than 3,000 late 19th- and early 20th-century manuscripts, the Falke Collection contains original material related to all aspects of Islamic learning.

Devine's and Grafakos's work on pigment analysis revealed the use of a wider variety of pigments than is documented in the current literature. In addition, fiber analysis revealed the presence of grass and cereal straw fibers in rare Arabic script watermarked papers, indicating a collection composed of richer and more varied materials than was previously assumed and providing a framework for further research. Ongoing work with the collection will include a project to catalog the watermarked papers and additional materials analysis research centered on the manuscripts' locally produced inks and dyes.

Photo above: Scott W. Devine and Tonia E. Grafakos in the library's conservation lab. Photo below: The 'Umar Falke Collection is the largest of four Arabic manuscript collections held by Northwestern University. (Falke MS 566).

Scott W. Devine

Marie A. Quinlan Director of Preservation and Conservation

NORTHWESTERN UNIVERSITY LIBRARY

Tonia E. Grafakos

Chief Conservator

NORTHWESTERN UNIVERSITY LIBRARY

Photo by Theresa Neef

Photo by Scott W. Devine

Rebecca Gilman

Associate Professor of Radio/Television/Film

Charles Deering McCormick Professor of Teaching Excellence

SCHOOL OF COMMUNICATION

Challenging Ingrained Prejudices

Rebecca Gilman, radio/television/film, has been described as an "idea" playwright, and her work does tend to deal with larger social issues. She writes primarily in a naturalistic style, which allows her to examine the role of environment in determining character. But her plays do not simply trace a causal relationship between a character's origins and actions. Gilman also tries to examine an audience's preconceived notions of how environment shapes us and to exploit those notions to challenge ingrained prejudices and commonly held misperceptions—such as that poor people are immoral, racism is someone else's problem, or a booming economy means the end of exploitation.

The misconception that poor people are immoral became the basis for Gilman's play, *Luna Gale,* which premiered at Chicago's Goodman Theatre in January 2014 under the direction of Robert Falls. The play follows Caroline, a veteran social worker in Iowa who thinks she has a typical case on her hands: two drug-addicted teenagers accused of neglecting their infant daughter. Her first impression of the parents turns out to be wrong, however. The more she knows them, the more she understands how deeply they have been affected by neglect. In the play Caroline must make a leap of faith to trust that these young people can reform and become good parents if given a proper chance.

The dialogue Gilman hopes to create with audiences through her plays is one that she also hopes to create with her students in the classroom. Gilman encourages them to consider their roles as artists in society as a first step to discovering and refining a distinctive voice and point of view. She believes that only by discovering what they want to say can they learn how best to say it.

Photos courtesy of Goodman Theater

Colin Sphar (Peter) and Reyna de Courcy (Karlie) in the world-premiere production of *Luna Gale* by Rebecca Gilman, directed by Robert Falls at Goodman Theatre (January 18 – February 23, 2014).

Matthew Goldrick

Associate Professor of Linguistics

WEINBERG COLLEGE OF ARTS AND SCIENCES

Photo by Eileen Molony

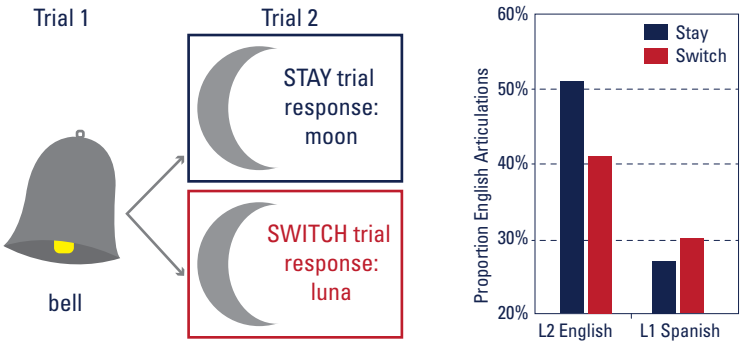
How You Think Changes How You Sound

When speaking, you must not only decide what words you're going to say—you have to articulate the sounds of words so that others may perceive them. However, most research has focused solely on the mental planning processes that lead up to initiating speech. Matthew Goldrick, linguistics, examines the interaction between these mental planning processes and what happens after you begin speaking—the articulation of speech sounds.

Bilingual language processing provides a critical window into such interactions. Goldrick's research examined how difficulties in second-language speech planning affect the degree to which articulation of speech sounds is foreign-accented. Proficient bilinguals can readily switch between languages—producing language-appropriate words (e.g., Spanish casa vs. English house) and speech sounds (e.g., pronouncing the first vowel in taxi as /a/ vs. /æ/ when speaking Spanish vs. English). However, switching is difficult. A variety of studies have shown that when bilinguals are shown pictures with a colored frame indicating which language they should use to name the image (e.g., when you see a blue frame, say moon; red, say luna), speech planning is more difficult if the speaker has to switch languages. In an English vs. Spanish stay vs. switch trial, speakers take longer to start saying the word luna when the previous response was in English.

Goldrick collaborated with Albert Costa (Universitat Pompeu Fabra) and Elin Runnqvist (Universitat Barcelona) to examine whether these effects extend to the articulation of speech sounds in Spanish-English bilinguals. Analysis of detailed aspects of their speech sounds revealed slight variations in their accents across trials; bilinguals were more foreign-accented in difficult-switch trials than in easier-stay trials. These results reveal the synergistic interactions between difficulties in speech planning and speech articulation. In ongoing work sponsored by the National Institutes of Health, Goldrick examines how such interactions might affect the speech of others who also have difficulty retrieving words from memory.

This work was supported by a CAREER Award from the National Science Foundation.



Left panel: Sequence of two trials in the language switching paradigm.Right panel: Native Spanish speakers' productions in the switching paradigm. On switch trials, they were more likely to produce the wrong pronunciation of the speech sound.

Cara Gottardi

Associate Professor of Medicine: Pulmonary and Critical Care

FEINBERG SCHOOL OF MEDICINE

Cell Adhesion in Health and Disease

Research in the laboratory of Cara Gottardi, medicine: pulmonary and critical care, focuses on gaining a deeper understanding of the mechanical properties of cells within tissues. Her research centers on a protein complex that projects from the cell surface, constituting a structural "Velcro" that holds cells to one another. This cadherin/catenin complex serves as the major cell-to-cell adhesion system in the human body.

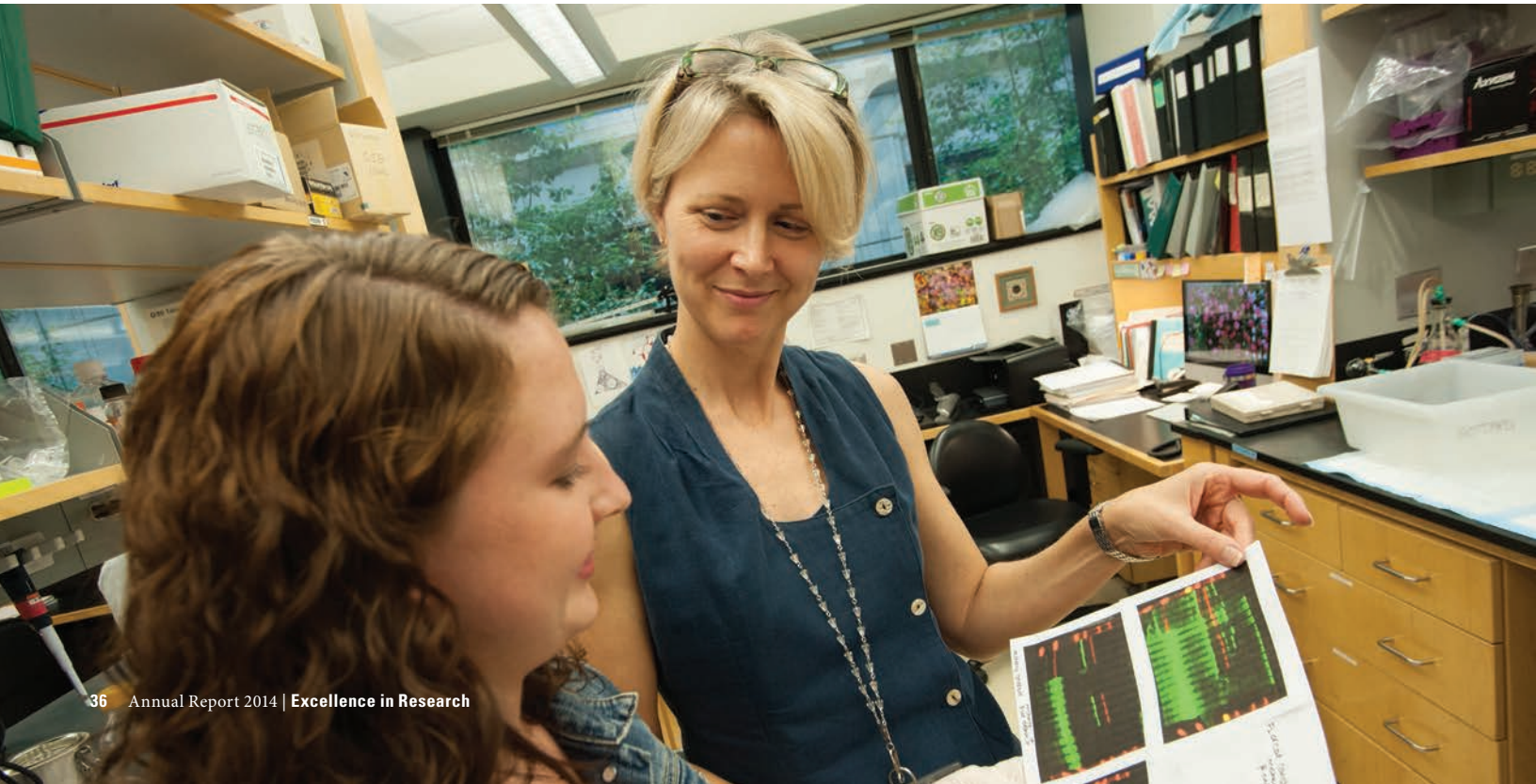
Gottardi has seen that mechanical tension structurally alters the cadherin/catenin complex, resulting in different protein-binding characteristics that lead to changes in the macromolecular structure of adhesions. A cell's stiffness might promote tissue proliferation and may serve as a biomarker for the potential for metastasis and organ fibrosis or scarring. Thus, her research seeks to understand how cadherins and catenins respond to changes in tension and how these changes are conveyed to a cell's interior to coordinate developmental cell behaviors—such as cell-on-cell migrations or intercellular changes that cause tissue elongation and disease.

She and members of her laboratory have recently validated a handful of genome-wide association studies linking a particular catenin variant to asthmas. Using a mouse model lacking this catenin, they have induced these asthmas by exposure to certain chemicals. The surprise is that this particular catenin variant is almost exclusively found in heart cells, suggesting that cardiac cell-junction dysfunction, and the accumulated mechanical stress to these junctions as we age, may underlie certain forms of asthma.

Since a widely used heart medication curiously improves lung function in asthmatics through a poorly understood mechanism, Gottardi and her colleagues may be able to unravel the relationship between cardiac cell-junction function, lung physiology, and asthma susceptibility as a guide to future heart cell–directed therapeutic strategies. The researchers' longstanding collaborations with biophysicists, crystallographers, developmental biologists, and physicians allow their projects to achieve a more integrated view of cell contact and adhesion in health and disease.

Their work is supported by the General Medicine and Heart Lung and Blood Institutes of the National Institutes of Health and by the American Heart Association.

Photo by Bruce Powell



Khaled Hroub

Professor in Residence

NORTHWESTERN UNIVERSITY IN QATAR

Photo courtesy of Khaled Hroub

Photo by Alisdare Hickson via Flickr

The Arab Uprisings and Arab Activist Media

The first year of the 2010–11 Arab Spring witnessed the Arab media's finest hour, according to Khaled Hroub, Middle Eastern studies and Arab media studies. It was a moment of immediate and remarkable ad hoc synergy between the TV screen and the smartphone screen: traditional media and social-activist media. Neither of these two media alone was able to convey the rapidly unfolding developments to the "masses" across the related countries and externally. The immediate creative process that made the media an astonishing part of the Arab uprisings was the spontaneous integration between broadcasting and social media, offering round-the-clock inclusive coverage. Social media picked up small and off-the-beaten-track events, tactics, stories and/or mobilization instructions, and the broadcasting media (such as Al-Jazeera) relayed it all on the broadest scale. This functional complementarity was characterized by:

Mobilization and mobility: Social media enabled Arab Spring activists to mobilize people, organize events, and create immediate and energized networks, while staying mobile. Activists were able to remain instantly informed nationwide while reporting and covering their own "hot spots" without any dependence on fixed equipment—freeing people from staying stuck in front of a TV screen to follow the latest developments.

Uncontrollability: Activist journalism's coverage of the Arab uprisings challenged state control and government surveillance technologies because of its widely spread nature and intensive use by vast numbers of people. Unlike traditional media, whose designated correspondents could easily be monitored or even banned, activist journalists and mobilizers outpaced state security skills and surveillance, gaining a clear technological advantage.

Inclusivity: Social media devices, applications, and tools have become extensively and easily available, offering an unprecedented degree of immediate coverage of events and locations. With seeming suddenness, everyone with a smartphone—even in the most remote areas—could become an activist journalist.

Affordability: Activist journalism is an affordable practice wherein the chief tool of the in-field social media is the camera-equipped mobile phone, an affordable item already carried by the vast majority of people. No expensive, highly sophisticated machines or operations were required for reporting and covering events.

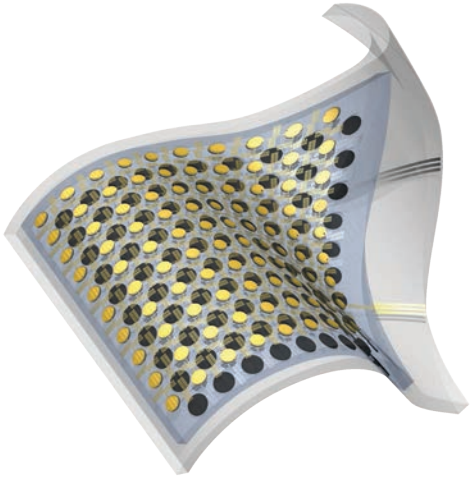
February 10, 2011. One of the biggest problems with using a camera or phone during the revolution was running out of power and being far from home or any power source. Here a shop allows protesters to use its supply to charge phones.

Yonggang Huang

Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering

MCCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE

Photo by Jason Brown



Schematic illustration of a completed device for the stretchable lithium-ion battery, in a state under complex loading with both stretching and bending. Illustration by Prof. Yonggang Huang and Dr. Yihui Zhang

Stretchable Electronics

Yonggang Huang, mechanical engineering and civil and environmental engineering, and his collaborator John A. Rogers from the University of Illinois are the first to demonstrate a stretchable lithium-ion battery—a flexible device capable of powering their innovative stretchable electronics. Huang led the research focused on theory, design, and modeling, while Rogers led the group conducting the experimental and fabrication work.

No longer needing to be connected by a cord to an electrical outlet, these stretchable electronic devices could potentially be used anywhere, including inside the human body. The implantable electronics could monitor anything from brain waves to heart activity, succeeding where flat, rigid batteries would fail.

Huang and Rogers have demonstrated a battery that continues to work—powering a commercial light-emitting diode (LED)—even when stretched, folded, twisted, and mounted on a human elbow. The battery can operate for eight to nine hours before it needs recharging.

This new battery allows true integration of electronics and power into a small, stretchable package. Huang and his collaborators start with multiple battery components side by side in a very small space and then connect them with long, tightly packed, wavy wires. These wires provide the flexibility; when the battery is stretched, the interconnecting lines unfurl, much like yarn unspooling. Even when they stretch a great deal, the device remains a working battery.

The power and voltage of the stretchable battery are similar to those of a conventional lithium-ion battery of the same size, but the flexible battery can stretch to as much as 300 percent of its original size and still function. The stretching process is reversible. And the battery can be recharged wirelessly: The design allows for the integration of stretchable inductive coils to enable charging through an external source but without a physical connection.

Kirabo Jackson

Associate Professor, Human Development and Social Policy

SCHOOL OF EDUCATION AND SOCIAL POLICY
FACULTY FELLOW, INSTITUTE FOR POLICY RESEARCH

Photo by Veronica Hinojosa

Does School Spending Improve Student Outcomes?

Social scientists have long studied the educational policies, practices, and structures that aim to promote the production of human capital—the skills and knowledge embodied in the ability to work and produce economic value. Recent research by Kirabo Jackson, human development and social policy, and his coauthors tackles the foundational question in this field: Does money matter?

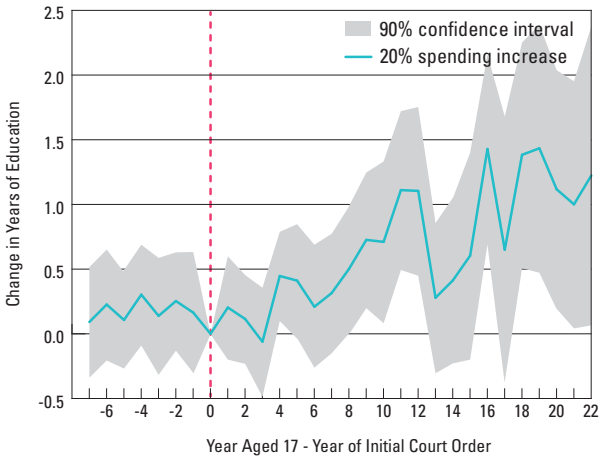
After the influential *Coleman Report of 1964* showing that differences in school resources are unrelated to differences in student test scores, many have questioned whether increased school spending can improve student outcomes. Jackson and his colleagues point out that because much state aid to local districts since the 1960s has been compensatory, districts that receive larger increases in school spending over time are often those that are experiencing deteriorating student outcomes for other reasons (such as neighborhood decline). This means that simple comparisons of changes in spending and changes in outcomes likely confuse the effect of spending with the effect of neighborhood decline.

To avoid this problem, Jackson's research team compiled detailed information on the timing of the passage of state school finance reforms and used this information to identify school districts that experienced sudden changes in school spending at the time the reforms were enacted. Importantly, the results show that such sudden changes in spending, resulting from the enactment of reforms, are unrelated to underlying changes in neighborhoods.

Jackson and his coauthors then link these data to longitudinal data on a nationally representative sample of children born between 1955 and 1985 and followed into adulthood. The authors find that cohorts who were between the ages of 5 and 17 at the time of reforms had much better outcomes than those who were 18 or older when reforms were passed (see figure at right). They find that reform-induced increases in per-pupil spending correlate with increased high school graduation rates and educational attainment for poor children. Importantly, such students as adults enjoyed higher earnings and family income and were less likely to be in poverty themselves.

This research was funded by the National Science Foundation.

EFFECT OF COURT-ORDERED SCHOOL FINANCE REFORM ON EDUCATIONAL ATTAINMENT, POOR KIDS



Joe F. Khalil

Associate Professor of Communication

NORTHWESTERN UNIVERSITY IN QATAR

Photos courtesy of Joe Khalil

Youth-Generated Media and the Arab Uprisings

It is a great time to be studying youth movements and media. As the means of producing media becomes cheaper and more accessible, youth are appropriating these tools to produce messages in nontraditional forms. Alerted by classroom experiences, Joe Khalil, NU-Q communication program, set out to investigate the motivations and methods behind young people's development and circulation of media in nontraditional forms. Focused on the Arab region with its significant youth demographic, Khalil's methods combine oral history and ethnography with analysis of artifacts collected over the past decade.

Between 2005 and 2009 Khalil conducted fieldwork in Saudi Arabia and Lebanon, asking simple questions (such as "Why do you do what you do, and how do you do it?") to collect narratives from graffiti artists, video makers, rappers, bloggers, and political activists. By introducing the concept of youth-generated media into his research, he aims to identify the multitude of communication forms that young people develop. These media include, but are not restricted to, songs, videos, graffiti, murals, blogs, and performance art by young people without or with the support of adults.

The youth-led social movements of 2010's so-called Arab Uprisings coincided with Khalil's first year at NU-Q. With classes such as Alternative Media in the Middle East, he involves students in conceptual discussions and research activities on how these media have been instrumental in maintaining collective memory (Palestine), crystallizing political dissent (Egypt), sustaining a national identity (Kurds, Berbers), and reflecting the demands of social movements (Lebanon, Egypt) and individuals (Saudi Arabia, United Arab Emirates).

"Point for the collection of photos and videos." Tahrir Square, 2011.

As a research fellow at the London School of Economics from 2012 to 2014, Khalil examined youth-generated media as acts of cultural citizenship. He argues that these self-expressive artifacts can help us understand changing social, cultural, economic, and political practices in the contemporary Middle East. As a 2013–15 grantee of the Arab Council for Social Sciences, he is investigating the emerging relationships between the evolving youth-generated media and the traditional mainstream media (radio, television, film) in the context of the Arab Uprisings.

Khalil is currently working on a book on this issue while actively engaged in commenting and consulting on various aspects of the media industry.

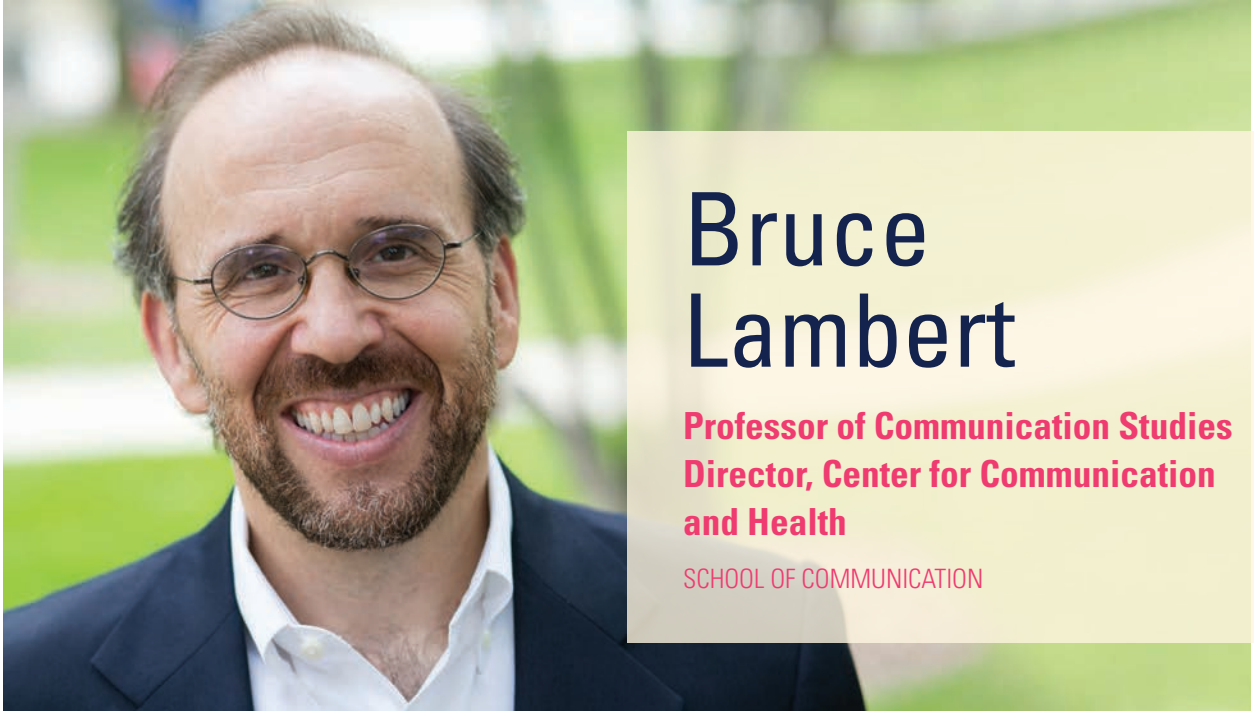


Photo courtesy of Bruce Lambert

Bruce Lambert

Professor of Communication Studies
Director, Center for Communication and Health

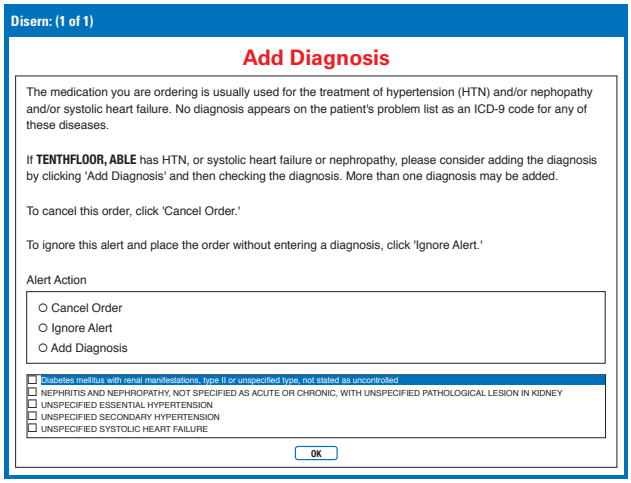
SCHOOL OF COMMUNICATION

Automating Patient Safety

The mission of the School of Communication's new Center for Communication and Health is to improve the quality and safety of healthcare as patients experience it, to improve the health of populations, and to reduce the cost of care by applying the interdisciplinary tools of the communication arts and sciences to the most pressing challenges in healthcare. The center's director, Bruce Lambert, leads a large interdisciplinary research team that focuses on making medication use safer.

In the United States, hospitalized patients experience an average of one medication error per patient per day. One common type of error is the so-called wrong-patient error, when one patient gets the medication intended for another. Doctors now order the vast majority of medications and lab tests by computer, using computerized physician order-entry (CPOE) systems. These CPOE systems are built into electronic medical records, and many of the systems allow doctors to open more than one patient's record at a time, each in a separate tab, much as one might open multiple tabs in a web browser.

This multiple-tab capability is a potential threat to patient safety, because doctors can, and sometimes do, forget which patient's record they are in and then order Mr. Smith's medicine while in Mr. Johnson's record. One way to stop this is by warning doctors when they attempt to order a medicine for a disease that the given patient doesn't have. With collaborators at the University of Illinois at Chicago, Lambert and his colleagues implemented a simple set of alerts in UIC's CPOE system to give this type of warning (see figure above), and it effectively intercepted wrong-patient errors.



They found that about 1 out of every 4,000 of these alerts prevented a wrong-patient error. In the other 3,999 cases the doctor was ordering medicine for the right patient, but the patient's medical record was missing a diagnosis, which the alert prompted the doctor to add—thereby improving the quality and completeness of the patient's record.

Interfaces to electronic medical records are critical to the quality of human-computer interaction in healthcare settings. This type of research reflects one of the major themes of the center's work: to improve the safety of medical care by improving the quality of computer interfaces.

This work was funded by a contract from the US Agency for Healthcare Research and Quality.

Yoram Lithwick

Assistant Professor of Physics and Astronomy

Member, Center for Interdisciplinary Exploration and Research in Astrophysics

WEINBERG COLLEGE OF ARTS AND SCIENCES

Photo by Veronica Hinojosa

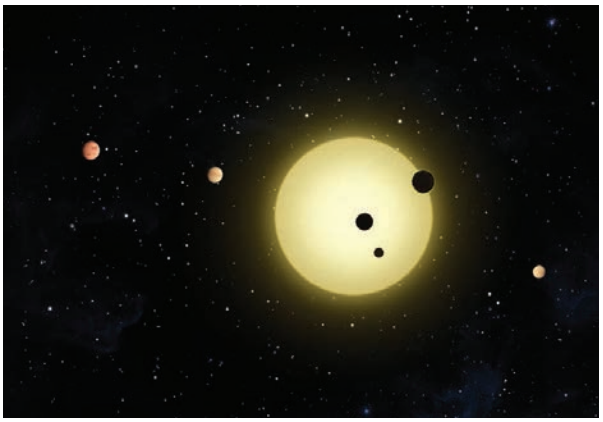


Photo by NASA/Tim Pyle

Kepler-11 is a star orbited by six planets. This artist's conception shows the star as three of its planets transit simultaneously.

Compositions of Exoplanets

Until around 20 years ago, the only known planets were the eight in our solar system. Since then, astronomers have discovered thousands of exoplanets—planets that orbit stars other than the Sun. As a result, scientists are beginning to address age-old questions: How unique is our solar system? Are there planets beyond Earth that are suitable for life?

Although many exoplanets have been found, much remains unknown about them, including their makeup: Are they mostly rock like Earth, or mostly ice and gas like Neptune? Yoram Lithwick, physics and astronomy, and members of his group have measured the masses of 56 exoplanets smaller than Neptune. These measurements greatly expand scientists' knowledge of sub-Neptune exoplanets, because once the mass is known, the density can be determined and the composition of the planet inferred. Lithwick found that planets only a few times bigger than Earth are covered in a lot of gas—their gas atmospheres are millions of times more massive than Earth's. This indicates that these exoplanets formed very quickly after the birth of their star, while the star was still surrounded by a gas disk. By contrast, Earth likely formed much later in the lifecycle of the Sun, after its gas disk had disappeared.

To measure exoplanet masses, Lithwick used times of transit. A planet that transits in front of its star during its orbit blocks some of the star's light, and the time when that happens can be measured accurately. When a star has two orbiting planets, they tug on one another gravitationally, which slightly alters their times of transit. Lithwick was thus able to use observed times of transit to infer the strength of the gravitational tugs, and hence the planets' masses.

Understanding the composition of exoplanets helps unravel the mystery of their origin. However, the discovery of so many planets has created a wealth of new challenges that Lithwick and his group have only begun to explore.

This work is supported by the National Science Foundation and the National Aeronautics and Space Administration.

Too Hot to Handle

When things get too hot, that's a problem for electronic systems of all shapes and sizes. When chips in your smartphone get too hot, the device literally burns your hand. Chips in a supercomputer get too hot, too, and their cooling systems end up burning a lot of money on electricity bills. Cooling costs are starting to dominate total expenses in datacenters, ranging from 30 to 60 percent of the total electricity charges.

Seda Ogrenci-Memik, electrical engineering and computer science, and her group develop tools, methods, and devices to manage, sense, and dispose of heat accumulated in integrated circuits and the rest of computing systems. Her efforts range from enabling thermal-aware operating systems for supercomputers to devising thermal management software for reducing heat-induced discomfort in smartphones.

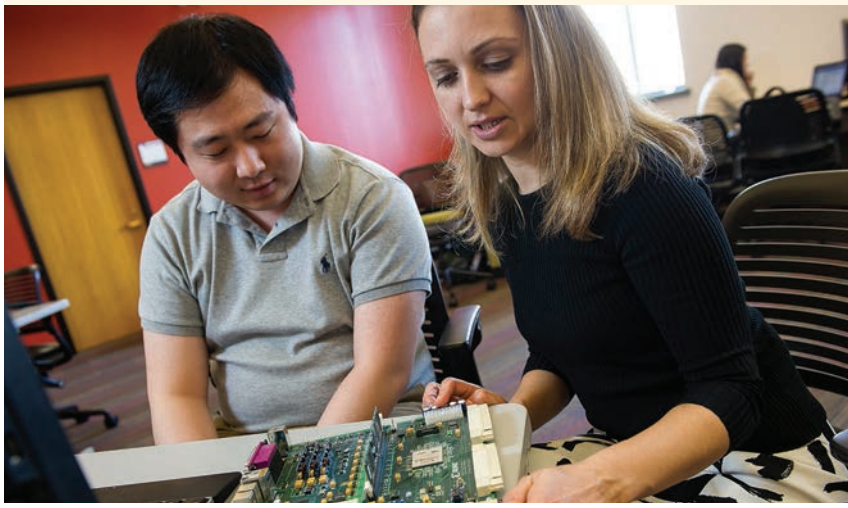
Ogrenci-Memik's team develops thermal models and run-time temperature prediction mechanisms. In the past her thermal models have been embedded into dynamic random-access memory (DRAM) management to optimize data layout so that fewer access requests are sent to hotter memory banks. One of her current projects, in collaboration with Argonne National Laboratory, focuses on providing hints to a supercomputer's operating system on the thermal consequences of its job allocation policies. For instance, constantly pounding on a hot rack with high-intensity computing jobs would make the system slow down when the heat-induced leakage power wasted by that rack's chips begins to snowball, leaving much less power available for crunching numbers. With proper guidance, when allocating computing jobs that need to be well synchronized, the operating system can successfully avoid allocating them on racks of wildly different temperatures and, hence, execution speeds.

Ogrenci-Memik also applies her expertise on thermal-aware design to new ways of sensing and monitoring chip temperatures. Her team develops novel nanoscale sensors, using thin film materials that can be layered between stacks of semiconductors and effectively organized as a large thermal monitoring network.

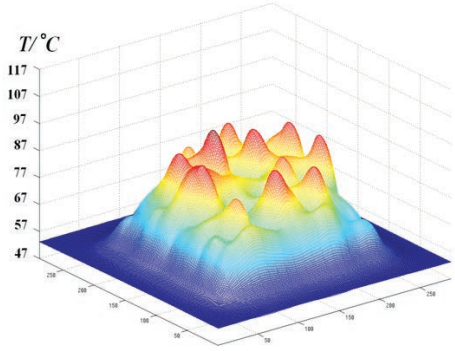
Seda Ogrenci-Memik

Associate Professor of Electrical Engineering and Computer Science

MCCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE



Seda Ogrenci-Memik and Dawei Li (a PhD student from her lab) examine a computer board to gain insights on how to model the air cooling mechanisms used for the on-board chips. Photo by Jason Brown



Thermal behavior can vary drastically both temporally and spatially within a processor chip. This image illustrates the temperature distribution within a multicore processor chip under a heavy workload. High temperature peaks denote the so-called hotspots. All modern processor chips are equipped with thermal sensors, which trigger a forced slowdown on the entire chip or parts of it, in an attempt to maintain the temperature of the hottest point on the chip below a predetermined threshold. This inevitably hurts performance, especially when a few localized hotspots dominate the thermal response due to uneven activity distribution across system components.

Adilson E. Motter

Charles Morrison Professor of Physics and Astronomy

WEINBERG COLLEGE OF ARTS AND SCIENCES

Photo by Eileen Molony

The Answer Is the Network. What Is the Question?

Imagine a world without power grids, the Internet, transportation infrastructure, banking systems—without social structure, ecosystems, biogeochemical cycles—without life. These are just some of the many components that the world would be missing had it been devoid of complex systems. A complex system is a system that is made up of a large number of interacting parts and that exhibits collective behavior that cannot be inferred from the behavior of the parts themselves.

Adilson E. Motter, physics and astronomy, points out that these are systems in which the interactions can be at least as important as the parts in determining collective behavior. Think of graphite, diamond, and graphene, which have fairly different physical properties. They are all made up of the same parts—carbon atoms—but with differing networks of interactions between those parts, which makes all the difference.

Complex systems lend themselves naturally to be modeled as networks. The study of networks is not new but has flourished over the past decade, fueled by the availability of vast amounts of new information. The novelty lies in scale and complexity and in the development of new quantitative approaches.

Motter has focused on using theoretical and computational approaches to control complex networks underlying important physical and biophysical systems. Work done in his group can be used, for example, to control cascading failures in infrastructure systems and to identify potential therapeutic targets for the development of new drugs. In addition to the control of existing networks, his group has developed "control-by-design" to create systems with unprecedented physical properties, such as the first material that can contract in response to increased tension.

Motter's strategy is to design the relevant network for a desired response to a simple control input, such as the change in applied force; this is the inverse of the standard control problem in which the system is given and the control input is designed. His approach reaches beyond materials design. It can be used, for example, to create lab-on-a-chip microfluidic systems that require no external controllers—another part of Motter's current research portfolio.

His research is funded by National Institutes of Health, National Science Foundation, and Army Reserve Office.

Justin Notestein

Associate Professor of Chemical and Biological Engineering

MCCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE

Photo by Sally Ryan

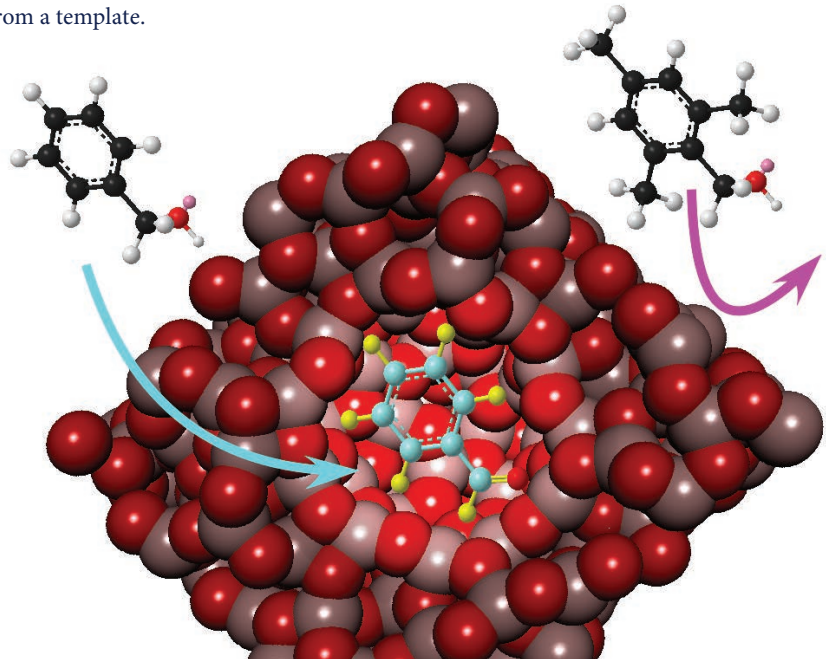
New Catalysts for Sustainable Chemistry

Nearly a third of global gross domestic product is made possible by catalysts: They are essential to the production of the materials we use, the medicines we take, and the fuel we consume. Justin Notestein, chemical and biological engineering, and his group are working to understand and develop a variety of new catalysts, with an emphasis on making products or processes that are more sustainable. Many of the challenges undertaken by the group are managed through successful industry-university and intra-Northwestern collaborations.

These challenges include designing catalysts that will enable the manufacture of commodity plastics without the use of toxic intermediates, and those that will lower automobile emissions while simultaneously improving gas mileage and eliminating the use of costly precious metals. In other projects, materials have been designed to efficiently trap CO_2 from the air or to extract biofuels from solution. Recent areas of interest include harnessing solar energy for the selective synthesis of useful molecules and—a grand challenge—artificial photosynthesis to make new fuels from waste CO_2.

On a more fundamental level, the group is developing new methodologies for catalyst synthesis and understanding that are precise to the atomic scale. These innovations include developing methods to count the metal atoms that are active in typical catalyst formulations (often a tiny percentage), and building novel catalysts where up to 100 percent of the metal is active.

Finally, the group has developed new ways for synthetic catalysts to mimic biology. Using the "nanocavities" shown below, synthetic solid catalysts can selectively react with only one molecule out of a complex mixture or (like oysters producing pearls) grow nanoparticles of a specific size starting from a template.



Schematic of a "nanocavity" catalyst 2-nanometers in diameter that, by virtue of its precise structure, can react selectivity with one molecule in a mixture, mimicking biological modes for selective catalysis. These nanocavities can also be used to template the growth of other metal nanoparticles.

Jide Nzelibe

Harry R. Horrow Professor in International Law

SCHOOL OF LAW

Photo courtesy of Jide Nzelibe

Foreign Affairs, the President, and the Constitution

At a time when the president's authority in foreign affairs is often in the headlines, Jide Nzelibe, law, stresses the importance of understanding how such authority is constrained in practice. A widespread view is that presidents usually prevail in expanding their foreign affairs authority because they face little or no resistance from Congress or partisan groups. By contrast, Nzelibe argues that because the allocation of foreign affairs authority can shape policy outcomes in ways that create losers and winners, partisan groups often fight over the scope of such authority, regardless of the occupant of the White House. Thus, members of Congress from dovish constituencies may prefer constraints on presidential war powers, even under a dovish President.

Such an approach helps illuminate certain historical puzzles, such as why presidents have often faced constraints on their foreign affairs authority from their copartisans in Congress or received support for expanding their authority from the political opposition. It was President Eisenhower's fellow Republicans in the Senate, for instance, who proved to be the biggest thorn in his side in the early 1950s when he sought authority to negotiate human rights treaties. Similarly, in the 1990s Republicans in Congress were solicitous toward expanding President Clinton's international trade authority and war powers, but he often faced significant resistance from congressional members of his own party.

The constitutional structure of US foreign affairs has other surprising implications. In a 2007 project, Nzelibe argued that requiring congressional authorization of wars might actually have a perverse effect. Rather than minimizing the impulse to rush into imprudent wars, congressional authorization might sometimes produce the opposite result: because such authorization allows the president to spread the political costs of potential military failure among other elected officials, it might lead the president to enter more high-risk wars than if he had to act always unilaterally.

Mary Pattillo

Harold Washington Professor of Sociology and African American Studies

WEINBERG COLLEGE OF ARTS AND SCIENCES

Photo courtesy of Mary Pattillo

The Limits of Choice

Chicago is known for its contentious and controversial politics and policies. This is no less true in the realm of public school reform. Mary Pattillo, sociology and African American studies, has been studying one aspect of school reform that has gained considerable popularity: school choice.

In Chicago and other cities across the country, students are no longer simply assigned to their neighborhood schools. Instead, there is a marketplace of schools, and parents and children are encouraged to choose among a panoply of options—some with curricular emphases, some offering international baccalaureate classes, some requiring high test scores for admission. The assumption is that choice will empower parents to demand more of schools, resulting in higher school quality all around.

In a paper forthcoming in the journal *Du Bois Review,* Pattillo asks: What does this policy look like from the perspective of the low-income African American families who make up a large percentage of the Chicago Public Schools population? What she finds is not nearly as hopeful as policymakers' predictions.

First, many parents did not even know they had a choice. Nearly half of the parents with teenagers entering a poor-performing neighborhood high school said they had been assigned there, sometimes against their preferences. When families did try to exercise choice, they faced significant barriers. Transportation challenges, poor health, caregiving responsibilities, unpredictable or inflexible work schedules, finances, and single parenthood all made it hard to search for high schools. Finally, most parents described the process as "being chosen" (or not chosen) rather than choosing. Paperwork, deadlines, testing requirements, enrollment lotteries, and admissions decisions were all under the control of schools, not parents.

In the end, Pattillo found that choice represented a significant burden for many parents and frequently did not lead to better school outcomes. She urges school district leaders to recognize the limits of choice for many Chicago families and to offer high-quality school options that are accessible to parents and students without undue burdens or barriers.

Jelena Radulovic, MD/PhD

Dunbar Professor of Bipolar Disease

Asher Center for the Study and Treatment of Depressive Disorders

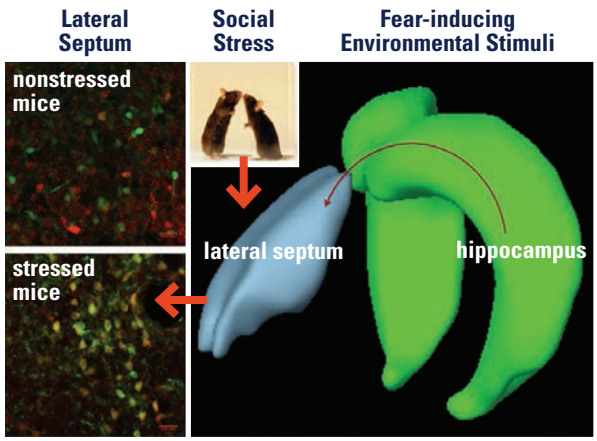
FEINBERG SCHOOL OF MEDICINE

Photo by Steven Gross

Memories Can Prompt Anxiety and Depression

Fear and anxiety arise in the face of real or perceived danger and often guide behaviors essential for survival. They can also be triggered by memories of past stressful experiences, and when the associated stress is overwhelming, the emotional reaction can become excessive, leading to debilitating psychiatric disorders such as dissociative anxiety and posttraumatic stress disorders.

The main goal of work in Jelena Radulovic's lab—psychiatry and behavioral sciences—is to establish how memories of aversive events become a gateway to anxiety and depression. Using genetic mouse models, the research focuses on the molecular mechanisms by which stress-related memories are encoded in the hippocampus, a brain area required for memory formation, exploring how these memories are retrieved or modulated within the subcortical and cortical areas receiving hippocampal inputs. Recent results indicate that in one of these areas—the lateral septum—oxytocin, popularly referred to as "the love hormone," intensifies the encoding of negative social memories, resulting in an enhanced fear in response to future stress. This is an important finding, because chronic social stress is one of the leading causes of anxiety and depression; oxytocin might play a role in their genesis.



Oxytocin receptor-positive neurons are not activated (green) in nonstressed mice but activated (yellow) in stressed mice, intensifying fear in response to future environmental stress.

The lab is also engaged in a translational program designed to identify the mechanisms by which stress-induced neurotransmitter systems interact. The findings of preclinical models are validated in lymphocytic preparations obtained from patients suffering from affective disorders. Radulovic hopes that her work will unravel fundamental mechanisms relating to stress, fear, and memory, thereby contributing to the development of novel treatment targets for affective disorders.

This research is funded by the National Institutes of Health (grants R01 MH078064 and R21 MH098793), a Ruth Dunbar Davee Professorship, and the Ken and Ruth Davee Award for Innovative Investigations in Mood Disorders.

William Reno

Professor of Political Science

WEINBERG COLLEGE OF ARTS AND SCIENCES

Rebel Governance

Rebel leaders everywhere deal with factional splits in their ranks and wayward behavior among their fighters. This is especially true of contemporary rebels fighting in societies where divisions are especially deep and militarized. In this kind of environment, rebel group organization and behavior usually reflect these societal divisions. But is this always true? Can a rebel leader find a formula to build a cohesive organization that is focused on a program bridging these social divides? Although the great majority of rebels fail or do not even attempt to overcome these challenges, a few are able to manage factional splits and maintain internal discipline while advancing a coherent political agenda that attracts members and supporters from across social divides.

Will Reno, political science, has argued that while social fragmentation has always challenged rebels, this is a more serious issue in contemporary failing states. Governments in Somalia, Sudan, Libya, Syria, and comparable nations have cultivated community tensions, often arming all sides as part of a divide-and-rule strategy of regime survival. As these regimes collapse, rebel groups usually reflect this armed social tension. In these environments, how do the rare rebels pull off the feat of cohesive organization? Through field research in Somalia, Sudan, and Afghanistan, including extensive time with current and past rebel leaders, Reno has found that the rebels' leadership positions in the preconflict regimes' patronage networks shape their capacity to pursue broad political strategies. Also enhancing this capacity is their selective infiltration of the very states they fight. Through this research Reno hopes to discover how new institutions and ideas about governance appear and what they will look like in places that currently seem ungovernable.

Photo courtesy of William Reno

Todd Rosenthal

Associate Professor of Theatre

SCHOOL OF COMMUNICATION

Photo by Steven Gross

Scale model of Todd Rosenthal's set design for *The Seagull* at Chicago's Goodman Theatre

An Organic Seagull

In his original set designs for the Goodman Theatre's production of Chekhov's *The Seagull,* Todd Rosenthal, theatre, explored naturalistic architecture. He and the director, Robert Falls, spent a good deal of time looking at images of 19th-century Russian country estates. But—not wanting the play to feel like a museum piece behind glass—they feared that heavy, naturalistic costumes and scenery would visually weigh down the production.

Then Rosenthal and Falls discovered a wonderful book, Leonid Andreyev's *Photographs by a Russian Writer: An Undiscovered Portrait of Pre-Revolutionary Russia,* offering exquisite color photographs of late 19th-century Russian country life. The images in the book were not staged; they were real people in domestic spaces wearing real clothes. It was as close to candid photography as Rosenthal had seen from this period.

Rosenthal decided to abandon realism, evoking the color and texture of Russian farmlands abstractly and creating a more open landscape to bring focus to the performers. He derived his inspiration from German abstract artist Anselm Keifer, who creates evocative paintings using authentic organic materials.

The final design for the Goodman's Owen Theatre featured a simple wooden platform positioned at an angle. Abstract artwork composed of real materials from the Russian countryside (straw, mud, wood) filled the back wall. A discarded samovar, downstage in the mud, was the only remnant of Rosenthal's original design. The actors never left the stage; when they weren't performing, they sat on benches against the upstage wall. No rigid scenic artifice separated the audience from the cast. The abstract scenery complemented the fluidity of the staging, which changed every night according to the whim of the actors—each performance was unique.

Race and Judicial Discretion

Do federal judges discriminate on the basis of race? The United States Sentencing Guidelines, enacted in 1987, constrain judicial discretion and are premised in part on concerns about racial bias. But even under the constraints of the guidelines, studies of federal sentencing have found that great racial disparities have persisted.

In theory, judicial discretion could exacerbate or mitigate racial differences in sentences. Some biases emanate from the structure of the guidelines, such as more severe penalties for possession of crack versus powder cocaine. Statutory mandatory minimums, which are binding on federal judges and operate independently of the guidelines, require harsher penalties for drug crimes and offenders with prior criminal histories. Other actors in the system, including prosecutors, also exercise significant discretion, especially in charging decisions. Judges could exercise discretion to offset disparities emanating from prosecutorial discretion or from sentencing policies that have disparate impacts.

Previous research by Max Schanzenbach, law, had indicated that racial differences in sentences were not correlated with the race, gender, or political party affiliation of federal judges. Recent sentencing-law changes imposed by the Supreme Court provided him with an ideal opportunity to test claims regarding race and judicial discretion. In 2007 a trio of Supreme Court decisions in Rita, Gall, and Kimbrough transferred significant sentencing authority back to federal judges. The United States Sentencing Commission asserted in a series of reports that racial disparities increased after these decisions.

In work coauthored with Northwestern law professor Joshua Fischman, Schanzenbach found that the increases in racial disparities are primarily the result of the statutory mandatory minimums, which were unaffected by the Supreme Court's rulings. Statutory minimums are particularly important in drug offenses and for offenders with prior criminal histories. After the US Supreme Court relaxed the Sentencing Guidelines, prosecutors were more likely to charge based on mandatory minimums, which are more likely to affect black offenders; increased reliance on these minimums has exacerbated racial disparities in sentencing. There is no evidence that federal judges discriminated more on the basis of race after Rita, Gall, and Kimbrough, even though their sentencing discretion was greatly enhanced.

Max Schanzenbach

Professor of Law

SCHOOL OF LAW

Photo courtesy of Max Schanzenbach

Keith Tyo

Assistant Professor of Chemical and Biological Engineering

MCCORMICK SCHOOL OF ENGINEERING
AND APPLIED SCIENCE

Photo by Rob Hart

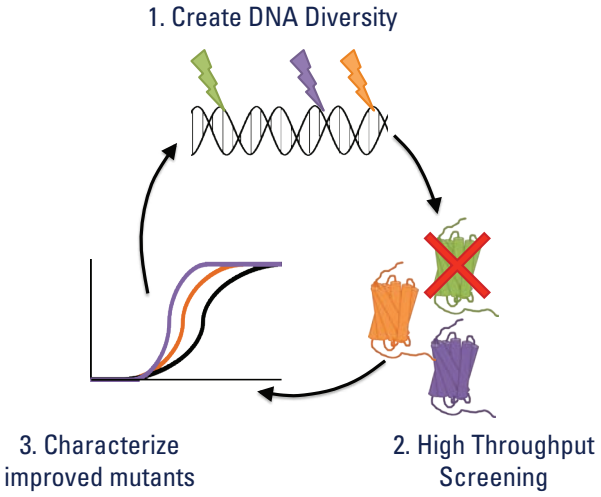
Bake Bread and Check Your Kidney Function, Too!

Plants, animals, and microbes have sensitive mechanisms to monitor their environment—on par with some of the best medical diagnostic devices. Many of these mechanisms (involving such senses as sight, smell, and taste) rely on variants of a common protein sensor, the G-protein coupled receptor (GPCR), which Keith Tyo, chemical and biological engineering, believes can be harnessed for healthcare. In pursuing such research objectives, his lab operates at the intersection of synthetic biology (the genetic engineering of new functions) and global health (the sustainable deployment of high-quality healthcare solution regardless of income level).

Active-dry yeast (used for baking bread) has GPCRs, and —unlike many other diagnostic devices—is extremely cheap and lightweight but with the diagnostic power of clinical tests that cost 1,000 times more. The Tyo lab is engineering GPCRs in yeast to detect important clinical biomarkers. Tyo envisions a pregnancy test-like device at the cost of a packet of baker's yeast but with the diagnostic power of nature's protein sensors.

Currently the Tyo lab is focused on receptors for detecting renal failure (cystatin) and tuberculosis using the directed evolution approach. As with natural evolution, diversity is introduced in a population of millions, but in this case in millions of receptors. The receptors showing some functionality for detecting cystatin are allowed to propagate and take over the population. These improved receptors are rediversified, and the cycle continues as with natural evolution. After many generations, receptors evolve that detect cystatin. The next step—a simple genetic trick—programs the yeast to turn purple when cystatin is present.

To maximize the impact of these new yeast-based sensors, the Tyo lab plans to start a company to commercialize the technology for a range of other applications in both the developed and developing world.



Directed evolution enables engineering receptors for cystatin. (1) Receptors are encoded in DNA. First, the Tyo lab creates diversity in the receptor's DNA. (2) After making millions of different receptors, a high throughput screen serves as "natural selection" for receptors that can detect cystatin. (3) A range of properties are measured for receptors with improved cystatin sensing abilities. Promising receptors are rediversified in (1), and after several generations, a receptor with strong cystatin-sensing abilities will evolve.

Joel Voss

Assistant Professor of Medical Social Sciences and Neurology

FEINBERG SCHOOL OF MEDICINE

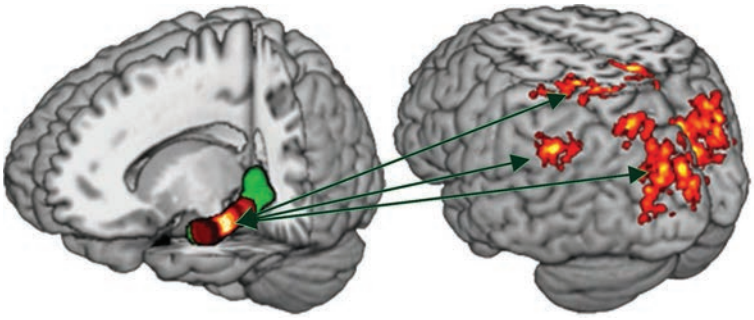
Enhancing Memory and Cognition by Stimulating the Human Brain

In the Laboratory for Human Neuroscience, Joel Voss, medical social sciences and neurology, and his team develop new ways to study the operation of the human brain and to enhance its capabilities using noninvasive electromagnetic stimulation. They perform this research in healthy individuals as well as those with various brain disorders in order to better understand the nature of cognitive impairment in these disorders and to create new treatments using noninvasive brain stimulation.

Brain regions important for cognitive abilities, such as memory, do not act alone. Instead, brain networks—collections of interacting brain regions—work together to support cognition. Researchers in the Voss laboratory focus on the hippocampal network, a brain network that is important for memory. Disruption of this network occurs in many brain disorders, including Alzheimer's disease, traumatic brain injury, stroke, and psychiatric conditions, such as schizophrenia and PTSD. Currently there are no therapies to improve the functioning of the hippocampal network in these conditions.

Researchers in the Voss laboratory determine how the hippocampal network supports memory by using methods, such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), to record the hippocampal network in action. They then use this knowledge to create new noninvasive stimulation procedures intended to enhance the hippocampal network and the memory functions that it supports. For example, the Voss laboratory recently developed a stimulation procedure that increased the mutual synchronization of hippocampal network regions. This increase in synchrony produced long-lasting improvements in memory. Individuals were better able to memorize new information after stimulation than they were beforehand, for a period of up to 15 days after the stimulation treatment. These experiments have shown that it is possible to develop noninvasive stimulation procedures that can produce lasting improvements in the hippocampal brain network.

Voss and his colleagues hope to use similar procedures as novel treatments for individuals with memory disorders that are currently intractable. Their hope is that this research will translate into improved cognitive ability and life quality for patients suffering from these debilitating brain disorders.



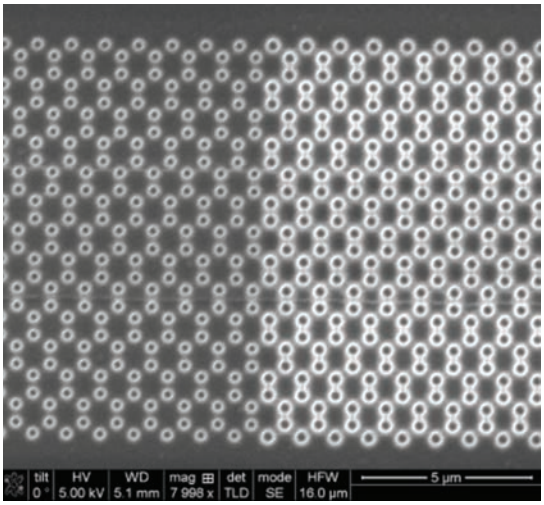
Researchers in the Voss laboratory recently found that noninvasive stimulation could be used to increase the mutual synchronization of the hippocampus (left) with regions of the cerebral cortex that are part of the hippocampal brain network (right). This increased synchronization persisted after the stimulation period and was associated with improved memory abilities. This image is adapted from Wang et al. (2014) *Science,* 345:1054-7

Photo courtesy of Feinberg School of Medicine

Bruce Wessels

Walter P. Murphy Professor of Materials Science and Engineering

MCCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE



Scanning electron micrograph of $BaTiO_3$ photonic crystal used in optical modulators

Accelerating Data Transmission

In the future, communication and cyber systems will require optical subsystems that transmit data at one trillion bits (one terabit) per second for a single channel. To do this, they will need to integrate active optical devices that operate at a speed of 50 billion hertz (50 GHz) per second.

Bruce Wessels, materials science and engineering, and his group are working on developing optical devices that depend on optical nonlinearities to create the right frequency response. Optical nonlinearity is an effect in which, for example, the optical input frequency results in twice the output frequency at high light intensity. As a platform for these devices, the researchers have been using a synthetic material, ferroelectric oxide barium titanate. Wessels and his group have shown that, using a thin-film deposition technique, they can form optically transparent thin films. The film shows significant nonlinear optical interaction, which enables efficient optical modulation. Using nanolithography, they can pattern high-speed yet low-power modulators with a small footprint. They have demonstrated modulators with a bandwidth approaching 20 GHz.

Wessels and his group are improving these devices' operating performance by using optical resonance. A resonant structure allows the speed of light to be slowed in the material, thereby increasing the interaction between light and the material. They have developed a photonic crystal (see figure at left) to form an optical modulator structure using an ion beam to mill an array of submicron-sized holes. This array forms the basis of the resonant structure or photonic crystal. By changing the hole size and array symmetry, they can modify its optical properties to enable high-speed modulation rates at frequencies of 50 GHz and greater.

To achieve terahertz data transmission rates, they are using wavelength division multiplexing to combine different wavelengths of light on a single optical channel. This can potentially allow for 50 GHz modulators and 20 different wavelengths to transmit one terabit per second over a single optical fiber.

Wessels and his group are developing and integrating these photonic crystal modulators with support from the National Science Foundation.

Photo courtesy of McCormick School of Engineering and Applied Science

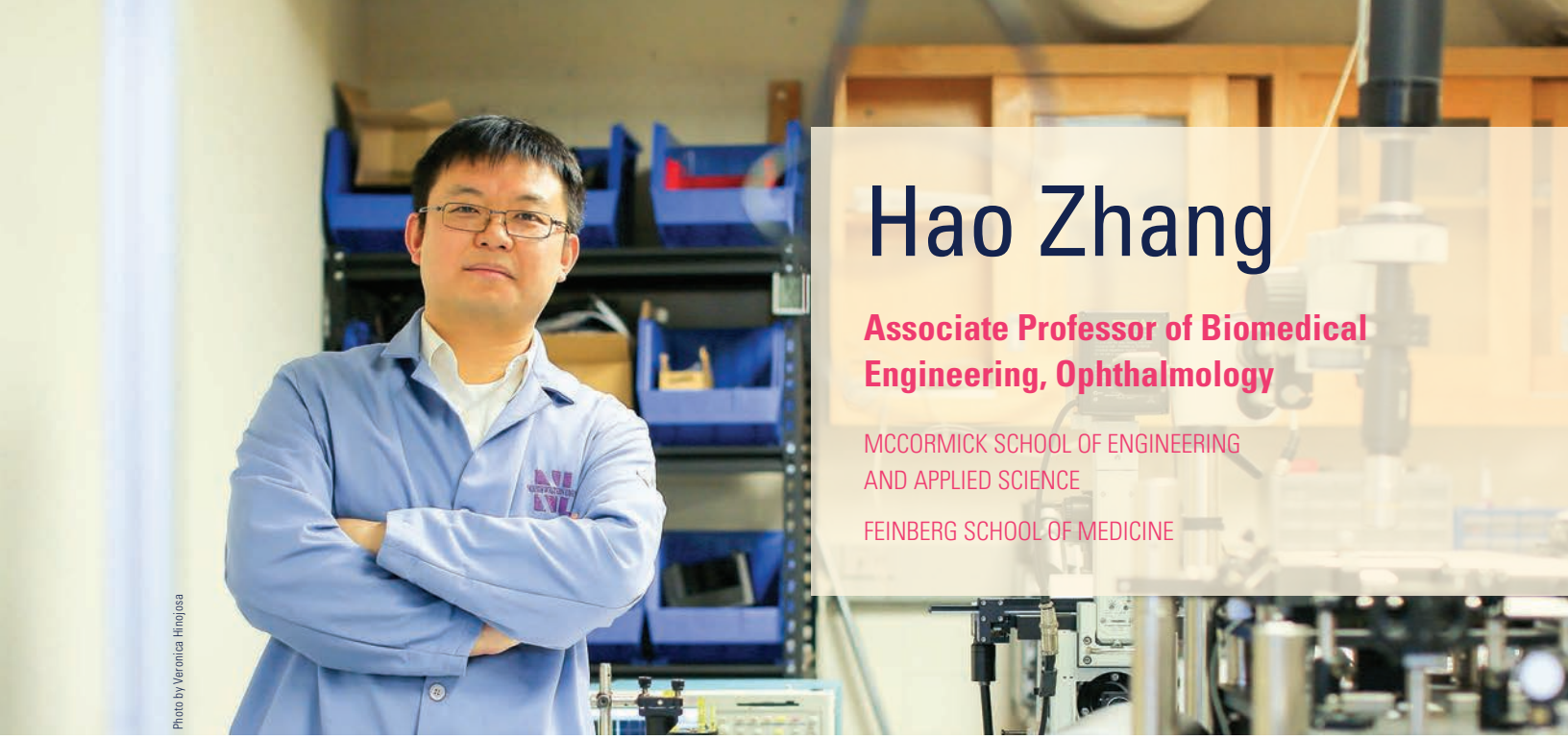


Photo by Veronica Hinojosa

Hao Zhang

Associate Professor of Biomedical Engineering, Ophthalmology

MCCORMICK SCHOOL OF ENGINEERING AND APPLIED SCIENCE

FEINBERG SCHOOL OF MEDICINE

Optical Technologies to Prevent Blindness

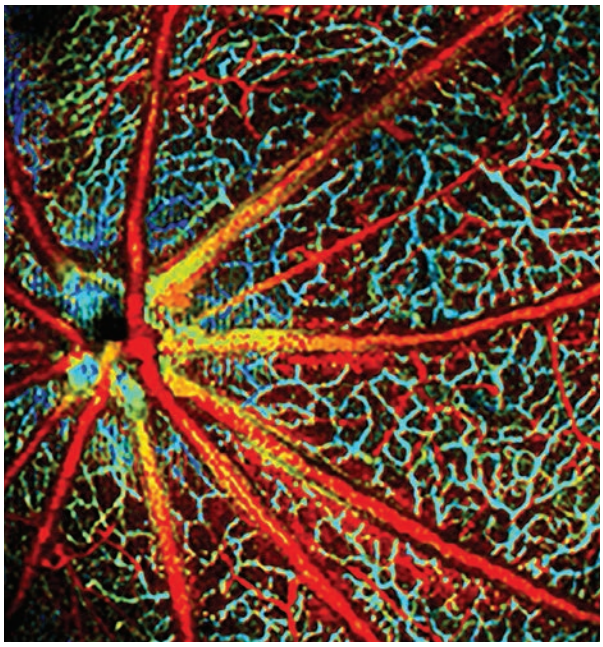
According to Hao Zhang, biomedical engineering and ophthalmology, visual loss is widely considered "the most feared complication of human disease, other than death." Working at the boundary of engineering and medicine, Zhang develops tools that help prevent vision loss. These new functional optical imaging tools detect the earliest physiological abnormalities in the retina long before vision-damaging pathological alternations occur, allowing prompt medical attention to reverse or significantly delay vision loss. Currently the Zhang team is tackling two leading diseases that cause blindness: diabetic retinopathy and age-related macular degeneration (AMD).

In late-stage diabetic retinopathy, excessive growth of fragile vessels causes hemorrhaging in the retina and leads to blindness. Visible-light optical coherence tomography, developed by Zhang, is the first technology capable of measuring the earliest malfunctions in retinal oxygen metabolism, which precedes abnormal vessel growth.

In investigating AMD, Zhang focuses on quantifying the retinal melanin, which is believed to play critical roles in maintaining normal visual functions. Until now there was no way of precisely measuring retinal melanin at the cellular level. Using a newly developed technology, photoacoustic ophthalmoscopy, the Zhang group can quantify melanin concentration in single cells and monitor melanin variation over time, providing critical information for understanding the profound pathogenesis of AMD.

Zhang hopes that these new technologies will be translated to clinics in the near future so that patients can benefit from advanced technologies. Toward this goal, he is working closely with ophthalmologists from Northwestern and other institutions around the country. In addition, he is commercializing these technologies through a recently established start-up company, Opticent Health.

Zhang's work has been supported by the National Institutes of Health, the National Science Foundation, the Juvenile Diabetes Research Foundation International, the Howard Hughes Medical Institute, the Illinois Society for the Prevention of Blindness, and the Greater Milwaukee Foundation.



Photos by Brian Soetikno used courtesy of the Zhang lab

Rodent retinal vessels with capillary details color-coded according to their depths.

SPONSORED RESEARCH AWARDS

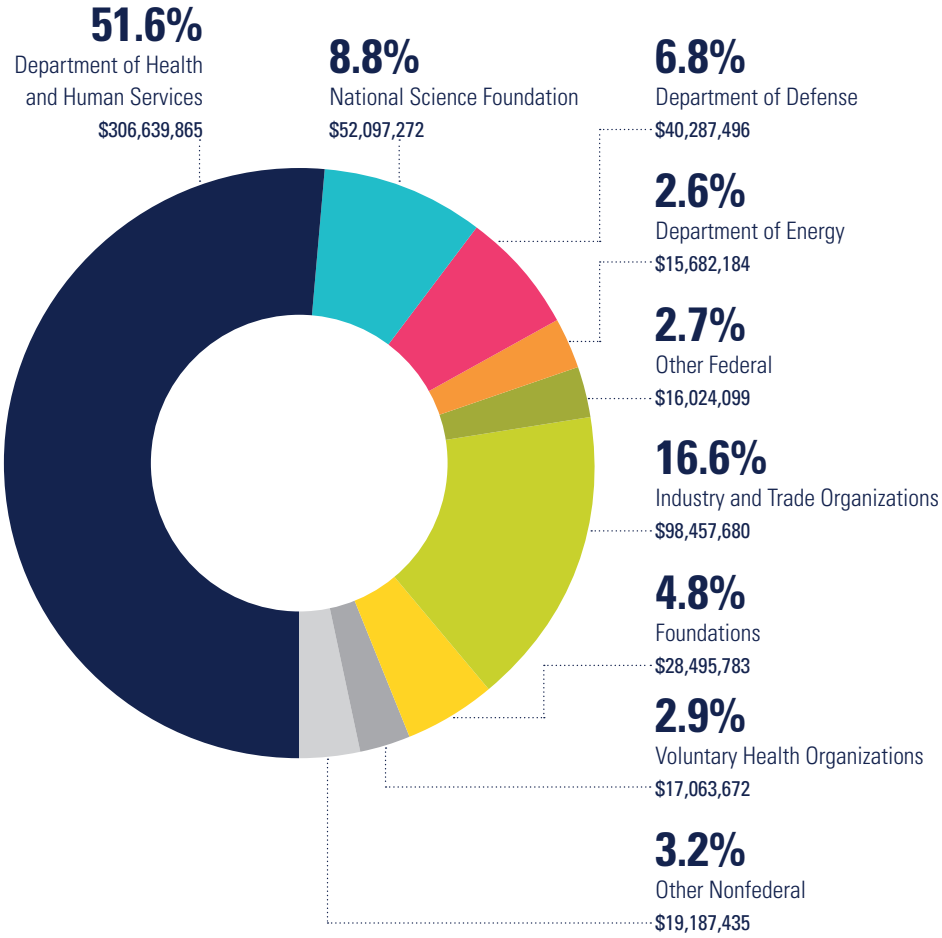
Northwestern University was awarded research grants and contracts of more than a half-billion dollars for the fifth year in a row during fiscal year 2014. The amount awarded in FY 2014 was $593.9 million, an 8 percent increase over last year's $549.5 million. In the past five years Northwestern has received more than $2.7 billion in external research grant funding.

THE AMOUNT AWARDED IN FY 2014 WAS $593.9 MILLION, AN 8 PERCENT INCREASE OVER LAST YEAR'S $549.3 MILLION.

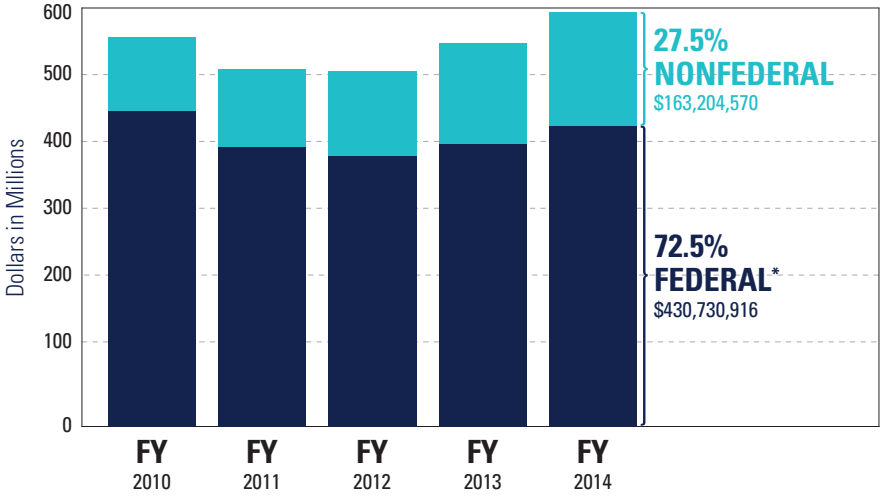
The increased dollar volume of research funding in 2014 came from several sectors, including federal agencies (a 7 percent increase of $26.6 million) and industrial sponsors (47 percent, $31.6 million). Awards from foundations decreased by 16 percent ($5.5 million), while those from the state of Illinois decreased by 56 percent ($5.6 million). Approximately 73 percent of research funding came from federal sources.

Relative to 2013, awards increased in most schools: by 12.1 percent to $389.8 million for the Feinberg School of Medicine; by 20.1 percent to $68.3 million for the McCormick School of Engineering and Applied Science; by 10.2 percent to $11.9 million for the School of Communication; by 24.0 percent to $8.1 million for the School of Education and Social Policy; by 5.0 percent to $2.9 million for the Kellogg School of Management; and by 57.9 percent to $2.5 million for the Medill School of Journalism, Media, Integrated Marketing Communications. Awards more than tripled for Northwestern University in Qatar. Award funding dropped by 2.1 percent to $60.0 million for the Weinberg College of Arts and Sciences; by 66.3 percent to $1.9 million for the School of Law; and by 15.0 percent to $35.5 million for the University's research centers.

AWARDS by Sponsor

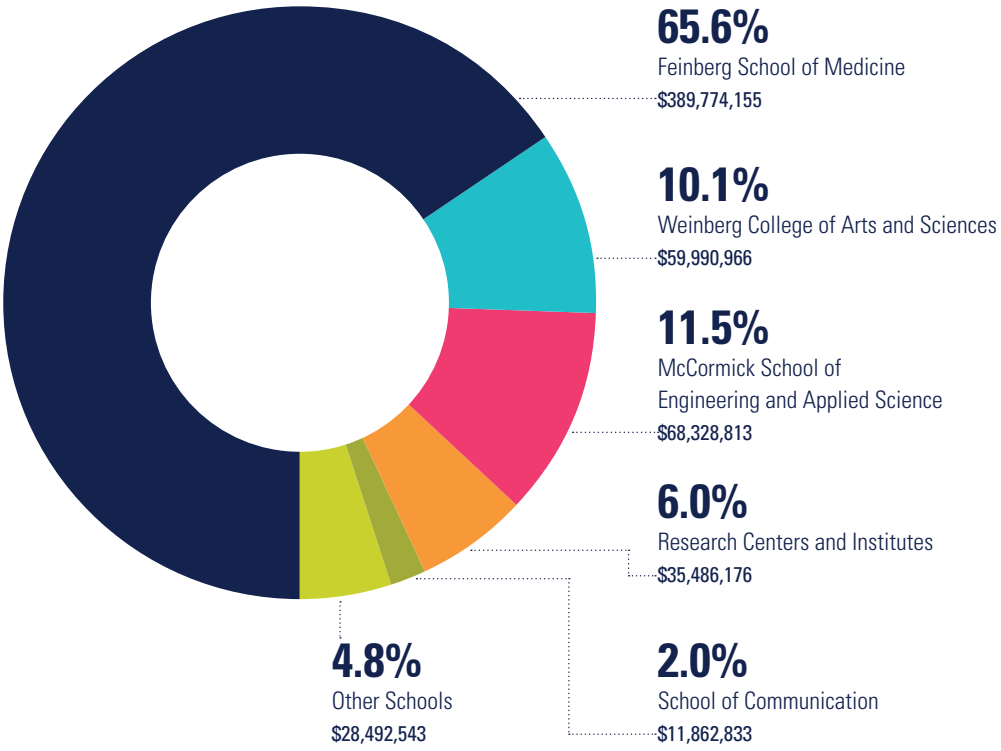


FEDERAL AND NONFEDERAL AWARDS

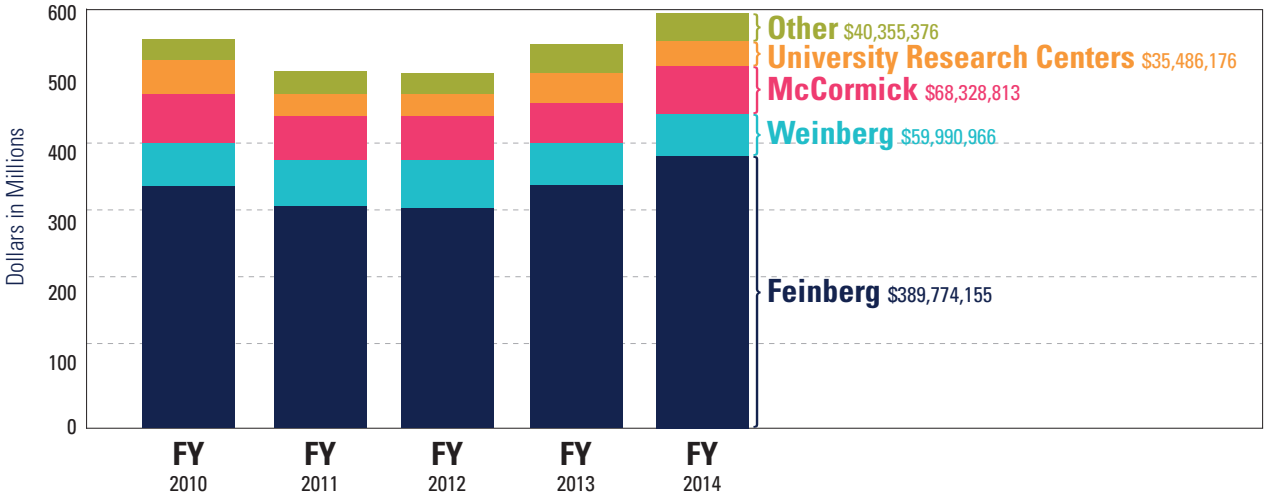


* Federal includes American Recovery and Reinvestment Act Awards (ARRA) funding: 2010, $72.2 million; 2011, $34.2 million; 2012, $13.5 million; 2013, $6.9 million; 2014, $1.1 million.

AWARDS by Administrative Unit



AWARDS BY ADMINISTRATIVE UNIT

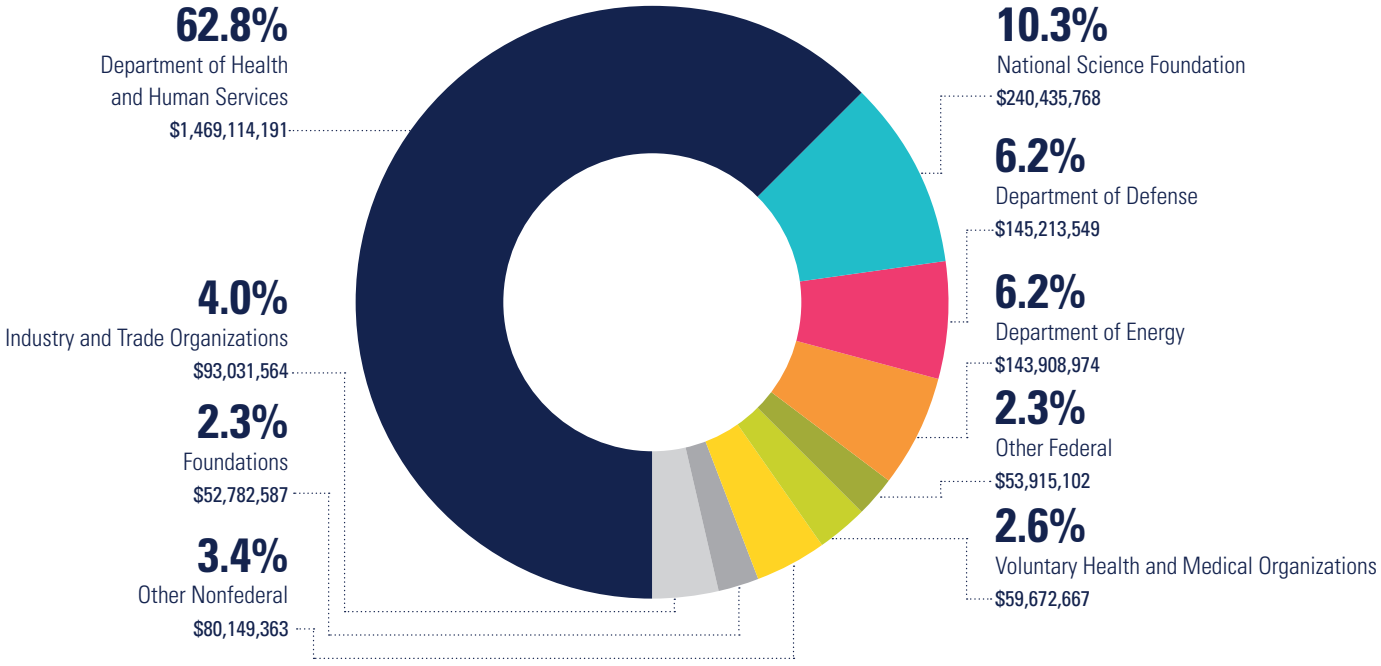


Includes American Recovery and Reinvestment Act Awards (ARRA) funding: 2010, $72.2 million; 2011, $34.2 million; 2012, $13.5 million; 2013, $6.9 million; 2014, $1.1 million.

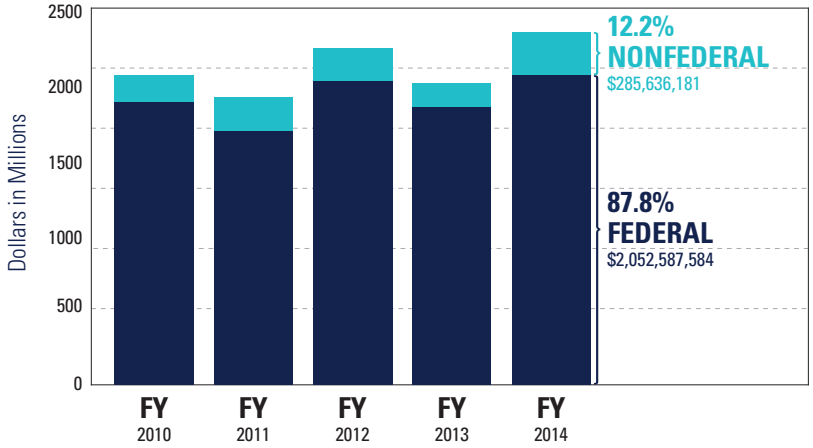
SPONSORED RESEARCH PROPOSALS

Relative to 2013, overall proposal activity grew by 11.5 percent to a cumulative dollar volume of $2.34 billion in submissions. Proposal activity was up by 14.9 percent (an increase of $192.8 million) in Feinberg, by 22.8 percent ($61.0 million) in McCormick, and by 56.3 percent ($10.7 million) in Education and Social Policy. For the University research centers, proposals rose by 17.4 percent, an increase of $27.5 million to $177.3 million. In what was NU-Q's third year of submitting proposals, proposal activity was up by 12.3 percent ($0.4 million). Proposal activity decreased by 8.6 percent (down by $23.5 million) at Weinberg; by 11.9 percent ($5.1 million) at Communication; by 43.5 percent ($3.0 million) at Kellogg; by 67.1 percent ($3.3 million) at Law; and by 38.1 percent ($0.4 million) at Medill.

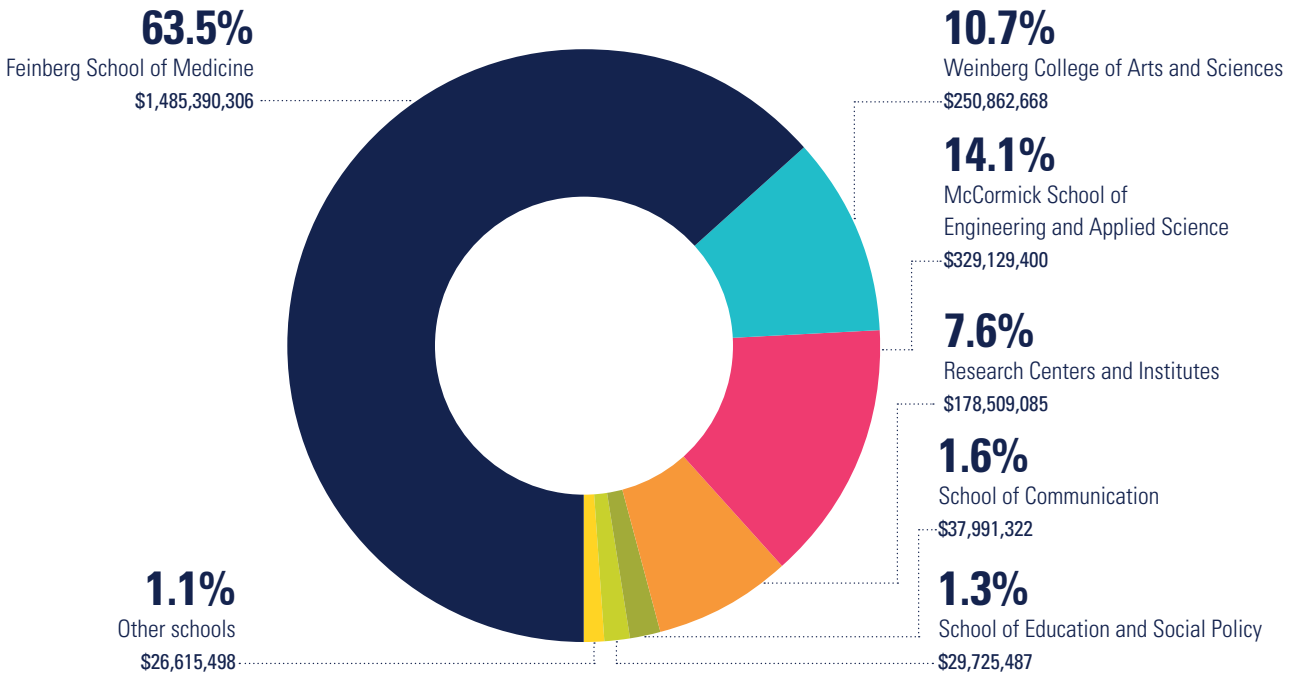
PROPOSALS by Sponsor



FEDERAL AND NONFEDERAL PROPOSALS



PROPOSALS by Administrative Unit



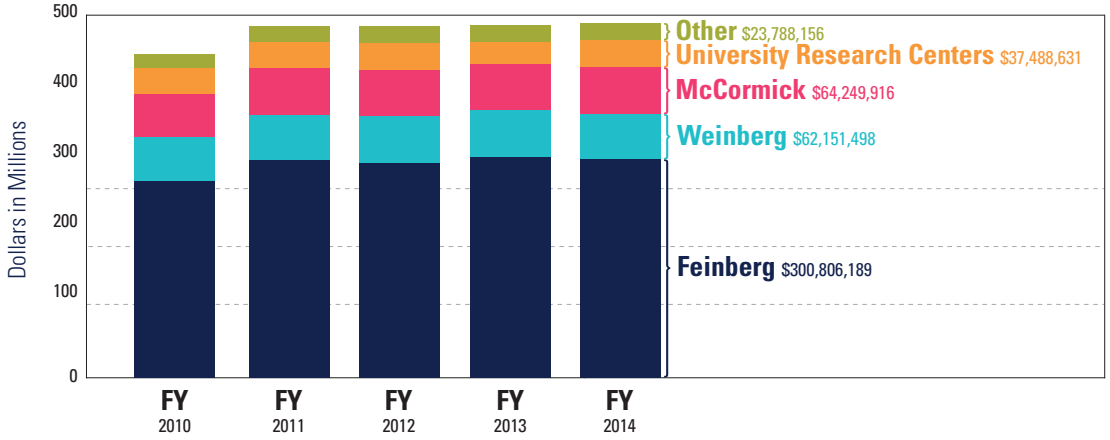
EXPENDITURES

The numbers reported here represent dollars actually spent on sponsored programs. This money is spent on personnel, equipment, consumables, and support for graduate students among other items. The money is drawn from the funding for sponsored projects.

Expenditures remained stable in 2014. Total expenditures (direct plus indirect) increased by less than 1 percent over 2013, to $488.5 million.

Expenditures grew by 2.1 percent (to $64.2 million) for McCormick and by 21.0 percent (to $37.5 million) for the University's research centers. Expenditures dropped by less than 1 percent (to $300.8 million) at Feinberg and by 4.3 percent (to $62.2 million) at Weinberg.

EXPENDITURES BY ADMINISTRATIVE UNIT



INNOVATION AND NEW VENTURES OFFICE AND TECHNOLOGY TRANSFER

The leadership and staff of the Innovation and New Ventures Office (INVO) work to bring together faculty, students, and postdocs at all Northwestern's schools to advance innovation and entrepreneurship. The former Technology Transfer Program is managed through this office.

In 2014 Northwestern executed 81 license agreements (up from 66 in 2013) and was responsible for the launch of 13 startup companies. INVO processed 207 invention disclosures, slightly down from 2013's 212. The office filed 328 patent applications, up from 289 in 2013. A total of 167 patents were issued—twice as many as last year—resulting in revenues of $575 million for Northwestern and Northwestern inventors.

Since 2005–06 the bulk of the monetary returns from technology transfer has come from the patent on pregabalin, a synthesized organic molecule discovered by Richard Silverman, chemistry. Pregablin was ultimately developed and marketed as Lyrica, a drug sold by Pfizer and used to combat epilepsy, neuropathic pain, and fibromyalgia. Northwestern's drop from first to third place in 2012 among universities in licensing income resulted from third-party payments. The table below shows licensing income from 2008-2012, the last year for which these data are available.

US LICENSING INCOME *FY2008-FY2012*

Institution	2008	2009	2010	2011	2012
Columbia University	$134,273,996	$154,257,579	$147,237,631	$146,319,455	$161,748,043
Massachusetts Institute of Technology	$88,924,500	$66,450,000	$69,200,000	$76,120,000	$137,070,000
Northwestern University	**$824,426,230**	**$161,591,544**	**$179,930,000**	**$191,541,162**	**$122,198,183**
Stanford University	$62,514,524	$65,054,187	$65,466,286	$66,797,246	$76,727,029
University of Rochester	$72,264,249	$49,832,714	$42,000,000	$41,813,373	$39,436,018
Duke University	$15,591,503	$19,048,244	$25,733,526	$24,481,478	$24,590,271
University of Pennsylvania	$8,200,086	$11,658,000	$11,259,000	$14,397,705	$17,944,068
Harvard University	$20,980,563	$12,308,207	$10,052,098	$13,811,527	$11,390,691
Vanderbilt University	$8,322,536	$11,329,700	$5,635,486	$9,959,122	$10,013,743
Cornell University	$6,928,171	$5,100,407	$11,579,905	$8,503,975	$9,606,906
University of Chicago	$8,623,473	$9,025,392	$9,072,022	$8,673,127	$8,635,381
Washington University	$15,715,818	$6,301,462	$5,028,595	$5,371,218	$5,292,164
Case Western University	$13,294,612	$16,281,957	$14,333,273	$6,303,230	$4,648,435
University of Pittsburgh	$6,666,734	$4,129,172	$3,839,157	$3,880,594	$4,215,544
Johns Hopkins University	$11,362,574	$12,387,415	$12,413,714	$1,404,556	$755,529
New York University	N/A	N/A	N/A	N/A	N/A
Boston University	N/A	N/A	N/A	N/A	N/A
Yale University	N/A	N/A	N/A	N/A	N/A

Source: Association of University Technology Managers

EXTERNAL METRICS

Based on 2013 data (data from federal agencies lag by one year), Northwestern had a relatively stable year in terms of federal awards rankings. In the volume of awards for universities, Northwestern dropped slightly from 33rd to 34th in the National Science Foundation (NSF) rankings and rose from 22nd to 21st in the National Institutes of Health (NIH) rankings.

When viewed across a greater span of time, however, the trend in research volume at the University has been positive at both agencies. Since 2004 Northwestern's NIH funding has increased by 48.1 percent to $233.1 million, and its ranking has moved from 36th to 21st. Since 2004, although Northwestern's NSF ranking has dropped from 25th to 34rd, the University's NSF funding has increased by 4.7 percent to $44.5 million.

NATIONAL INSTITUTE OF HEALTH AWARDS *IN THOUSANDS*

Institution	2004 NIH Ranking	2004 NIH	2010 NIH	2011 NIH	2012 NIH	2013 NIH Ranking	2013 NIH
Johns Hopkins University	3	$599,151	$610,467	$625,134	$645,692	3	$574,844
University of Pennsylvania	5	$464,076	$481,559	$462,600	$457,486	5	$451,194
University of Pittsburgh	8	$360,635	$424,154	$416,264	$430,027	8	$408,811
Stanford University	14	$301,733	$339,893	$332,383	$341,779	9	$357,812
Harvard University	11	$325,665	$396,501	$386,696	$391,994	10	$352,922
Duke University	9	$343,825	$351,616	$340,621	$355,648	11	$350,249
Columbia University	13	$303,714	$334,203	$351,909	$364,037	12	$348,996
Yale University	12	$323,614	$378,805	$366,307	$371,068	13	$348,058
Washington University in St. Louis	6	$388,307	$386,470	$371,213	$381,462	14	$321,046
Vanderbilt University	16	$251,147	$322,051	$320,224	$329,043	15	$311,110
Case Western Reserve University	17	$250,009	$262,934	$254,892	$250,885	18	$255,350
Northwestern University	**36**	**$157,346**	**$191,207**	**$203,282**	**$241,615**	**21**	**$233,095**
New York University	39	$148,236	$177,764	$195,520	$212,416	23	$220,178
Cornell University	28	$185,957	$186,162	$182,836	$184,606	31	$175,420
University of Chicago	30	$178,565	$198,347	$196,393	$186,624	32	$160,450
Boston University	34	$160,311	$154,223	$156,890	$172,894	35	$152,993
University of Rochester	35	$157,549	$186,789	$158,400	$164,396	38	$146,849
Massachusetts Institute of Technology	29	$181,897	$119,215	$106,816	$102,189	47	$94,736
AVERAGE							
NIH Annual Budget Authority (in $M)		$27,248	$30,189	$29,831	$30,010		$28,341

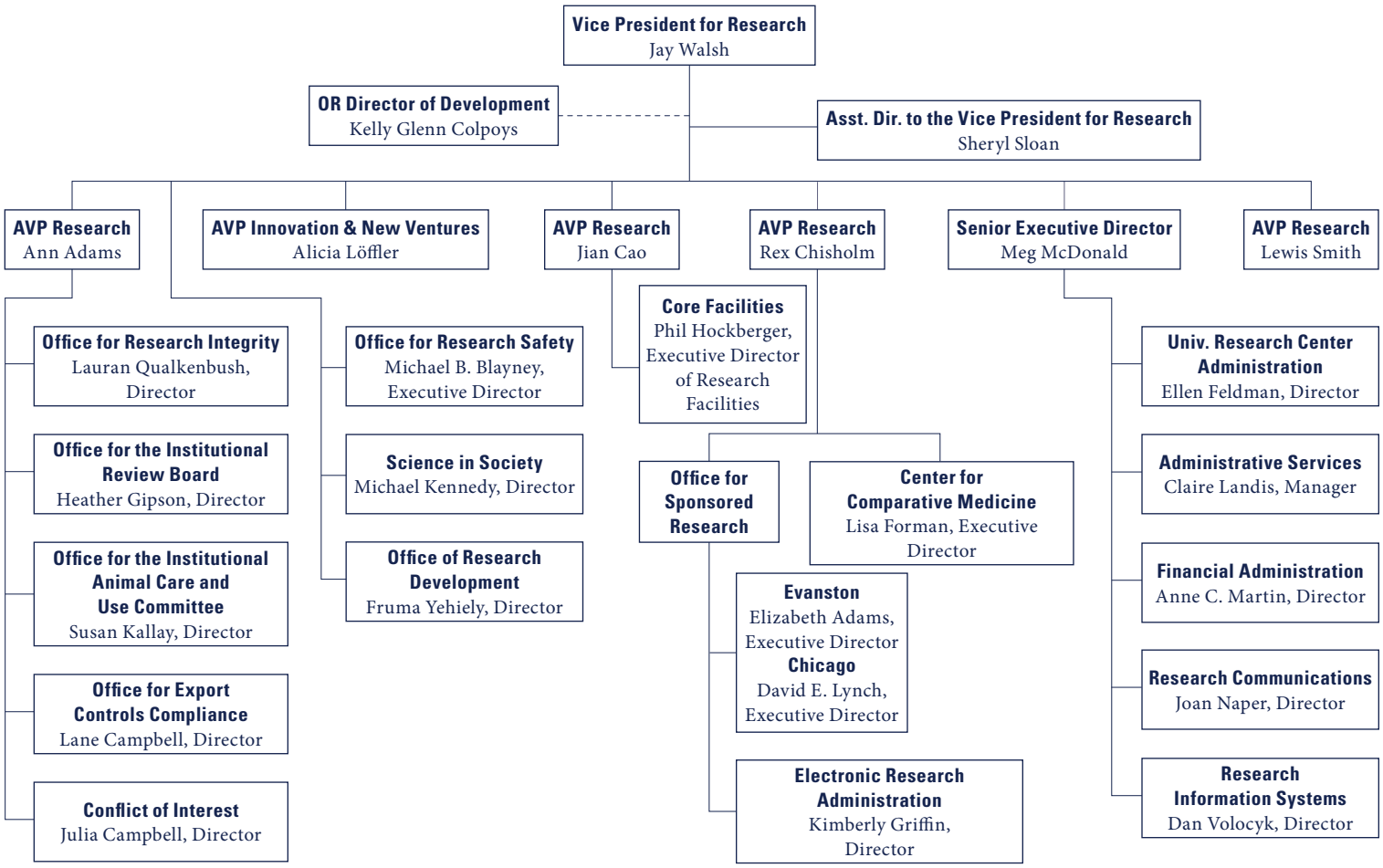
AAU Members: Private Institutions w/ Schools of Medicine and Engineering; plus MIT, U Chicago
Source (accessed 25 September 2014)
http://report.nih.gov/award/index.cfm?ot=DH,27,47,4,52,64,10000,MS,20,16,6,13,10,49,53,86,
OTHDH&fy=2013&state=&ic=&fm=&orgid=&distr=&rfa=&om=n&pid=

NATIONAL SCIENCE FOUNDATION AWARDS *IN THOUSANDS*

Institution	2004 NSF Ranking	2004 NSF	2010 NSF	2011 NSF	2012 NSF	2013 NSF Ranking	2013 NSF
Cornell University	3	$94,306	$102,551	$113,742	$113,422	2	$118,327
Columbia University	8	$70,424	$86,405	$81,508	$94,996	9	$82,143
Massachusetts Institute of Technology	9	$69,337	$66,779	$81,222	$83,086	13	$72,252
Stanford University	11	$68,203	$74,692	$56,788	$76,575	19	$66,113
Harvard University	22	$46,370	$53,561	$45,875	$55,312	20	$62,305
University of Chicago	39	$31,990	$44,317	$51,002	$51,074	31	$45,017
Duke University	44	$29,434	$42,685	$49,789	$45,973	32	$44,633
Northwestern University	**25**	**$42,475**	**$35,899**	**$36,605**	**$39,388**	**33**	**$43,976**
Johns Hopkins University	43	$30,170	$42,775	$37,332	$36,357	37	$40,282
University of Pennsylvania	28	$33,006	$32,608	$34,842	$31,999	40	$38,366
Yale University	55	$24,142	$28,652	$31,748	$31,789	50	$29,612
Boston University	41	$31,058	$34,897	$30,064	$30,005	52	$28,724
University of Pittsburgh	66	$18,556	$22,082	$22,659	$24,746	55	$26,555
Vanderbilt University	74	$16,111	$15,765	$17,777	$22,779	66	$21,950
New York University	61	$21,144	$25,494	$20,242	$27,799	71	$20,138
Washington University in St. Louis	93	$10,831	$16,422	$11,650	$14,445	75	$18,977
Case Western Reserve University	113	$9,180	$13,487	$15,604	$18,266	86	$15,192
University of Rochester	92	$10,841	$16,462	$14,268	$15,814	101	$11,304
AVERAGE							
NSF Annual Budget Authority (in $M)		$4,123	$5,392	$5,494	$5,705		$5,328

AAU Members: Private Institutions w/ Schools of Medicine and Engineering; plus MIT, U Chicago
Source (accessed 25 September 2014); http://dellweb.bfa.nsf.gov/Top50Inst2/default.asp

Office for Research Organization Chart, December 2014



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Back cover images, left to right, beginning at the top:

Scott W. Devine and **Tonia E. Grafakos** are both conservators at the Northwestern University Library. Devine is Marie A. Quinlan Director of Preservation and Conservation and Grafakos is chief conservator. Together they assessed the condition of Northwestern's collection of Arabic manuscripts, produced in Nigeria in the late 19th and early 20th century. Read more about their work on page 33.

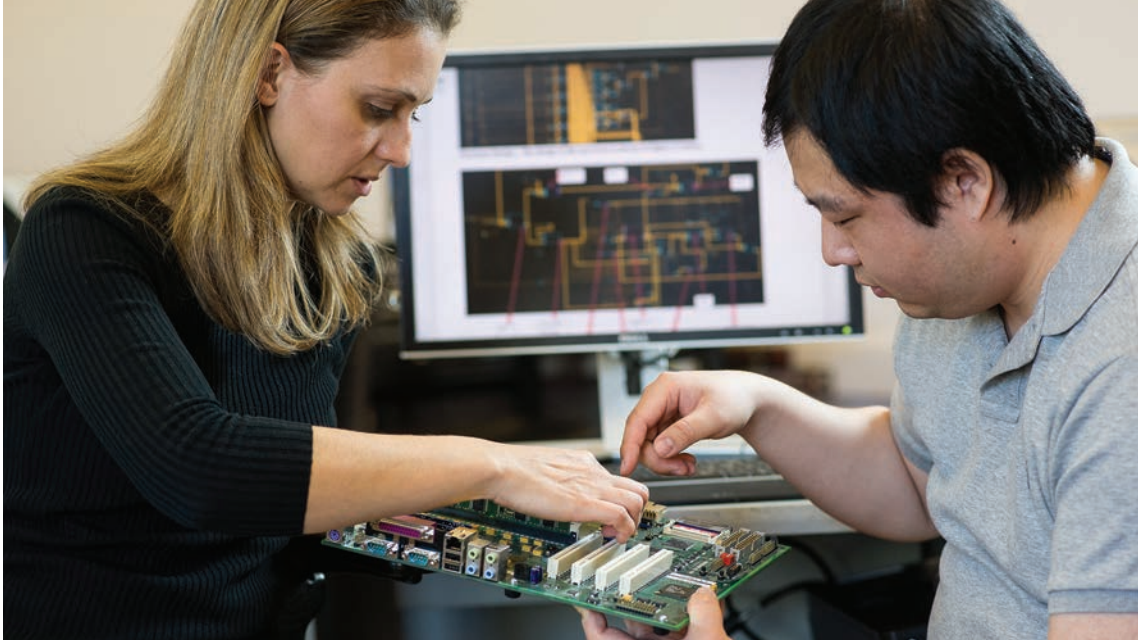
Seda Ogrenci-Memik, associate professor of electrical engineering and computer science, develops tools and methods to manage the heat that accumulates in integrated circuits and the rest of computing systems. Read more about Ogrenci-Memik's work on page 43.

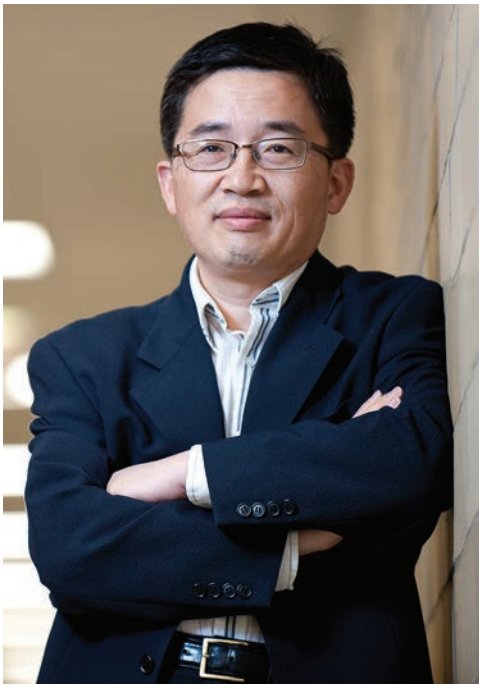
Mary Pattillo, Harold Washington Professor of Sociology and African American Studies, has been studying the policy of school choice as it relates to school reform. Read more about her work on page 47.

Todd Rosenthal, associate professor of theatre, recently designed the set for the Goodman Theatre's production of Chekhov's *The Seagull*. Read more about his work on page 50.

Yonggang Huang, the Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering, has developed a stretchable lithium-ion battery capable of powering innovative stretchable electronics. Read more about his work on page 38.

Yoram Lithwick, assistant professor of physics and astronomy, is a member of the Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA). His research probes into the characteristics of exoplanets, which orbit stars other than the Sun. Read more about his research on page 42.





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