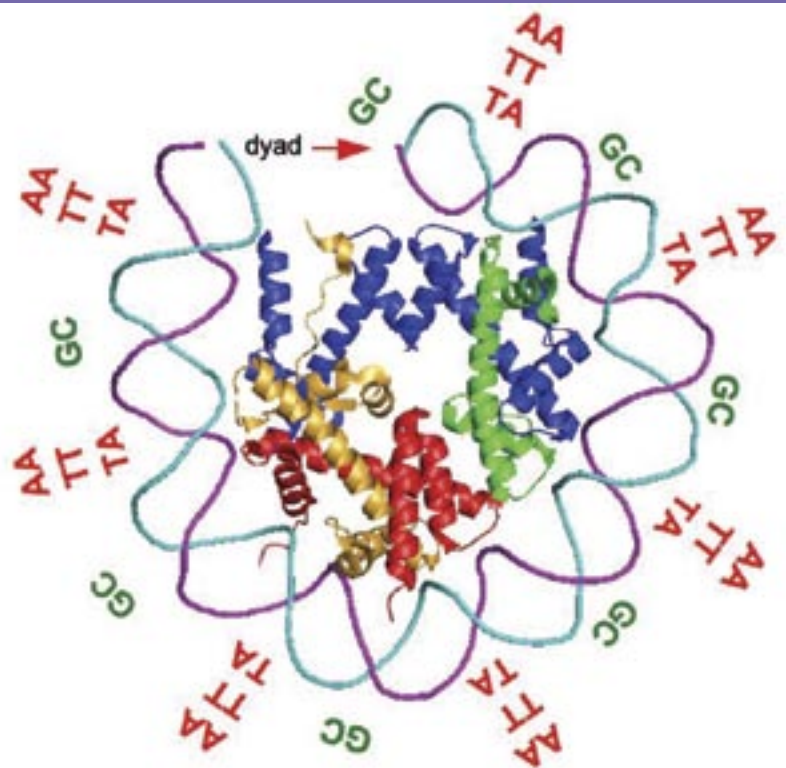


Northwestern University CREATING NEW KNOWLEDGE

Office for Research Annual Report 2006



ON THE FRONT COVER

Top, left to right

From research in the laboratory of **Robert J. Vassar**, professor of cell and molecular biology, Feinberg School of Medicine, this is a microscopic image of an Alzheimer's model mouse brain showing amyloid plaques (blue) surrounded by nerve cells with elevated levels of BACE1 enzyme (red). Immune cells of the brain called astrocytes are shown in green. Figure: J. Zhao, L. Chew (Cell Imaging Facility, Feinberg School of Medicine), and R.J. Vassar.

Photograph of **Robert J. Vassar**. Details of his research may be found on page 28. Photograph by Sam Levitan Photography.

Bottom, left to right

Georgette Moyle, graduate student in the Interdepartmental Biological Sciences (IBiS), and **Jonathan Widom**, professor of biochemistry, molecular biology, and cell biology and chemistry, Judd A. and Marjorie Weinberg College of Arts and Sciences. Moyle is a member of the Widom group. Details of the Widom laboratory's research may be found on page 30. Photograph by Jill Carlson, Martin Woods Image Consulting, LLC.

Research image from the Widom group: the genomic code for nucleosome positioning is shown superimposed on the nucleosome structure. Nucleosomes prefer to form on sequences having certain letters (shown in red) at certain locations, as indicated. Locations of the nucleosomes along the DNA then determine which parts of the DNA are easily accessible to the cell's genetic machinery and which are hidden.

Northwestern University
CREATING NEW KNOWLEDGE

Office for Research Annual Report 2006



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VICE PRESIDENT'S LETTER

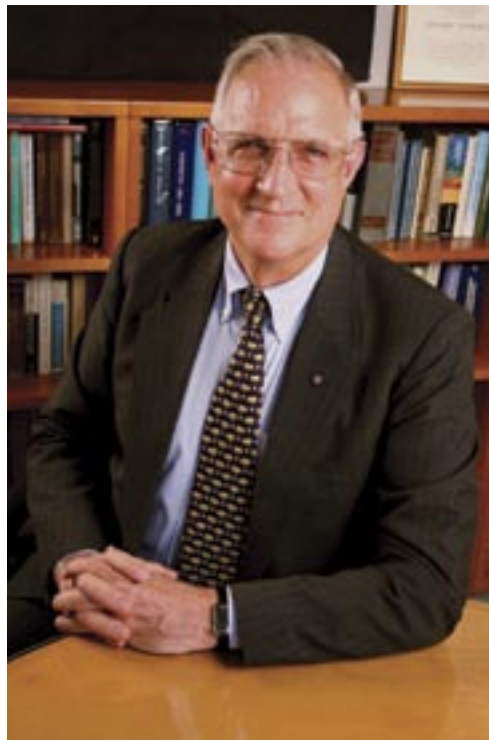
The Office for Research promotes, facilitates, and enhances research at Northwestern University.

December 2006

Dear Colleagues,

During the 800 years or so since they were first founded, universities have been among the most stable and least adaptable institutions on Earth. It is natural that the institution responsible for the creation and dissemination of knowledge should take on an added importance with the establishment of a knowledge-based economy and the creation of our “flat” world. Thus we are in a period of relatively rapid change in the research university.

Today many of the most difficult, complex, and interesting problems that human society faces — and many of the most interesting intellectual opportunities — require people from multiple disciplines to work together. The research university is the only institution that is home to all disciplines. Historically, scholars in each discipline have worked in isolation or possibly in collaboration with a few scholars in the same discipline; the organization of research universities by college or school, department, and sub-discipline discourages multidisciplinary research in many ways. The formation of multidisciplinary research teams thus constitutes a major culture change for most universities.



C. Bradley Moore, Vice President for Research

Photograph ©2006 Jim Ziv. All rights reserved.

Tradition of Research Centers at Northwestern

Northwestern is well prepared for such multidisciplinary work since it has had a half century of research experience in multidisciplinary centers and institutes such as the Program of African Studies, the Materials Research Center, and the Institute for Policy Research. The interdisciplinary culture that other universities are just now struggling to establish already exists throughout Northwestern University.

The Program of African Studies is an example of the real value of interdisciplinary research. During its more than 50-year history, PAS has been sparking critical discussions and building a fundamental understanding of Africa, Africans, and African institutions. The PAS Consortium for Development Partnerships was recently funded by the Dutch government to help build stable governments and strong economies in Africa.

Last year, PAS and the University of Ibadan in Nigeria created the Research Alliance to Combat HIV/AIDS (REACH). Thanks to a generous grant from the Bill and Melinda Gates Foundation, REACH will conduct research that will help to design and build more effective HIV-prevention programs. Nigeria really needs this help. It has the third largest number of HIV-positive people in the world and little of the infrastructure needed to deal with them.

The Gates Foundation again was generous in awarding a four-year, \$4.9 million grant to develop and produce affordable diagnostic devices for infectious diseases plaguing developing countries. While some diagnostic tests are available for low-income countries in Africa and Asia, they can

be improved to detect diseases earlier and more cost effectively. Faster and cheaper tests also are needed to monitor diseases and to detect the emergence of infectious agents resistant to drugs. **David M. Kelso**, professor of biomedical engineering, has assembled a team of experts in engineering, life sciences, business, infectious diseases, and African governance and culture to address these challenges through the Robert R. McCormick School of Engineering and Applied Science's new Center for Innovation in Global Health Technologies, which includes faculty and students from McCormick as well as the Kellogg School of Management, the Feinberg School of Medicine, and PAS. In addition, two commercial collaborators, Abbott and Inverness Medical Innovations, Inc. (Amex: IMA), are contributing their expertise in diagnostic testing.

Materials science as an interdisciplinary field was pioneered here at Northwestern. The Materials Research Center, which opened in 1960, has a new director, **Monica Olvera de la Cruz**, professor of materials science and engineering and of chemical and biological engineering. After guiding the successful renewal of the National Science Foundation (NSF) center grant, **John M. Torkelson**, professor of chemical and biological engineering, stepped down in order to focus more intensively on his research on glass-forming polymer systems and their nanoscale heterogeneous relaxation processes.

The Institute for Policy Research (IPR), an interdisciplinary public policy research institute founded in 1968, last year created Cells to Society (C2S): The Center for Social Disparities and Health. Directed by **P. Lindsay Chase-Landsdale**, professor of education and social policy, researchers at the center are working to explore how broad social, ethnic, and economic disparities "get under the skin" and affect human development, psychological well-being, and longevity. C2S expects to apply for a grant to fund a full-fledged population research center in the next four to five years.

Northwestern Institute on Complex Systems (NICO), established in 2004, is working on projects addressing the dynamics of governance; group decision-making in online environments; patterns in the complex web of biological information, with promise for guiding drug designs that can cure diseases while avoiding unwanted side effects; and stress as a route to discovery of the dynamics of Alzheimer's disease.

In the new Center for Technology and Social Behavior, **Justine M. Cassell**, professor of communication studies and of electrical engineering and computer science, is bringing together researchers from a variety of fields to examine how we understand and use new communications technologies and how changes in technology affect human society.

The new Spatial Intelligence and Learning Center is one of four NSF-funded university centers to explore how the human mind develops and uses spatial intelligence. Director **Dedre Gentner**, professor of psychology and cognitive science, is encouraging researchers from psychology, education and social policy, and electrical engineering and computer science to work together in studying many aspects of spatial cognition and intelligence.

Multi-institutional Partnerships

Big problems often require the intellectual and physical resources of multiple institutions to make significant progress. For example, Northwestern University and the University of Illinois at Chicago and the University of Illinois at Urbana-Champaign have joined the University of Chicago in the management of the Argonne National Laboratory. Northwestern is part of a similar consortium with a larger group of universities that won the contract to manage the Fermi National Accelerator Laboratory. These management roles facilitate joint appointments and joint programs between universities and national laboratories that add greatly to the strength and quality of all the institutions involved.

Fermilab's accelerator is coming to the end of its useful lifetime. High-energy physics research is focusing on a new accelerator in Europe. Looking into the next decade, there will be a competition among countries to host a new international linear collider (ILC). If this multibillion dollar facility comes to the United States, it will be built at Fermilab. In that case, there would be a

major opportunity to attract high-energy physicists to the Chicago region. If the ILC is built here, Chicago-area universities will be able to join forces with Fermilab to provide the staff, researchers and students to make the collider as productive as possible.

The Chicago Biomedical Consortium brings together the University of Chicago, the University of Illinois at Chicago and Northwestern. Launched with impetus and support from the Searle Funds at the Chicago Community Trust, the CBC stimulates collaborative biomedical research programs, training, and creation of shared facilities.

These collaborations add considerably to the strength of the Chicago region in research, in support for knowledge-based business and industry, and in potential for economic growth.

Meeting the World's Energy Needs

Researchers are moving forward with a collaborative initiative in global energy and environmental strategy involving local universities, industries, and Argonne National Laboratory. Energy is a strongly multidisciplinary issue. All sorts of basic science and engineering knowledge is needed to define and optimize various options for energy sources: fossil fuels, biofuels, solar energy, nuclear power, fusion energy, wind energy, and others.

The Department of Energy has put out requests for proposals for major biofuels centers that would be funded at \$25 million per year per center for five years. Northwestern is partnering with the University of Illinois at Urbana-Champaign, the University of Illinois at Chicago, Argonne, and industry to compete for one of these centers. Biofuels are a significant part of the federal strategy for energy independence. Northwestern and Argonne are submitting a proposal for a solar energy research center funded at about \$6 million per year for five years. A proposal for graduate research support for transportation energy research is pending at NSF.

To build a global energy economy, the sources and uses of energy must be acceptable to society and sustainable within a healthy environment for our entire planet. This requires research in economics, business, environmental science, politics, law, social science, communications, religion, and other fields. With a little more social science and communications research, the U.S. nuclear industry might look more like that of France, where nuclear energy generates 76 percent of the country's electricity. The U.S. dependence on oil from the Middle East suggests that serious work is needed in geopolitics, religion, social science, and many other areas. The rapidly growing appetite for energy throughout the world has several possible consequences:

- In the absence of other energy sources, large quantities of dirty coal will be burned and cause a steep acceleration of global warming and atmospheric pollution.
- Intense competition for oil and natural gas will increase military activity.
- New technologies based on new science could be developed and implemented at an absolutely unprecedented rate. This is not a safe bet. Work on solar and fusion energy has been underway for half a century with no power plants ready to build.

A concerted global effort is required to meet the world's energy needs while maintaining a sustainable environment. By drawing on multiple institutions, disciplines, investigators, and funding sources, we hope to create new energy technologies that will command the huge investment required to meet the needs of human society.

Recognition for Young Researchers

Many Northwestern researchers are winning important national and international awards and recognition as recorded in the following section of this report. Honors for young faculty bode especially well for the future of Northwestern.

Jennifer Richeson, professor of psychology and an IPR faculty fellow, recently received a MacArthur Foundation "genius grant." She was recognized for her studies of interracial contact and dynamics. Read more about her work in the **Excellence in Research** feature on page 20.

Last summer **Luis A.N. Amaral**, professor of chemical and biological engineering and a member of NICO, was one of five researchers in the nation to be named one of the Distinguished Young Scholars in Medical Research by the W.M. Keck Foundation. The award comes with up to \$1 million over five years for Northwestern University to support Amaral's work. His research focuses on the use of computational methods to identify and map patterns in the complex web of biological information, with promise for guiding drug designs that can cure diseases while avoiding unwanted side effects.

Mark Hersam, professor of materials science and engineering, won a 2005 Presidential Early Career Award for Scientists and Engineers, which he received at a ceremony at the White House on July 26. This award is the highest honor given by the U.S. government to outstanding scientists and engineers who are beginning their careers. His research focuses on developing scanning probe microscopy techniques that enable sensing, characterization, and actuation at the single molecule level. His research affects many fields including materials science, chemistry, biology, physics, and electrical engineering. In September 2006, in recognition of remarkable achievements in his field, Hersam was promoted from assistant professor directly to full professor, a recognition rarely given at Northwestern. More about his research may be found in the **Excellence in Research** feature on page 17.

Both Amaral and Hersam were featured in last year's Office for Research *Annual Report*. In the following pages the pioneering work of more than 20 other Northwestern researchers are spotlighted in **Excellence in Research** features for this year.

Funding

The bottom line is that research money is tight with funding from the NIH down, a trend that is affecting many research universities. With *luck* the American Competitiveness Initiative will provide some new money for the physical sciences and fund pending proposals. It is clear that to be competitive in research Northwestern needs to raise more private money through development. Endowments that provide funds for seeding new research projects and for infrastructure that cannot be charged to research grants are tremendously valuable.

Northwestern does a relatively modest amount of research supported by industry. It was 10 percent of the total a few years back, but that number has been gradually falling. In 2005 only 7.5 percent of research support came from industry and trade organizations. There are many interesting research areas of great importance to industry, and the downsizing of industry laboratories creates opportunities for academia. Of course, diligence and care are required since industry-sponsored research can potentially bring risks and conflicts of interest. Interactions with faculty-founded start-up companies can be particularly complex, albeit potentially very beneficial.

This past year saw some progress; industry awards in 2006 were 7.8 percent of total. A systematic effort by University leadership, faculty, staff, and students could produce significantly more industry funding.

Strengthening the Research Infrastructure

A strong research infrastructure is essential to do research at the cutting edge and to recruit and retain the best faculty. Northwestern's new science and engineering buildings are crucial in that regard. In some areas such as nanoscience and materials science much of the expensive equipment and facilities has been obtained. Some of the royalties from the drug Lyrica are establishing an endowment that will be important in the future.

There are other areas, however, in which Northwestern is lagging behind. Proteomics, the branch of genetics that studies the full set of proteins encoded by a genome, is an important, fast-developing research area in which new faculty are urgently needed.

Construction on the \$95 million building that will house the Chemistry of Life Processes Institute is slated to begin in early 2007. The building will provide nearly 80,000 square feet for research facilities and is expected to take approximately two and a half years to complete — time

during which a strong effort is needed to develop and attract the faculty to explore this emerging field.

We will be helped greatly in this task through our collaborative work with the Chicago Biomedical Consortium. The CBC has initiated Catalyst Awards as part of its strategy to seed and nurture scientific collaboration across Chicago around the technologies of proteomics, imaging, and informatics as they are used to address biological complexity. We are awaiting results of this year's proposals.

Research costs a lot and comes with its share of difficulties, but its benefits much more than compensate. The goal of research is to understand the basic principles of how nature, human society, and culture actually work and to apply these principles to improve the human condition on planet Earth. It is this sense of purpose that motivates Northwestern faculty, students, and staff to raise the money, build the facilities and partnerships, and do the hard work of research itself.

Sincerely,



C. Bradley Moore
Vice President for Research
Professor of Chemistry



Sam Levitan Photography

Members of the Office for Research Faculty Advisory Committee and Office for Research administration. Front row, l. to r., Patricia G. Spear, C. Bradley Moore, Justine M. Cassell, Kasturi Haldar, Lewis J. Smith; middle row, l. to r., Eva Redei, Victoria H. Medvec; back row, l. to r., Frank J. DiSanto, Mark A. Ratner, Andrew B. Wachtel, David Austen-Smith, Richard A. Joseph, Timothy J. Fournier. Committee members not pictured: P. Lindsay Chase-Lansdale, Martin S. Eichenbaum, Sarah E. Fraser, Mary J.C. Hendrix, Richard I. Morimoto, Julio M. Ottino, Jill C. Pelling, Brian Uzzi, Jay Walsh, and Teresa K. Woodruff.

Table I — Excellence in Schools and Programs

SCHOOL/PROGRAM	RANK	SCHOOL/PROGRAM	RANK
Feinberg School of Medicine	20	School of Law	12
AIDS	12	Clinical Training	9
Clinical Psychology	11 (2004)	Dispute Resolution	11
Community Health	2 (2003)	International Law	18 (2005)
Health Services Administration	4 (2003)	Legal Writing	5
Internal Medicine	20	Tax Law	4
Pediatrics	12	Trial Advocacy	7
Physical Therapy	10 (2004)	School of Music	6 (1998)
Women's Health	15	Weinberg College of Arts and Sciences	
Kellogg School of Management	4	Biological Sciences	28
Accounting	12	Chemistry	9
Entrepreneurship	8	Economics (all areas ranked in 2005)	8
Finance	10	Industrial Organization	3
General Management	4	Econometrics	8
Information Systems	22	Macroeconomics	8
International Business	19	Microeconomics	9
Marketing	1	Public Finance	11
Nonprofit Organizations	6	Labor Economics	12
Production/Operations Management	8	English (all areas ranked in 2005)	19
Quantitative Analysis	11 (2002)	18th- to 20th-Century British Lit.	18
Supply Chain/Logistics	14	African American Literature	17
McCormick School of Engineering and Applied Science	21	American Literature before 1865	12
Applied Mathematics	14 (2002)	Geology	25 (1996)
Biomedical Engineering	12	History (all areas ranked in 2005)	17
Chemical Engineering	16	African American History	12
Civil Engineering	10	African History	1
Computer Engineering	21	Cultural History	15
Computer Science	42 (2002)	European History	14
Electrical Engineering	29	U.S. Colonial History	15
Environmental Engineering	20	Women's History	18
Material Sciences	3	Mathematics	21
Mechanical Engineering	10	Physics	29
Industrial Engineering	7	Political Science	21 (2005)
School of Communication		Psychology (all areas ranked in 2005)	22
Audiology	4 (2004)	Cognitive Psychology	16
Drama (MFA)	10 (1998)	Social Psychology	14
Film (MFA)	9 (1998)	Sociology (all areas ranked in 2005)	11
Speech and Language Pathology	3 (2004)	Economic Sociology	6
School of Education and Social Policy	10	Historical Sociology	6
Education Policy	18		
Educational Psychology	19		

All rankings are for 2006 unless otherwise noted. Earlier year rankings reflect the most recent as not all programs are ranked each year.

Source: *U.S. News and World Report*

HALLMARKS OF EXCELLENCE

Creating New Knowledge

The excellence of Northwestern's faculty is the foundation for the excellence of Northwestern University's research enterprise. As the subtitle of this report, "Creating New Knowledge," suggests, faculty members generate new knowledge, perform innovative research, attract and mentor exceptional students, and engage in outreach and service activities that benefit and enrich society. While sponsored project funding levels provide one clear indicator of the vitality of the University's research endeavors, the distinction of Northwestern's faculty is also evidenced by membership in prestigious national academies and societies, awards from preeminent grant and fellowship programs, citations, and other recognition and honors.

This report focuses on both the broad hallmarks of research excellence — sponsored project awards, expenditures, and proposals — and more individual hallmarks of faculty achievement during the past fiscal year. It also places Northwestern research within the broader context of a benchmark group

of universities. This year a new cohort of educational institution peers is being used in order to better coordinate with the University benchmarks, which are based on the Consortium on Financing Higher Education (COFHE) groupings. COFHE member institutions are private schools that attract a national undergraduate applicant pool and have enough characteristics in common with the other members to permit each school's inclusion in various cooperative studies.

Excellence in Schools and Programs

Northwestern's schools and graduate programs generally are ranked highly in "America's Best Graduate Schools," published in *U.S. News and World Report*. Table 1 on page 6 highlights the Northwestern schools and programs that are ranked in the top 20.

Members of National Academies and Societies

One of the highest honors for faculty is election to membership in prestigious national academies and societies: National Academy of Sciences (NAS), National Academy of

Table 2 — New National Academy Members, 2006

UNIVERSITY	NATIONAL ACADEMY OF SCIENCES		NATIONAL ACADEMY OF ENGINEERING		INSTITUTE OF MEDICINE		AMERICAN ACADEMY OF ARTS AND SCIENCES	
	2005	2006	2005	2006	2005	2006	2005	2006
Columbia	2	2	0	0	1	4	10	8
Cornell	0	0	0	2	0	0	3	4
Duke	2	1	0	0	2	1	3	1
Harvard	3	6	1	0	5	9	14	7
Johns Hopkins	2	0	0	2	1	3	2	2
MIT	2	3	2	2	2	2	5	3
Northwestern	2	1	0	1	1	0	3	3
Princeton	6	2	2	2	1	0	8	2
Rice	0	0	1	0	0	0	1	0
Stanford	6	1	3	2	2	0	5	8
Univ. of Chicago	0	2	0	0	0	0	5	3
Univ. of Pennsylvania	1	0	0	0	5	2	2	4
Univ. of Rochester	0	0	0	1	0	0	0	2
Washington Univ.	0	0	0	0	1	1	3	2
Yale	1	1	0	1	6	1	5	8

Sources: The National Academies: www8.nationalacademies.org/onpinews/bydate.aspx (February 10, April 25, and October 9, 2006); American Academy of Arts & Sciences: www.amacad.org/news/alpha2006.aspx and www.amacad.org/news/alpha2005.aspx

Engineering (NAE), Institute of Medicine (IOM), and the American Academy of Arts and Sciences (AAAS). NAS, NAE, and IOM are members of the National Academies, created to advise the government in scientific and technical matters. NAS members are distinguished scholars engaged in scientific and engineering research; members of the NAE are among the world's most accomplished engineers. IOM members are charged with advising the government on policy matters pertaining to the health of the public. AAAS is an honorary society that recognizes achievement in the natural sciences, social sciences, arts, and humanities.

Five Northwestern faculty members were elected to national academies or societies in fiscal year 2006:

Darlene Clark Hine, professor of African American studies, American Academy of Arts and Sciences

Brian M. Hoffman, professor of chemistry, National Academy of Sciences

continued on p. 10

Table 3 — National Academy of Sciences 2006 Membership with Current Affiliation

UNIVERSITY	NUMBER OF MEMBERS	NATIONAL RANK
Harvard	165	1
Stanford	125	3
MIT	101	4
Princeton	71	5
Yale	60	8
Columbia	38	11
Univ. of Chicago	38	11
Cornell	37	13
Univ. of Pennsylvania	34	14
Duke	19	24
Northwestern	18	25
Johns Hopkins	18	25
Washington Univ.	14	--
Univ. of Rochester	7	--
Rice	2	--

Source: National Academy of Sciences of the United States of America Membership Directory/July 2006

Table 4 — National Academy of Engineering 2006 Membership with Current Affiliation

UNIVERSITY	NUMBER OF MEMBERS	NATIONAL RANK
MIT	107	1
Stanford	86	2
Cornell	24	8
Columbia	20	10
Princeton	19	11
Northwestern	18	14
Harvard	15	19
Rice	13	21
Johns Hopkins	11	24
Univ. of Pennsylvania	9	--
Yale	6	--
Univ. of Rochester	5	--
Washington Univ.	4	--
Duke	3	--
Univ. of Chicago	1	--

Source: National Academy of Engineering Membership Directory, www.nae.edu/nae/naepub.nsf/Home+Page?OpenView

Table 5 — Institute of Medicine 2006 Membership with Current Affiliation

UNIVERSITY	NUMBER OF MEMBERS
Harvard	143
Stanford	49
Johns Hopkins	48
Columbia	44
Univ. of Pennsylvania	42
Yale	39
Duke	33
MIT	28
Washington Univ.	20
Univ. of Rochester	14
Univ. of Chicago	10
Cornell	8
Princeton	8
Northwestern	3
Rice	1

Source: Institute of Medicine Public Directory, October 20, 2006

❁ EXCELLENCE IN RESEARCH

Vadim Backman, McCormick School of Engineering and Applied Science

Contemporary diagnostic medicine frequently relies on invasive procedures, such as endoscopy, to detect disease. In the fictional world of *Star Trek*, a doctor is able to make a diagnosis without ever interrogating an organ. Advances in biophotonics made by Northwestern University engineers bring this potential technology closer to reality.

Vadim Backman, professor of biomedical engineering, and Young Kim, a former graduate student in biomedical engineering, developed low-coherence enhanced backscattering (LEBS), an optical technique that senses changes in tissue nanoarchitecture otherwise undetectable by histopathology. Animal and human studies demonstrated that LEBS can detect subtle alterations in histologically normal-appearing cells due to the presence of precancer in a different part of an organ. This may lead to dramatic advances in cancer screening as it may no longer be necessary to interrogate an organ in order to find precancerous tissue.

Colon cancer is an example. It remains the second leading cause of cancer deaths in the United States largely because only a small fraction of Americans over age 50 undergo screening colonoscopy for reasons including expense, patient reluctance, complications, and insufficient number of endoscopists. LEBS may provide a potential solution. Pilot clinical studies performed in collaboration with **Hemant K. Roy**, gastroenterologist at **Evanston Northwestern Healthcare (ENH)**, showed that LEBS analysis of rectal tissue alone can accurately identify patients who harbor precancerous adenomas anywhere in the colon. The researchers envision LEBS as the first truly population-wide screening test for colon cancer without colonoscopy or bowel prep performed by a primary care physician to screen for the need for colonoscopy. Northwestern researchers (in collaboration with **Randall E. Brand**, gastroenterologist at **ENH**) currently are extending this methodology to other cancers including pancreatic and lung cancers. ■

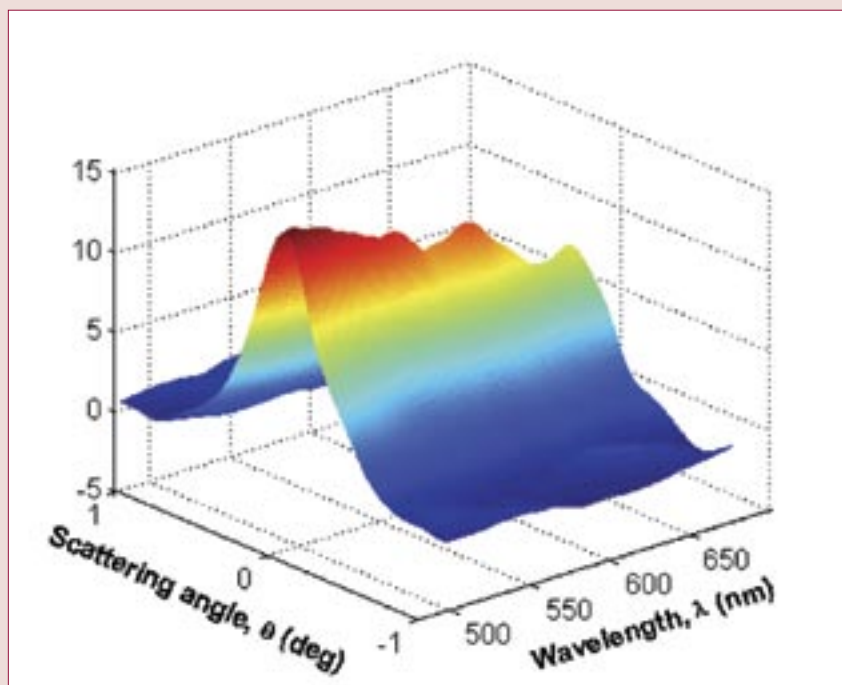


Figure 1

Unless otherwise noted, captions for **EXCELLENCE IN RESEARCH** figures may be found on pages 47 – 48 of this report.

Richard Kieckhefer, professor of religion, American Academy of Arts and Sciences

Richard H. Kraut, professor of philosophy, American Academy of Arts and Sciences

Surendra P. Shah, professor of civil and environmental engineering, National Academy of Engineering

Two visiting professors also were elected:

Lee Epstein, professor of political science and law at Washington University, American Academy of Arts and Sciences

Abraham Nitzan, professor of chemistry at Tel Aviv University, American Academy of Arts and Sciences

CAREER Awards from the National Science Foundation

The Faculty Early Career Development (CAREER) Program is the National Science Foundation's most prestigious award program for new faculty members. 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. Five Northwestern faculty members were recipients of CAREER Awards in 2006:

Guillermo A. Ameer, professor of biomedical engineering

Pablo L. Durango-Cohen, professor of civil and environmental engineering

Bartosz A. Grzybowski, professor of chemistry and biological engineering

Seda O. Memik, professor of electrical engineering and computer science

Hooman Mohseni, professor of electrical engineering and computer science

continued on p. 12

* EXCELLENCE IN RESEARCH

David Austen-Smith and Timothy J. Feddersen, Kellogg School of Management

What constitute legitimate reasons and arguments in group deliberations? The literature suggests that a legitimate reason appeals to some concept of the "common good." In contrast, arguments based on narrow self-interest (e.g., "we should do this because it will make me better off") are typically deemed illegitimate.

The literature also holds that requiring consensus to make collective decisions improves the quality of deliberations. This is often used as an argument in support of requiring juries to reach unanimous verdicts. The intuition is quite simple: the more diverse the set of people who must be persuaded, the more compelling the arguments that must be provided.

In "Deliberation, Preference Uncertainty and Voting Rules," published in the *American Political Science Review* (100:2, 2006), David Austen-Smith and Tim Feddersen, professors of economic decision science, develop a model that allows a logical test of these claims. They find that deliberation does work better when public arguments focus on the common good and public discussion of private interests is suppressed.

Perhaps surprisingly, the second intuition that the requirement of consensus supports information sharing, does not hold up. When consensus is required, each committee member can always block the formation of consensus. Consider a jury that must decide whether to convict someone for a crime using unanimity rule. The result suggests that the requirement of unanimity creates an incentive for jurors to suppress arguments favoring acquittal but not arguments in favor of conviction.

Overall, two insights emerge from this research. First, when deliberating in committees it is a good idea to offer arguments that are based on some notion of the common good and to suppress public discussion of private interests. Second, when designing decision rules for committees, note that the members are more likely to share information if consensus is not required. ■



David Austen-Smith



Timothy J. Feddersen

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Andrew Campbell

✿ EXCELLENCE IN RESEARCH

**Justine M. Cassell,
School of
Communication**

Children with autism, despite their difficulties in social interactions with peers, may spend hours playing with interactive computer games. Yet because autistic children have difficulty interacting face-to-face with others,

they often lack the communication and social interaction skills that lay the groundwork for academic and social achievement.

Justine M. Cassell, professor of communication studies and electrical engineering and computer science, and her students have developed a technology called virtual peers — 3-D life-sized animated characters that look like children and are capable of interacting, sharing real toys, and responding to children's input. Cassell and her students have demonstrated that these virtual peers can use the natural activities of peer collaboration and storytelling to significantly increase children's emergent literacy and social behaviors.

In a new research study funded by the Cure Autism Now Foundation and the National Association of Autism Research Foundation, Cassell and her students are designing and evaluating a computer system that allows children with Autism Spectrum Disorder (ASD) to interact with a life-sized virtual peer and to create and control its communication behaviors. By studying the effects of these interactions, they will develop information about the underlying mechanisms of communication and social reciprocity in autistic children while providing an innovative intervention for ASD.

In a pilot study, an eight-year-old girl with Asperger Syndrome, a form of high-functioning autism, was notably enthusiastic about her experience with Sam, the virtual peer, exclaiming, "It interacts to us," after Sam spoke to her for the first time. The study analyzed her verbal and nonverbal behaviors in interacting with Sam, and compared them with Cassell's existing model of collaboration in nonautistic children.

Cassell and her students hypothesize that the results of their studies will add to the understanding of autism itself and lead to the design of improved interventions so children with ASD can become aware of the support they can receive from the social world around them. ■

Two children interact with an adorable virtual peer.

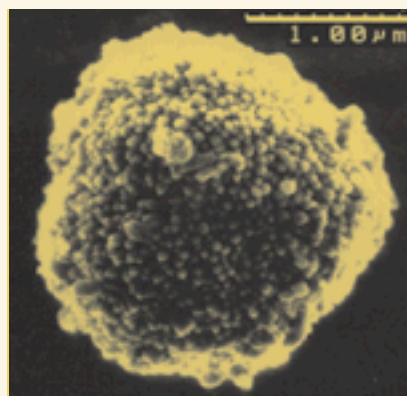
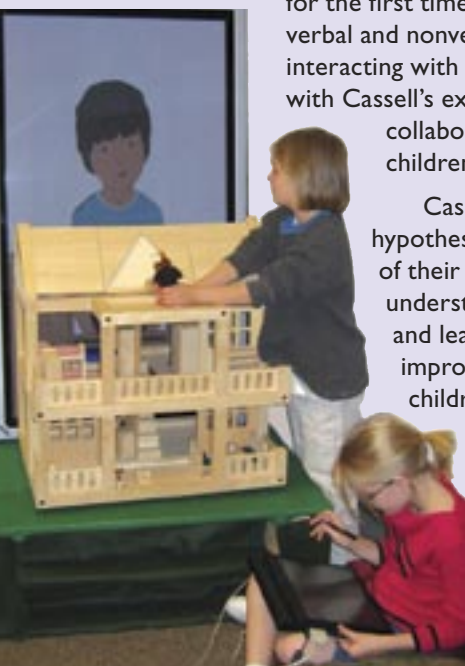


Figure 2

✿ EXCELLENCE IN RESEARCH

**Hui Cao, Weinberg College
of Arts and Sciences**

The behavior of light in disordered media is of great interest not only to physicists but also to biologists. One extraordinary phenomenon induced by strong light scattering is that light may be "frozen" inside a random medium. Utilizing that light, Hui Cao, professor of physics and astronomy, and her research team realized a new type of laser called random laser.

They took a cluster of zinc oxide (ZnO) nanoparticles fabricated in a simple chemical reaction. The average particle size is about 50 nanometers. Although the cluster has a dimension of about one micron, it consists of more than 10,000 ZnO nanoparticles. They then optically excited the ZnO so that it could emit and amplify light. Because the emitted photons cannot easily leave the cluster, the light is bounced from one nanoparticle to another thousands of times before finally escaping through the boundary of the cluster.

As it wanders inside the cluster, the light is amplified by ZnO. The longer the path length inside the cluster, the stronger the amplification. When the amplification is strong enough, coherent light is generated from the random media. This is a surprising result, as strongly scattering media are usually considered messy or useless. But such media can generate coherent light if sufficiently excited.

This process is general and happens in many material systems, such as disordered polymers and organic materials, and even in animal tissues. The process has potential applications in identification, encoding and labeling, machine vision, search and rescue mission, photo-dynamic therapy, and tumor detection. This work is done in collaboration with **Robert P.H. Chang**, professor of materials science and engineering at **McCormick School of Engineering and Applied Science**, and is supported by the National Science Foundation. ■



Courtesy Hui Cao

Table 6 — NSF CAREER Awards

UNIVERSITY	2001-2006	NEW AWARDS IN 2006
MIT	38	N/A
Cornell	34	6
Northwestern	34	5
Stanford	34	8
Columbia	33	1
Princeton	28	N/A
Duke	26	5
Univ. of Pennsylvania	24	2
Yale	24	6
Johns Hopkins	20	N/A
Harvard	18	0
Washington Univ.	16	4
Rice	15	N/A
Univ. of Chicago	14	N/A
Univ. of Rochester	12	2

Source: National Science Foundation Faculty Early Career (CAREER) Program, www.nsf.gov/crssprgm/career/awards.jsp, October 26, 2006.

With a total of 34 CAREER Awards, Northwestern is tied for second with Cornell University and Stanford University among its peer universities.

Citations

Among the nation's most influential researchers are those faculty members whose great influence is demonstrated by the citations to their work in the literature of their fields. In this way, their colleagues acknowledge their intellectual debt to these individuals. Those who have made fundamental contributions to the advancement of science and technology in recent decades are recognized in this list.

In 2006, 34 Northwestern faculty members appeared on the list of highly cited researchers, a selective list made up of less than one-half of one percent of the more than 5 million researchers indexed in the Institute for Scientific Information citation database. The following Northwestern faculty are among the most-cited researchers worldwide in their respective categories.

Table 7 — Highly Cited Researchers

UNIVERSITY	2006	INCREASE IN NUMBER SINCE 2005
Harvard	169	39
Stanford	133	6
MIT	73	N/A
Princeton	62	N/A
Yale	60	1
Univ. of Pennsylvania	55	3
Cornell	52	2
Columbia	45	3
Univ. of Chicago	43	N/A
Duke	39	2
Northwestern	34	3
Johns Hopkins	32	N/A
Washington Univ.	27	3
Univ. of Rochester	13	1
Rice	9	N/A

Source: Institute for Scientific Information Highly Cited Researchers, <http://isihighlycited.com>, October 2006

James C. Anderson, Economics/
Business

Alvin Bayliss, Mathematics

Zdenek P. Bazant, Engineering

Ted Belytschko, Engineering

Robert Ogden Bonow, Clinical
Medicine

Stephen H. Davis, Engineering

Greg J. Duncan, Social Sciences,
General

Katherine T. Faber, Materials Science

Arthur J. Freeman, Physics

Robert J. Gordon, Economics/Business

John Hagan, Social Sciences, General

Michael L. Honig, Computer Science
James A. Ibers, Chemistry
Leon M. Keer, Engineering
Robert A. Lamb, Microbiology
Wing Kam Liu, Engineering
Tobin J. Marks, Chemistry
Thomas O. Mason, Materials Science
Bernard J. Matkowsky, Mathematics
Marsel M. Mesulam, Neuroscience
Richard J. Miller, Neuroscience,
 Pharmacology
Jorge Nosedal, Mathematics
Mark A. Ratner, Chemistry
Martin H. Redish, Social Sciences,
 General
Bruce E. Rittmann, Ecology/
 Environment
Robert Schleimer, Immunology
Patricia G. Spear, Microbiology
Jeremiah Stamler, Clinical Medicine
Seth Stein, Geosciences
Allen Taflove, Computer Science
Martin A. Tanner, Mathematics
Peter W. Voorhees, Materials Science
Julia R. Weertman, Materials Science
Edward J. Zajac, Economics, Business

With 34 highly cited researchers,
 Northwestern University is ranked eleventh
 among the benchmark institutions.

continued on p. 15

* EXCELLENCE IN RESEARCH

Adam Galinsky and J. Keith Murnighan,
Kellogg School of Management

That sellers who ask for more will actually get more, i.e., a high starting price will bring a higher final price, is an intuition confirmed countless times by research. Sellers who ask for more do better.

This is not necessarily true in auctions, according to Adam Galinsky and J. Keith Murnighan, professors of management and organizations. In an article published in the *Journal of Personality and Social Psychology* in July 2006, they used a combination of laboratory experiments and analyses of eBay auction bidding to determine that, in the social setting of auctions, lower starting prices can result in higher final prices.

Unlike negotiations, where the starting price acts as an anchor that psychologically limits and constrains counteroffers, the social setting of auctions activates different dynamics. Particularly in Internet auctions, the number of potential bidders can be almost unlimited, and they can all be influenced by each others' bids.

Low starting prices reduce economic barriers to entry, encouraging more bids at little cost. Early bids then stimulate two psychological processes that combine to drive up the final price. First, early bidders get hooked by an auction. Early bids become "sunk costs," which motivate additional bids, especially when someone else's bid supersedes theirs. Second, more bidding activity suggests to other potential bidders that the item is valuable, further increasing bidding activity, heightening competitive feelings, and increasing final prices.

Whenever there is a barrier to entry or few interested buyers, however, low starting prices will lead to lower final prices. When a brand name is misspelled, for example, it draws less traffic than comparable items correctly spelled. When items do not generate traffic, lower starting prices lead to lower final prices. ■



Adam Galinsky



J. Keith Murnighan

Sam Levitan Photography

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❁ EXCELLENCE IN RESEARCH

Bartosz A. Grzybowski, McCormick School of Engineering and Applied Science

Self-assembly (SA) is the study of structures, materials, and systems that build themselves without human intervention. Experimental strategies based on SA are particularly challenging at the nanoscale, where neither the tools of chemical synthesis nor the conventional manipulators/robots are sufficiently selective and/or precise to guide the organization of individual nanoscopic parts.

Bartosz A. Grzybowski, professor of chemical and biological engineering and chemistry, and his research group managed to circumvent many of these limitations by using electrostatic and photo-induced forces to mediate self-assembly of thousands to millions of nanoparticles into ordered and functional structures. Interestingly, while some of these structures are “static”



Courtesy of Bartosz Grzybowski

(i.e., stable once assembled, Figure 3, top), others can be reconfigured and even structurally evolved “on demand” using light of different wavelengths. The bottom part of Figure 3 shows one such example where light controls self-assembly and disassembly of metal nanoparticles into large crystals or doughnut-shaped aggregates. These structures are not only the first known examples of metastable nanomaterials but are also of practical interest in sensors and “smart” delivery systems that would release their contents in response to an external stimulus. In addition, the self-assembly process poses several intriguing questions as to the fundamental nature of electrostatics at the nanoscale. “Electrostatic forces between charged nano-objects are quite peculiar,” says Grzybowski. “They are short ranged, allow oppositely charged particles to remain stable in solution, and can cause like-charged objects to attract one another. They are the living proof that nano really is different — and of course, quite fascinating.”

The Grzybowski laboratory now houses 20 people from five continents and many fields — chemistry, physics, engineering, mathematics, and biology — who share this fascination. The young team is generously supported by the National Science Foundation, National Institutes of Health, and American Chemical Society Petroleum Research Fund as well as industrial sponsors 3M and Baxter. ■

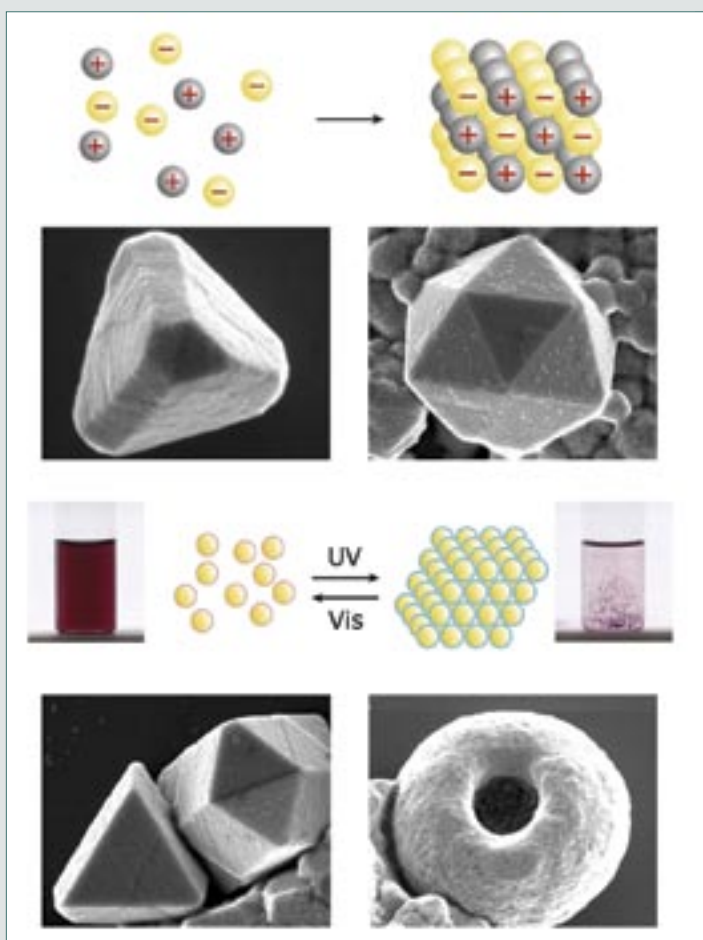


Figure 3

✱ EXCELLENCE IN RESEARCH

Mitra J. Hartmann, McCormick School of Engineering and Applied Science

When humans can't see ahead of them, they often use their hands to feel their way through darkness. Many mammals, however, are able to use their whiskers to explore their environment and to construct a three-dimensional image of their world. Rodents, for example, use their whiskers to determine the size, shape, and texture of objects, and seals use their whiskers to track the fluid wakes of their prey.

Sam Levitan Photography

Mitra J. Hartmann, professor of biomedical engineering and mechanical engineering, and Joseph H. Solomon, mechanical engineering graduate student, have been studying the whisker system of rats to better understand how mechanical information from the whiskers is transmitted to the brain and to develop artificial whisker arrays for engineering applications. Based on their studies, they have developed arrays of robotic whiskers that sense in two dimensions, mimicking the capabilities of mammalian whiskers and showing how the arrays can sense information about both object shape and fluid flow.

"We show that the bending moment, or torque, at the whisker base can be used to generate three-dimensional spatial representations of the environment," said Hartmann. The technology, she said, could be used to extract the three-dimensional features of almost any solid object. NASA researchers say rovers bristling with metal whiskers may one day aid the exploration of Mars or other worlds. Such sensors could provide 3-D images of rock textures, steer a rover around hazards, or help it function when dust storms reduce visibility.

This research is supported by two awards from the National Science Foundation and NASA's CICT/ITSR Revolutionary Computing Algorithms project at the Jet Propulsion Laboratory, California Institute of Technology. ■



Figure 4

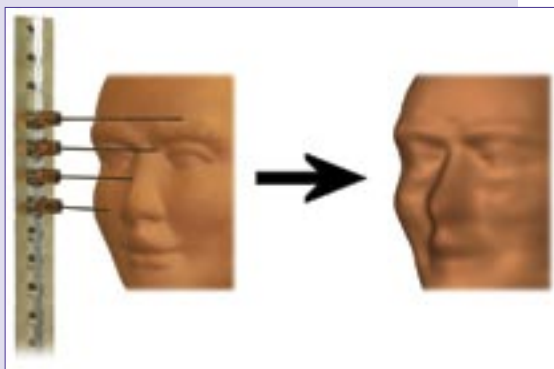


Figure 5

2006 Faculty Recognition and Honors

Each year, Northwestern's Office of Administration and Planning, in conjunction with the school deans, compiles a comprehensive listing of faculty awards and honors, which is then reviewed by the Faculty Honors Committee. The Faculty Honors Committee selects the most prestigious awards for University recognition. The following faculty members were honored by the University for bringing distinction to Northwestern through their important recognition from societies and agencies outside the University in 2005-06:

Luis A.N. Amaral, Distinguished Young Scholar in Medical Research, W.M. Keck Foundation

Guillermo A. Ameer, Early Career Development Award, National Science Foundation

Zdenek Bazant, Foreign Member, Accademia Nazionale dei Lincei

Robert Bonow, Distinguished Service Award, American College of Cardiology; Distinguished Achievement Award, American Heart Association

Francesca Bordogna, Fellow, National Humanities Center; Rockefeller Foundation Fellowship

Catherine L. Brinson, Friedrich Wilhelm Bessel Research Award, Alexander von Humboldt Foundation

Linda Broadbelt, Distinguished Scholar Award, U.S.-U.K. Fulbright Commission

Bruce G. Carruthers, Fellowship, John Simon Guggenheim Memorial Foundation

Aaron Michael Cassidy, Concert Music Division Award, American Society of Composers, Authors, and Publishers

William J. Catalona, Golden Glove Award, National Prostate Cancer Coalition; Donald S. Coffey Physician-Scientist Award, Prostate Cancer Foundation; Charles Huggins Award, Society of Urologic Oncology

Faculty Recognitions continued on p. 19



Jill Carlson, Martin Woods Image Consulting, LLC



✿ EXCELLENCE IN RESEARCH

Bryna R. Kra, Weinberg College of Arts and Sciences

Ergodic theory is a branch of abstract mathematics that studies the way abstract systems evolve over time. Ergodic theory originated with problems in statistical mechanics, but since then has developed applications in functional analysis, number theory, geometry, and many other areas of mathematics. Bryna R. Kra, professor of mathematics, uses ergodic theory to solve problems in number theory and combinatorics, an area now known as combinatorial ergodic theory.

An early important combinatorial result (proved by van der Waerden in the 1920s) states that if the natural numbers $1, 2, 3, \dots$ are grouped into two or more subsets, then at least one of these subsets contains certain highly structured patterns. Van der Waerden showed that some subset contains arithmetic progressions; for example, the sequence $2, 9, 16, 23$ is an arithmetic progression of length 4.

Underlying van der Waerden's Theorem is a notion of largeness called positive upper density. Roughly speaking, a set with positive upper density

contains a positive percentage of all natural numbers. Both the even numbers and the odd numbers have density one half, while the prime numbers and the set of perfect squares each have density zero. In the 1970s, Szemerédi showed that sets of positive upper density also contain arithmetic progressions.

Kra has uncovered new phenomena in ergodic theory related to the structure of abstract dynamical systems. These results, in turn, have given us a deeper understanding of the patterns that arise in sets of integers with positive upper density and have been applied to find patterns in other subsets of integers.

A particularly striking recent advance concerns patterns that must occur in the prime numbers. These discoveries about the prime numbers feed back to give more precise information on the structure of abstract dynamical systems. Kra continues to understand and develop the profound connections between these fields. ■

EXCELLENCE IN RESEARCH

Mark Hersam, McCormick School of Engineering and Applied Science

Carbon nanotubes are tubes of pure carbon molecules, approximately one nanometer in diameter, that have exceptional mechanical, thermal, optical, and electrical properties. Researchers worldwide are striving to use these nanostructures in electronics, high-resolution displays, high-strength composites, and biosensors, but they have encountered a fundamental problem relating to their synthesis. Current methods for synthesizing carbon nanotubes produce mixtures of tubes that differ in their diameter and twist. These structural differences result in variations in electronic properties, thus limiting the use of carbon nanotubes in most industrial-scale applications.

Now a new method developed at Northwestern University for sorting carbon nanotubes promises to overcome this problem. The method exploits subtle differences in the buoyant densities of carbon nanotubes as a function of their size and electronic behavior. Mark Hersam, professor of materials science and engineering, led the research team whose results were published in the inaugural issue of *Nature Nanotechnology* (October 2006).

Using the Northwestern method, carbon nanotubes first are encapsulated in water by soap-like molecules called surfactants. Next, the surfactant-coated nanotubes are sorted in density gradients that are spun at tens of thousands of rotations per minute in an ultracentrifuge. By carefully choosing the surfactants utilized during ultracentrifugation, Hersam and his research team found that carbon nanotubes could be sorted by diameter and electronic structure.

As a part of their study, the researchers demonstrated the fabrication of electrical devices that displayed either semiconducting or metallic behavior, depending on the sorted nanotubes used. The researchers also maintain that their technique can be translated to an industrial scale.

The research is supported by the National Science Foundation, U.S. Army Telemedicine and Advanced Technology Research Center, and U.S. Department of Energy. ■



Sam Levitan Photography

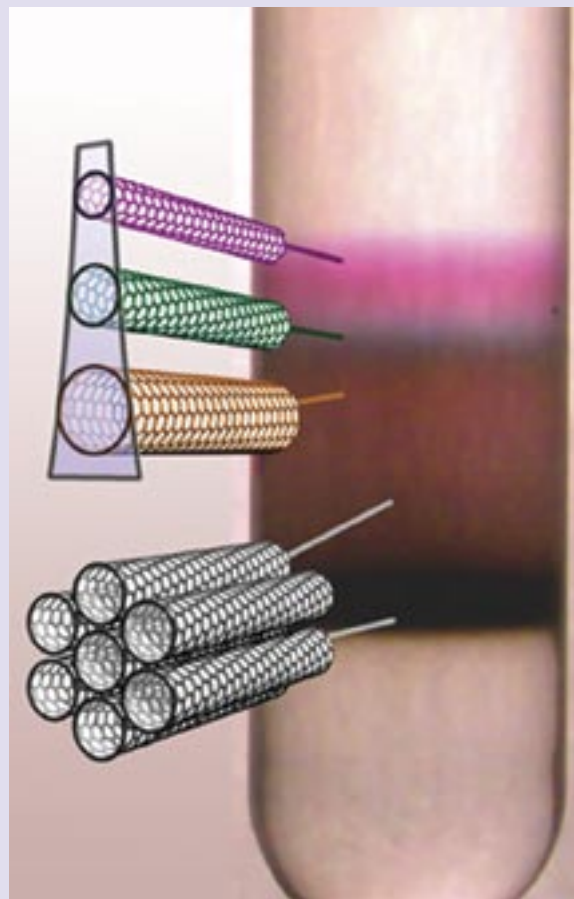


Figure 6



Ron Hayes

❁ EXCELLENCE IN RESEARCH

Nina Kraus, School of Communication, Weinberg College of Arts and Sciences, and Feinberg School of Medicine

Researchers in the Auditory Neuroscience Lab investigate how speech and music are encoded in the brain. Nina Kraus, professor of communication science and disorders, is interested in understanding how this neural encoding faithfully represents the acoustic characteristics of sound in the normal system, how it breaks down in the impaired system, and how it reacts to differing levels of expertise.

Her group's research has shown that for impaired systems (e.g., learning disorders, autism), the neural encoding of speech can be used as a biological marker of deficient sound encoding, while the musician's brain illustrates how extensive auditory expertise can enhance the sensory circuitry within the auditory system. The link between music

experience and the enhancement of sensory function underscores why it is important to keep music education in schools.

The Auditory Neuroscience Lab research team has discovered that speech sounds are translated into brain waves with remarkable precision by auditory pathway neurons. This precision is disrupted in some children with learning problems such as dyslexia.

Kraus's research has been translated to clinical use: BioMAP (Biological Marker of Auditory Processing, Bio-logic Systems Corp) provides an objective measure of auditory function used in the evaluation and diagnosis of children with learning, reading, and listening disorders. Auditory function is immensely malleable; the Kraus laboratory has shown that auditory training particularly benefits children with abnormal BioMAP scores by changing their brain activity and their learning abilities.

This research is funded by the National Institutes of Health and the National Science Foundation. ■

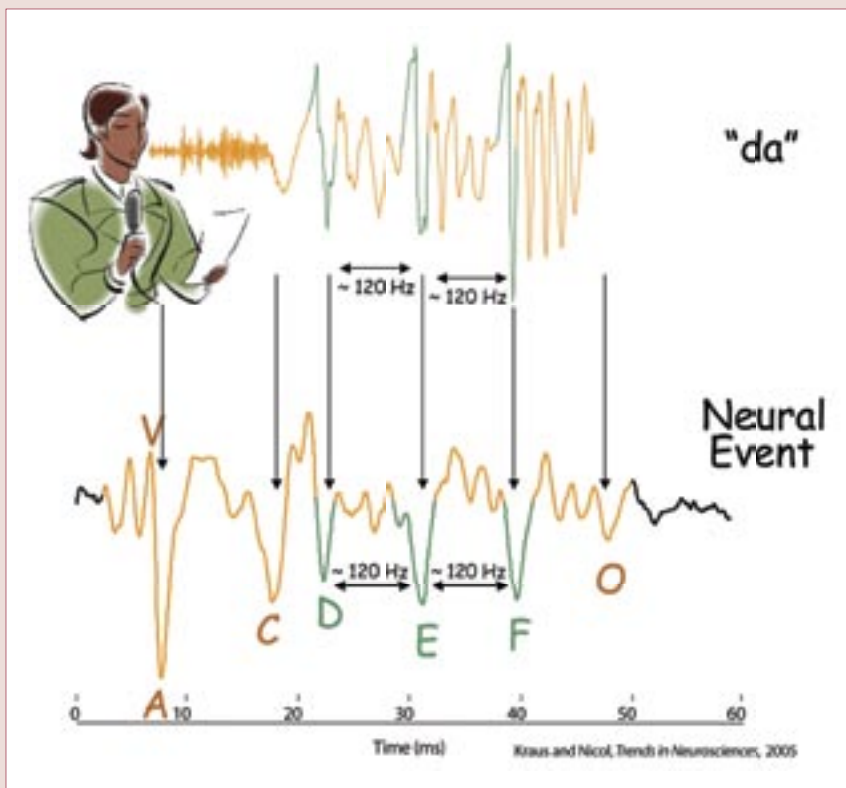


Figure 7

Navdeep Chandel, Anthony Linnane Young Investigator Award, Mitochondria Research Society

Wei Chen, Ralph R. Teetor Educational Award, Society of Automotive Engineers International

Yan Chen, Early Career Award, U.S. Department of Energy

Dante Renato Chialvo, Fellowship, Fulbright Scholar Program, Council for International Exchange of Scholars

Jamie Collings, Faculty Teaching Award, American College of Emergency Physicians

Averill Curdy, Writers' Award, Rona Jaffe Foundation

Isaac Daniel, P.S. Theocaris Award, Society for Experimental Mechanics

Mark Daskin, Fellow, Institute of Industrial Engineers; Inductee, Edelman Academy Institute for Operations Research and Management Sciences

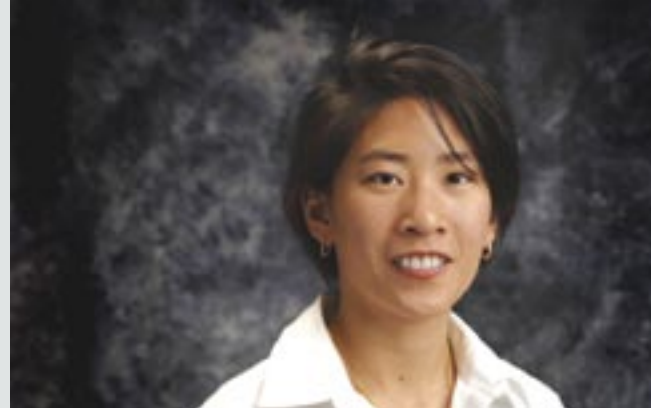
Tracy Davis, Distinguished Scholar's Prize, American Society for Theatre Research

Sumitraje Dhar, Early Career Contributions in Research Award, American Speech-Language-Hearing Association

Micaela di Leonardo, Residential Fellowship, National Endowment for the Humanities

James N. Druckman, Emerging Scholar Award, American Political Science Foundation, Section on Elections, Public Opinion, and Voting Behavior; Erik Erikson Early Career Award, International Society of Political Psychology; Founders' Award, Presidency Research Group; Fellow, Center for Advanced Study in the Behavioral Sciences

Faculty Recognitions continued on p. 20



Sandra Younger Photography

✿ EXCELLENCE IN RESEARCH

Teri Odom, Weinberg College of Arts and Sciences

Structures with at least one critical dimension on the nanoscale (1–100 nanometers) can exhibit unique size-dependent properties, such as tunable color, depending on the size, shape, and materials of the nanostructure. Even more intriguing is that the arrangement of the structures on surfaces — the nanoscale patterns — can produce unexpected and interesting behavior. Teri Odom, professor of chemistry, and researchers in her laboratory have developed a novel, powerful technique to produce free-standing nanostructures called PEEL, which can create arrays of complementary structures simultaneously: nanoscale holes and particles. [Henzie, et al., *Accounts of Chemical Research*, 39: 249–257 (2006)].

Using PEEL, they can create metallic pyramids composed of one or more materials and having nanoscale tips (radii of curvature < 2 nm). Gold pyramidal shells absorb and scatter

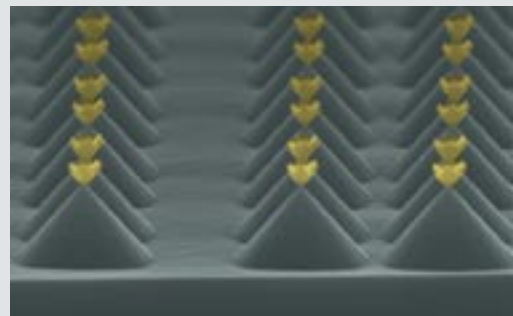


Figure 8

light from red to near-infrared wavelengths. Pyramids that are larger than 250 nm in diameter also exhibit multipolar plasmon resonances (compared with smaller particles that only support dipolar resonances). Because the arrays of pyramids can be precisely aligned within a transparent elastomeric film, researchers can observe the sensitivity of the plasmon resonances to the direction and polarization of the incident field. [Henzie, et al., *Journal of Physical Chemistry B* 110: 14028–14031 (2006)].

Pyramids are an ideal system for creating multifunctional particles since their materials, chemical, and biological functionality can be independently controlled. Since they also absorb and scatter light (which can be converted to heat) at wavelengths that can pass through tissue, they can potentially be used for the photothermal treatment of cancer.

Odom's work is supported by the David and Lucile Packard Foundation and the NSF Materials Research Science and Engineering Center at Northwestern. ■

Andrea Dunaif, Berthold Medal, German Endocrine Society; Honorary Doctorate, University of Athens

Greg Duncan, Social Policy Award for Best Research Journal Article, Society for Research on Adolescence

Pablo Durango-Cohen, Early Career Development Award, National Science Foundation

Lee Epstein, Member, American Academy of Arts and Sciences

Horatio D. Espinosa, Young Investigator Medal, Society of Engineering

Richard Finno, Thomas A. Middlebrooks Award, American Society of Civil Engineers

Wendi Gardner, Early Career Contribution Award, International Society for Self and Identity

Erwin Goldberg, Honorary Degree, Binghamton University, State University of New York

Kathleen Grady, Nursing and Social Sciences Excellence in Research Award, International Society for Heart and Lung Transplantation

David Green, Outstanding Life Achievement Award, Hemophilia and Thrombosis Research Society

Paul Greenberger, Distinguished Service Award, American Academy of Allergy, Asthma, and Immunology

Bartosz A. Grzybowski, Early Career Development Award, National Science Foundation; Scholars Award in Biomedical Sciences, Pew Scholars Program; Unilever Award, American Chemical Society, Division of Colloids and Interfaces

Karsten Hansen, Dennis J. Aigner Award for Best Article, *Journal of Econometrics*

✿ EXCELLENCE IN RESEARCH

Jennifer Richeson, Weinberg College of Arts and Sciences

Through the ages, there have been multiple attempts to read the minds of others. Clairvoyance, extrasensory perception, telepathy and the thought bubbles in cartoons all have tried to capture the difference between what people say and what they are thinking. Jennifer Richeson, professor of psychology and African American studies, is a social psychologist who uses modern scientific tools to penetrate the minds of others in order to understand and, she hopes, improve intergroup dynamics, especially in interactions between

members of minority and majority groups. Her research focuses on prejudice, stereotyping, and intergroup relations, using functional brain imaging, survey techniques, self-reporting, and other empirical methods.

“People today generally understand that prejudice is a bad thing but still don’t quite know how to converse or behave with people different from themselves,” Richeson said. Intergroup interactions can be awkward, less effective, or even avoided “because ‘good people’ don’t want to offend or appear prejudiced,” she added.

A faculty fellow of the Institute for Policy Research, Richeson has also studied motivational and contextual variables that influence how racial cues are used in categorizing other people.

Richeson and her colleagues have found that increased contact between members of different racial groups can be accompanied by unintended negative consequences for both whites and racial minorities. They are currently investigating the underlying mechanisms of this negative effect on cognition, particularly on self-control, which involves inhibiting one’s behaviors, thoughts, and urges to combat, for example, prejudicial thoughts.

After getting a doctorate at Harvard University, Richeson taught at Dartmouth College in Hanover, New Hampshire, before coming to Northwestern last year. The John D. and Catherine T. MacArthur Foundation awarded her a \$500,000 “genius” grant in September in recognition of her work in the psychology of racial bias. ■



Steve Anzaldi



Sam Levitan Photography

✿ EXCELLENCE IN RESEARCH

Anne H. Rowley, Feinberg School of Medicine

Kawasaki disease (KD) is the leading cause of acquired heart disease in children in developed nations and can lead to coronary artery aneurysms, myocardial infarction, and sudden death. Clinical and epidemiologic data point to an infectious cause of KD, but its origins remain unknown.

Anne H. Rowley, professor of pediatrics, and her research team at Children's Memorial Research Center discovered that immunoglobulin A (IgA) plasma cells infiltrate coronary artery aneurysms in children who died of acute KD, and that the IgA produced in the arterial wall is oligoclonal,

or antigen-driven.

They made synthetic versions of these oligoclonal antibodies in their laboratory and incubated them with tissue sections from children who died of acute KD. The synthetic KD antibodies bound specifically to an antigen in bronchial epithelium of acute KD but not in control children and to a subset of macrophages

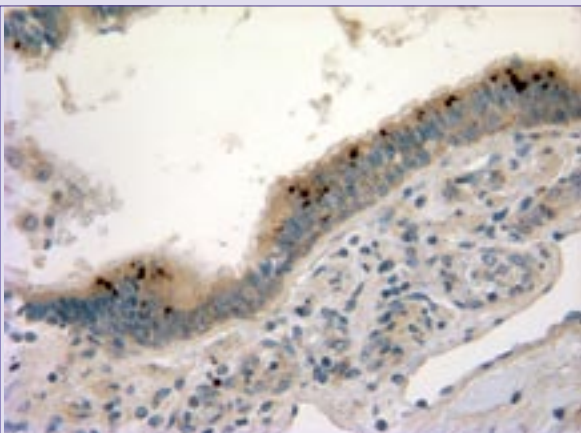


Figure 9

in acute inflamed KD tissues, including the coronary arteries. The antigen is localized to distinctive perinuclear cytoplasmic inclusion bodies in medium-sized ciliated bronchi.

Light microscopy showed that the inclusion bodies contain protein and nucleic acid, and electron microscopy revealed that the inclusion bodies are homogeneous and electron-dense and compatible with aggregates of viral proteins and associated nucleic acid. Their identification of cytoplasmic inclusion bodies in acute KD ciliated bronchial epithelium, which are targeted by the acute KD IgA immune response and thus strongly implicated in the etiology of the disease, is an exciting new breakthrough in the study of KD pathogenesis. Rowley suspects that KD is caused by a new, previously unidentified infectious agent, and she is currently cloning and sequencing the nucleic acids within the inclusion bodies to identify novel microbial DNA or RNA sequences. ■

Faculty Recognitions, cont'd.

Eszter Hargittai, Fellow, Center for Advanced Study in the Behavioral Sciences

Daniel Harrington, First Place Research Award, Society for Pediatric Urology

Mary J.C. Hendrix, Henry Gray Award, American Association of Anatomists

Mark Hersam, Presidential Early Career Award for Scientists and Engineers, U.S. Government; Peter Mark Memorial Award, American Vacuum Society

Darlene Clark Hine, Member, American Academy of Arts and Sciences

Barton J. Hirsch, Social Policy Award for Best Authored Book, Society for Research on Adolescence

Brian Hoffman, Member, National Academy of Sciences

Wallace J. Hopp, Fellow, Production and Operations Management Society; Fellow, Manufacturing and Service Operations Management Society; Education Award, Society of Manufacturing Engineers

Joel L. Horowitz, Member, International Statistical Institute

John Hunwick, Distinguished Africanist Award, African Studies Association

Joseph Hupp, Carl Wagner Memorial Award, Electrochemical Society

Ian Hurd, Robert O. Keohane Prize for Best Article, *International Organization*

J. Larry Jameson, Member, Institute of Medicine

Faculty Recognitions continued on p. 24



Jill Carlson, Martin Woods Image Consulting, LLC

Rudolph T. Ware and Rüdiger Seesemann

✿ EXCELLENCE IN RESEARCH

Rüdiger Seesemann and Rudolph T. Ware, Weinberg College of Arts and Sciences

Rudolph T. Ware, professor of history, and Rüdiger Seesemann, professor of religion, are co-investigators on the Ford Foundation grant: “Constituting Bodies of Islamic Knowledge: Deepening and Expanding the Study of Islamic Thought in Africa.” Through this project, which supports field research in Africa, Ware and Seesemann are investigating how African Muslims of all social strata actively shape religious life through their engagement with texts and bodies of religious knowledge.

In addition to historical manuscripts, Ware and Seesemann’s project considers more widely circulated and contemporary religious material, such as audio and visual recordings and ephemeral texts. The recent proliferation of such materials has helped to reshape Islamic knowledge and its transmission within Africa.

Under Seesemann’s leadership, an international team of researchers is compiling a biobibliographical work on writings of scholars of the Tijāniyya Sufi order — the largest Sufi order in sub-Saharan Africa and one of the most important, but as yet understudied, mystical traditions within Islam.

Ware, in collaboration with several Senegalese researchers, is collecting data on the scholarly libraries maintained by clerical families in the Fuuta Toro region of Senegal and Mauritania. The contents of these libraries and their histories offer a unique perspective

on Islam’s development in an area widely thought to be the cradle of Islam in West Africa.

Seesemann and Ware are organizing workshops in thematic areas and a major interdisciplinary conference that will address broader themes of interest to a wide variety of scholars. One of their goals is to initiate a dialogue with scholars from other religious and regional contexts to better integrate the study of Islamic Africa into broader disciplines such as religious studies and history. ■



Village mosque and library of the Ba family, Paté Gallo, Senegal. Photo by Rudolph T. Ware.



The Ahlul Bayt Library, center for the diffusion of Shiite and general Islamic literature and audiocassettes in Lamu, Kenya. Photo by Rüdiger Seesemann.

❁ EXCELLENCE IN RESEARCH

Teresa K. Woodruff, Feinberg School of Medicine and Lonnie D. Shea, McCormick School of Engineering and Applied Science

A woman's risk for infertility after cancer is generally greater than a man's because sperm is more reliably banked than viable ova. Egg banking is not yet a secure option for fertility preservation, as the freezing and thawing can damage the larger eggs and smaller eggs are not sufficiently mature to be used. Teresa K. Woodruff, professor of obstetrics and gynecology, and Lonnie D. Shea, professor of chemical and biological engineering, have developed a new technique that may provide a fertility-sparing option for women with cancer and other women at risk of infertility.

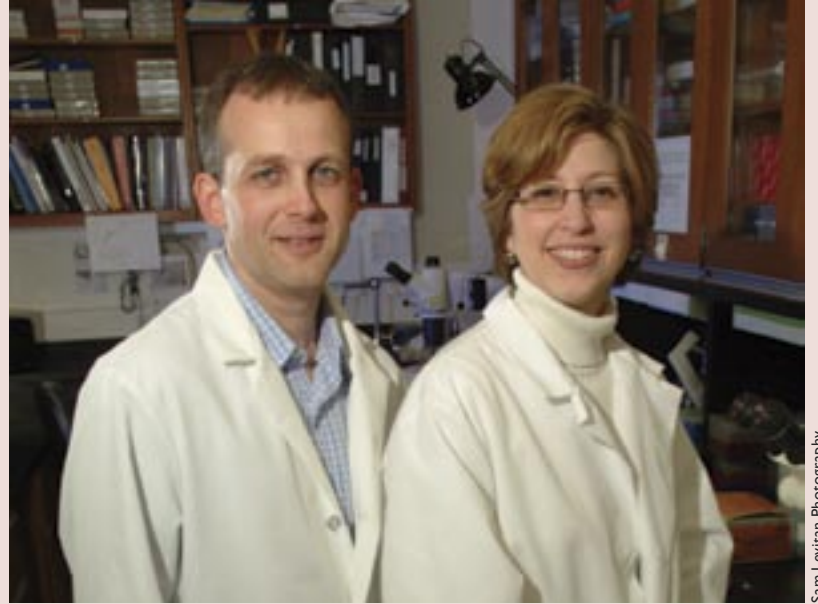
Woodruff and Shea have collaborated to produce a culture system that allows immature follicles, which consist of an immature oocyte or egg and surrounding somatic cells, to be grown *in vitro* and produce mature eggs that can be fertilized and produce live births. The culture system uses the hydrogel alginate, a polysaccharide isolated from seaweed that becomes a gel that entraps

the follicle. This entrapment maintains the three-dimensional architecture of the follicle, which is critical to maintaining the communication between the centrally located oocyte and the surrounding somatic cells. Growth factors, hormones, and extracellular matrix proteins present within the hydrogel stimulate growth of the follicle.

Importantly, the mechanical properties of the alginate were tuned to maintain the architecture

yet allow for the expansion of the oocyte and follicle as maturation progresses. The culture system design serves to coordinate the growth of each cell type in the follicle, leading to high-quality oocytes and healthy offspring.

This research is currently being translated to primates and humans through the newly formed Division of Fertility Preservation in the Department of Obstetrics and Gynecology at Feinberg School of Medicine. ■



Lonnie D. Shea and Teresa K. Woodruff

Sam Levitan Photography

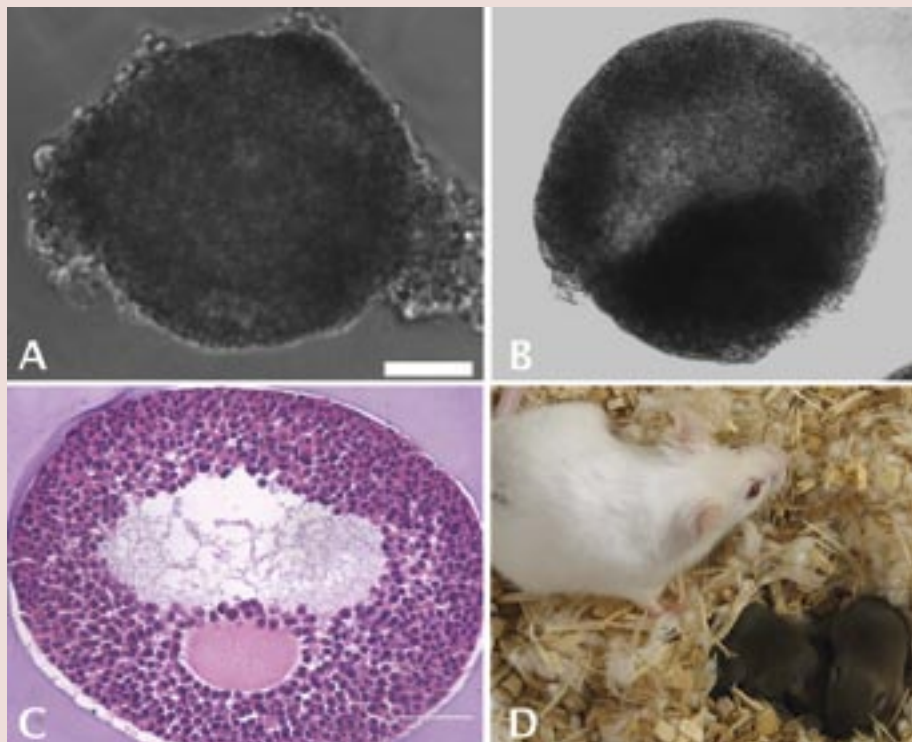


Figure 10

Carl Johnson, Fellowship, Fulbright Scholar Program, Council for International Exchange of Scholars

John Keene, Writers' Award, Mrs. Giles Whiting Foundation

Richard Kieckhefer, Member, American Academy of Arts and Sciences

Bryna R. Kra, Centennial Fellowship, American Mathematical Society

Richard Kraut, Member, American Academy of Arts and Sciences

Sridhar Krishnaswamy, Fellow, American Society of Mechanical Engineers

Todd Kuiken, Da Vinci Award for Innovative Engineering, National Multiple Sclerosis Society

Debiao Li, Fellow, International Society for Magnetic Resonance in Medicine

Michael Loriaux, Chevalier, Ordre des Palmes Académiques

James Mahoney, Early Career Development Award, National Science Foundation

Charles F. Manski, Honorary Doctorate, University of Rome–Tor Vergata

Tobin J. Marks, Member, Leopoldina, German Academy of Natural Sciences

Thomas Mason, Outstanding Educator Award, Ceramic Education Council

Bernard Matkowsky, Fellow, American Physical Society

Dan McAdams, William James Book Award, American Psychological Association; Richard Kalish Innovative Publication Award, Gerontological Society of America; Sarbin Award, American Psychological Association

June McKoy, Fellow, American Geriatric Society

Seda O. Memik, Early Career Development Award, National Science Foundation

Phillip Messersmith, Fellow, American Institute for Medical and Biological Engineering; Merit Award, National Institutes of Health

Hooman Mohseni, Early Career Development Award, National Science Foundation

Joel Mokyr, Dr. A.H. Heineken Prize for History, Royal Netherlands Academy of Arts and Sciences

Richard Morimoto, Huntington Award for Excellence in Medicine, Huntington's Disease Society of America

Aldon Morris, Joseph Sandy Himes Award for Lifetime Scholarship, Association of Black Sociologists

Enrico Mugnaini, Honorary Degree, University of Turin, Italy; Honorary Degree, University of Salamanca, Spain; Campano d'Oro Alumni Award, University of Pisa, Italy; Corresponding Member, Istituto Lombardo di Scienze e Lettere, Milan, Italy

Debjani Mukherjee, Fellowship, Fulbright Scholar Program, Council for International Exchange of Scholars

Toshio Narahashi, Fellow, Academy of Toxicological Sciences

Laura Beth Nielsen, Fellow, Center for Advanced Study in the Behavioral Sciences

Abraham Nitzan, Member, American Academy of Arts and Sciences

Teri Odom, Solid State Chemistry Faculty Fellowship, Exxon Mobil Corporation

Ann Orloff, Visiting Scholar, Russell Sage Foundation

E. Terry Papoutsakis, Fellow, American Academy of Microbiology

Thrasyvoulos Pappas, Fellow, Institute of Electrical and Electronics Engineers

Eric Patrick, Fellow, John Simon Guggenheim Memorial Foundation

Abe Peck, Chicago Journalism Hall of Fame Lifetime Achievement Award, International Press Club of Chicago

Angela Ray, Book Award, Rhetoric Society of America; James A. Winans – Herbert A. Wichelns Award for Distinguished Scholarship in Rhetoric and Public Address, National Communication Association

Manijeh Razeghi, Fellow, American Physical Society

Jennifer Richeson, Fellow, John D. and Catherine T. MacArthur Foundation

Hermann Riecke, Research Award, Alexander von Humboldt Foundation

Lance Rips, Book Award, American Association for Public Opinion Research

John Rudnicki, M.A. Biot Medal, American Society of Civil Engineers

Bradley Sageman, Fellow, Geological Society of America

Karla Satchell, Award for Investigators in Pathogenesis of Infectious Disease, Burroughs Wellcome Fund

Karl Scheidt, New Investigator Award in Organic Chemistry, Boehringer-Ingelheim Company

Paul Schumacker, Recognition Award for Scientific Accomplishment, American Thoracic Society

John J. Sciarra, Honorary Membership, International Society for Gynecologic Endoscopy

David Seidman, Fellow, American Society for Metals International; Albert Sauveur Achievement Award, American Society for Metals International

Hank Seifert, Fellow, American Academy of Microbiology

Surendra Shah, Member, National Academy of Engineering

Billy Siegenfeld, Dance Achievement Award for Outstanding Choreography, Ruth Page Center for the Arts

Wesley Skogan, Stephen Schafer Award, National Organization for Victim Assistance

Janine Spencer, Chevalier, Ordre des Palmes Académiques

Ted Spiegel, Hall of Fame Inductee, Direct Marketing Association

Gary E. Swanson, Fellowship, Fulbright Scholar Program, Council for International Exchange of Scholars

J. Iasha Sznajder, Doctor Honoris Causa, University of Murcia, Spain

Kathleen Thelen, Mattei Dogan Award, Society for Comparative Research at Yale University

Jacquelyn Thomas, H. Paul Root Award, Marketing Science Institute

Richard B. Thomson, Jr., Fellow, American Academy of Microbiology

John Varga, Doctor of the Year, Scleroderma Foundation

Joseph Walsh, William B. Mark Award, American Society for Lasers in Surgery and Medicine

Garry Wills, Laureate, Lincoln Academy of Illinois

Steven M. Wolinsky, Fellow, American Academy of Microbiology

Linda Zerilli, Fellowship, Stanford Humanities Center

Brook Anthony Ziporyn, Fellowship, Fulbright Scholar Program, Council for International Exchange of Scholars

Laurie Zoloth, Public Service Medal, National Aeronautics and Space Administration ■

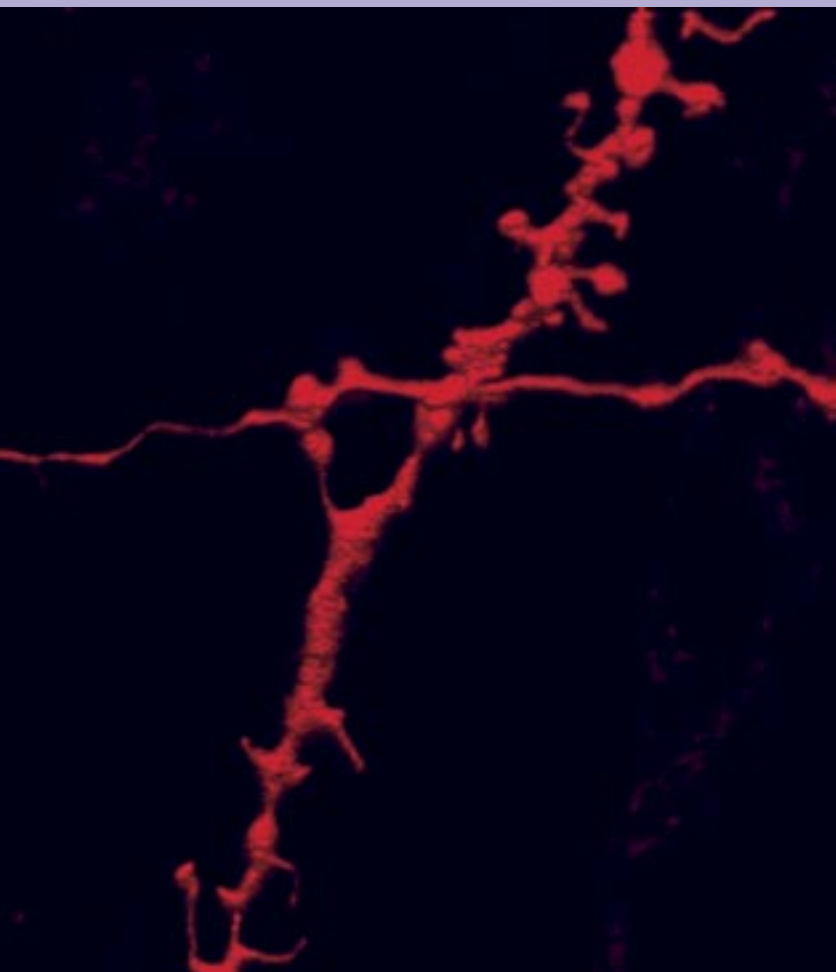


Figure 11

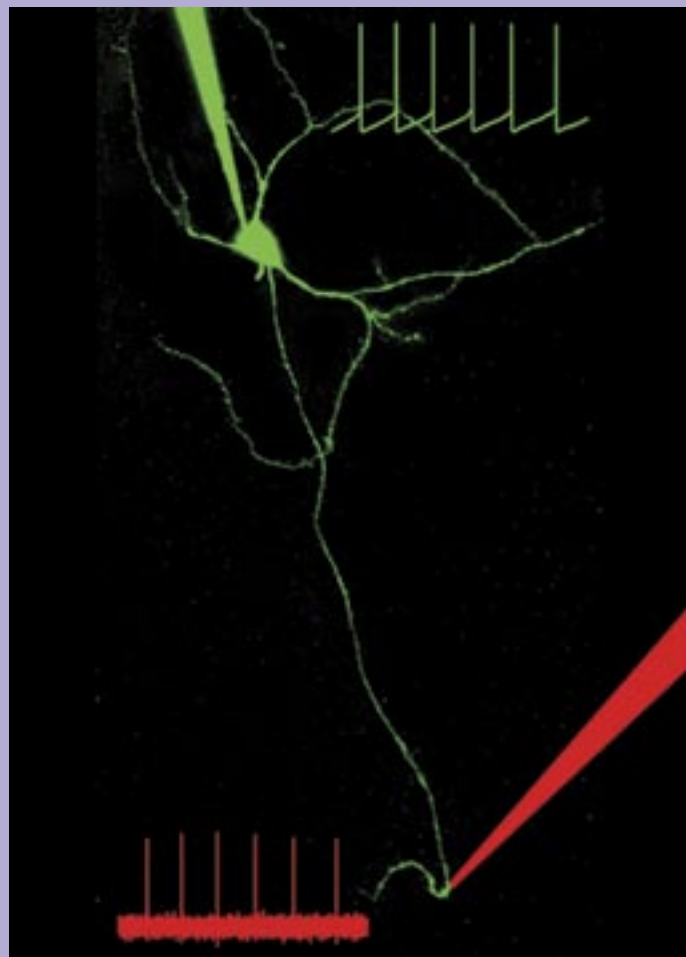


Figure 12

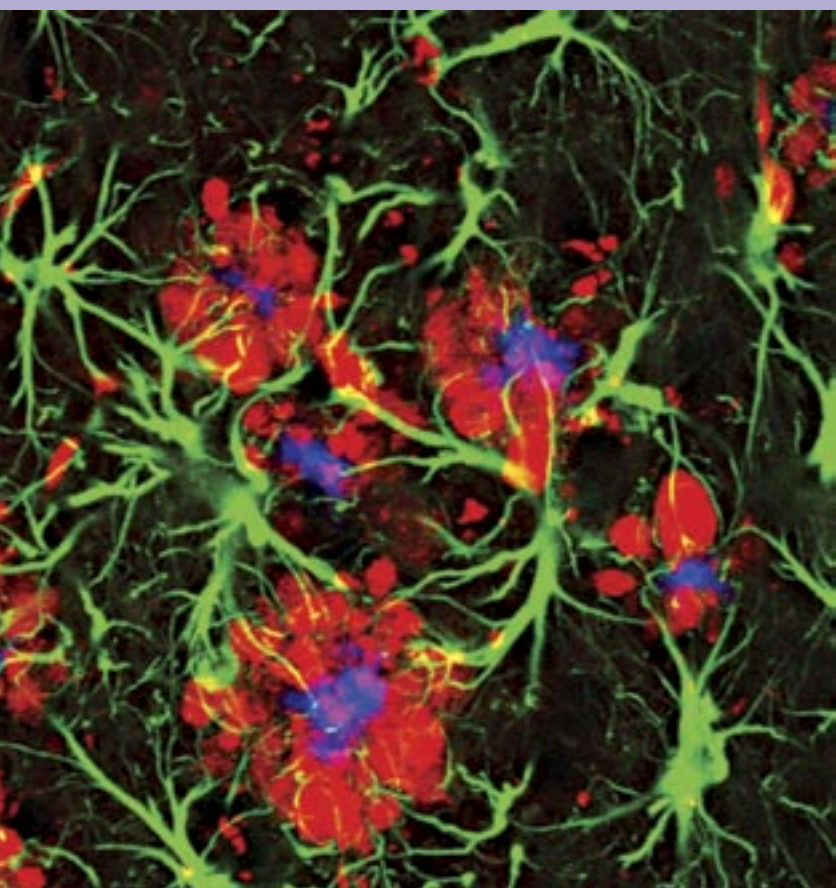


Figure 13

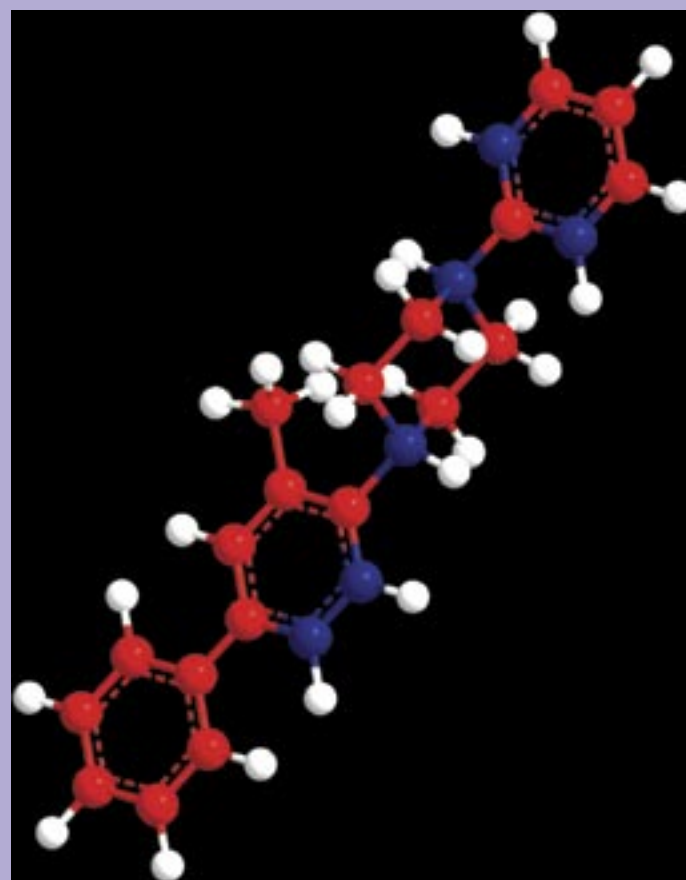


Figure 14



Melissa Snyder

Catherine S. Woolley



Courtesy Mark Bevan

Mark D. Bevan

✿ EXCELLENCE IN RESEARCH

Working to Make Neurodegenerative Diseases a Distant Memory

Americans are living longer than ever before because of improvements in public health and the treatment of infection, cancer, and heart disease. This new longevity has exposed them to a greater threat of the aging brain's vulnerability to degenerative disorders. Neurodegenerative disease has become one of the direst threats to human health in our time.

The need for innovative research into neurodegenerative diseases has never been more crucial, and vital opportunities for progress abound on many fronts, including basic research, diagnostics, and drug discovery. At Northwestern University, many faculty members and other researchers are working separately and in collaboration to unravel the mysteries of these threats to health and quality of life. And they are training students at all levels to understand and treat neurodegenerative diseases and to engage in research that will make a difference.

Here are a few of the researchers who are working to solve the mysteries of the brain, its inner workings, and its vulnerabilities.

Catherine S. Woolley, Weinberg College of Arts and Sciences

Catherine S. Woolley, professor of neurobiology and physiology, has been using reproductive hormones as tools to understand brain plasticity and brain function. Laboratory testing on rats has shown that the female sex hormone estrogen increases the number and complexity of the synaptic connections in the hippocampus, suggesting that the hormone can help protect the brain from degeneration. Her research opens doors to deeper understanding of many diseases, including Alzheimer's and epilepsy. Her

newest research studies the effects of addiction on the brain's neural circuitry. Woolley's experiments prepare the way to finding drugs that mimic estrogen's neuroprotective benefits without activating all of its hormonal effects and that can be used on both men and women.

Woolley's work is funded by the National Institutes of Health's National Institute on Drug Abuse and the National Institute on Neurological Disorders and Stroke. She was also the first Northwestern faculty member to be awarded the W.M. Keck Foundation Award for Distinguished Young Scholars in Medical Research, which she received in 2002.

Mark D. Bevan, Feinberg School of Medicine

Mark D. Bevan, professor of physiology, and his laboratory study the brain's basal ganglia and their dysfunction in movement disorders such as Parkinson's disease (PD). The researchers utilize a combination of electrophysiology, 2-photon imaging, and electron microscopy. Normal neuronal activity in the basal ganglia is arrhythmic, poorly correlated, and related to movement in a highly complex manner. In Parkinson's disease, neuronal activity is strongly correlated, and low-frequency rhythms develop that are associated with the disease's characteristic tremor and other motor symptoms. Bevan's strategy for understanding this transformation has been to first determine the principles underlying normal neuronal activity and then determine how dopamine depletion in PD generates the pathological activity pattern.

One recent therapy for PD is deep brain stimulation of the subthalamic nucleus, which greatly ameliorates the symptoms of PD. Bevan hopes that

— See *Neurodegenerative Diseases*, next page



Sam Levitan Photography

Robert J. Vassar



Courtesy Feinberg School of Medicine

D. Martin Watterson



Linda J. Van Eldik

— *Neurodegenerative Diseases, continued*

greater understanding of the mechanisms underlying the therapeutic efficacy of this treatment will facilitate the discovery of pharmaceutical or other nonsurgical treatments that are associated with less risk to the patient. His laboratory is funded by the NIH's National Institute on Neurological Disorders and Stroke and the National Parkinson Foundation and forms part of Northwestern University's Morris K. Udall Center of Excellence for Parkinson's Disease Research.

Robert J. Vassar, Feinberg School of Medicine

There is no treatment yet that addresses the underlying causes of Alzheimer's disease (AD), the leading cause of dementia in the elderly. Robert J. Vassar, professor of cell and molecular biology, and researchers in his laboratory are working to determine the process of AD in the brain by identifying the important aspects at the cellular and molecular level that lead to neurodegeneration. Their intent is to be able to design drugs or other interventions that would block a particular molecular process.

Vassar identified the enzyme BACE1 in 1999 and determined that it is critically necessary to the production of a peptide, beta-amyloid, that makes up the amyloid plaques, one of the characteristic AD brain lesions. He believes that if the production of beta-amyloid could be blocked, AD could be slowed down, stopped, or even reversed. He is looking at how BACE1 is regulated in the brain and what role it plays in the disease. His group is also making different genetically engineered mouse models of AD — called transgenic and knockout mice — to be used in further study of the AD disease process.

Vassar's research is funded by grants from the National Institutes of Health, the National Institute of Aging, the Illinois Department of Public Health, and the Alzheimer's Disease Association, as well as Searle funding through Northwestern University.

D. Martin Watterson and Linda J. Van Eldik, Feinberg School of Medicine

Researchers at Northwestern's Center for Drug Discovery and Chemical Biology have developed a revolutionary compound they hope will slow the deterioration of brain cells by targeting the inflammation that typically occurs with the onset of Alzheimer's. While current medication offers symptomatic relief to more than four million Alzheimer's patients in the U.S., it does not treat the underlying progression of the disease. Ultimately nerve cells continue to die, resulting in the agitation, loss of memory and disorientation that is associated with Alzheimer's patients.

D. Martin Watterson, professor of molecular pharmacology and biological chemistry, and Linda J. Van Eldik, professor of cell and molecular biology — codirectors of the Center for Drug Discovery and Chemical Biology — targeted the brain's inflammatory mechanisms, designing a compound that would limit brain inflammation and thus slow down the progression of the disease. The chief findings of interest with the compound they created concern the selective nature of the drug and that it appears to specifically block activation of glial cells, considered markers of inflammation in the brain.

Northwestern University has licensed this compound, called Minozac, to NMX, a biotechnology company that has done the FDA-required preclinical toxicology and produced the drug under FDA regulations for planned human trials, which will begin in 2007. The toxicology results so far show that Minozac has no major side effects that might limit its therapeutic use in patients. Recently, Watterson's laboratory received funding from the National Institutes of Health to continue development of drugs in this new class of therapeutics. ■

✿ EXCELLENCE IN RESEARCH

Hans-Georg Simon, Feinberg School of Medicine and Children's Memorial Research Center

Hans-Georg Simon, professor of pediatrics, and his group are focusing on the discovery of genes involved in regenerative processes. As models for these investigations the laboratory uses urodele amphibians, newts, which can regenerate limbs and heart ventricles throughout their lifetimes. The regenerative processes are dependent upon the formation of a blastema, a mass of immature, stem cell-like cells, at the site of injury. The blastema performs the difficult task of integrating new and existing tissues. Using animals that possess a natural inherent ability for repairing damaged limbs or organs, the Simon laboratory is studying nature's solution to rebuilding lost structures.

The regenerating blastema is a self-organizing system, suggesting that autonomous gene pathways control both tissue and position-specific developmental programs. The research group has generated regeneration-specific gene arrays to identify the signature of genes involved in limb and heart wound healing and tissue-rebuilding. The identification of genetic pathways that are operational in the regenerating newt but not in mammals will provide new insights into the restoration of regenerative abilities in nonregenerating species, including humans.

Recognizing the need for novel approaches that can restore, even partially, the structure and function of lost or damaged tissues, the Defense Advanced Research Projects Agency (DARPA) awarded an initial \$3.7 million grant to a consortium of six universities and research centers, including Simon's laboratory at Northwestern, to unlock the regenerative potential in humans. If their experiments succeed, DARPA could provide the researchers up to \$15 million in funding over four years. ■



Heather Stone

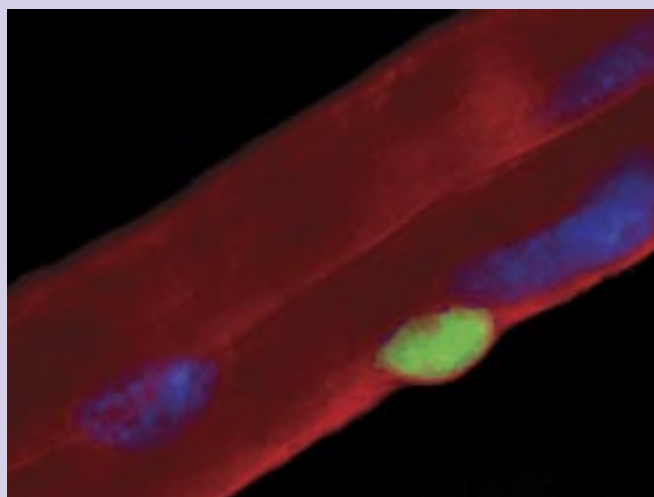


Figure 15

✿ EXCELLENCE IN RESEARCH

Karen R. Smilowitz, McCormick School of Engineering and Applied Science

The late 1990s Internet boom showed that intelligent strategies for the local distribution of goods are crucial to a successful e-commerce business model. The collapse of Internet-based grocer Webvan in 2001 is evidence of this; the "last mile" of distribution posed insurmountable problems for the company. In order to improve transportation and distribution systems to serve the greater demand posed by the Internet, new design and operating strategies are needed.

Karen R. Smilowitz, professor of industrial engineering and management sciences, is exploring potential for introducing operational flexibility in transportation systems for different modes and cargo types. Her research group is evaluating the trade-offs between the increased system efficiency of operational flexibility and the challenges of implementation for transportation providers and their customers.



Sam Levitan Photography

In work with Michal Tzur from Tel Aviv University, Smilowitz explores the impact of operational flexibility in periodic distribution problems, which involve customers requiring repeated visits over time, such as grocery delivery, waste collection, or equipment maintenance. The period vehicle routing problem (PVRP) is an extension of the vehicle routing problem, in which delivery routes are constructed over a time period to visit customers according to preset visit frequencies.

Smilowitz and Tzur have extended the PVRP to allow visit frequency as a decision of the model and developed the first exact solution method. Their results show that determining visit frequencies independent of routing decisions can lead to inefficient solutions in terms of vehicle routing costs and customer service benefits. Smilowitz is currently exploring extensions of this research with UPS to improve their local delivery operations.

This work is supported by the National Science Foundation and the Alfred P. Sloan Foundation. ■

✿ EXCELLENCE IN RESEARCH

Jonathan Widom, Weinberg College of Arts and Sciences

The many different kinds of cells in an organism — hair, skin, nerve, blood, and so on — all have the same DNA and thus the same genes. Their very different sizes, shapes, and functions are created by the different subsets of these genes that they express. The detailed patterns of gene expression characteristic of any given cell change over time in response to environmental changes such as in the availability of food, infection, or signals from another cell. Jonathan Widom, professor of biochemistry, molecular biology and cell biology and of chemistry, and his research group are investigating molecular mechanisms that allow cells to control which genes are expressed at any given time in an organism's life.

This year Widom and colleagues, including **Ji-ping Z. Wang**, professor of statistics, reported the discovery of a code in the DNA that specifies the stretches of the DNA that will be organized into nucleosomes, nanometer-scale protein pools around which much of the DNA is wrapped. The nucleosomes both protect and control access to the DNA itself. These nucleosomes compete with gene regulatory proteins for binding to DNA. The location of the spools along the DNA then determines which parts of the DNA are easily accessible to the cell's genetic machinery.

Certain DNA sequences are much easier to bend sharply, as required to wrap the DNA into nucleosomes, than are other DNA sequences. Widom and colleagues identified the sequence patterns that facilitate such sharp DNA bending and showed how they can be decoded to predict the locations of nucleosomes in living cells. This nucleosome positioning code is superimposed on top of the genetic code, which specifies how the sequence of DNA is read out to produce the body's proteins.

Widom's discovery was published in *Nature* (August 17, 2006). ■



Jill Carlson, Martin Woods Image Consulting, LLC

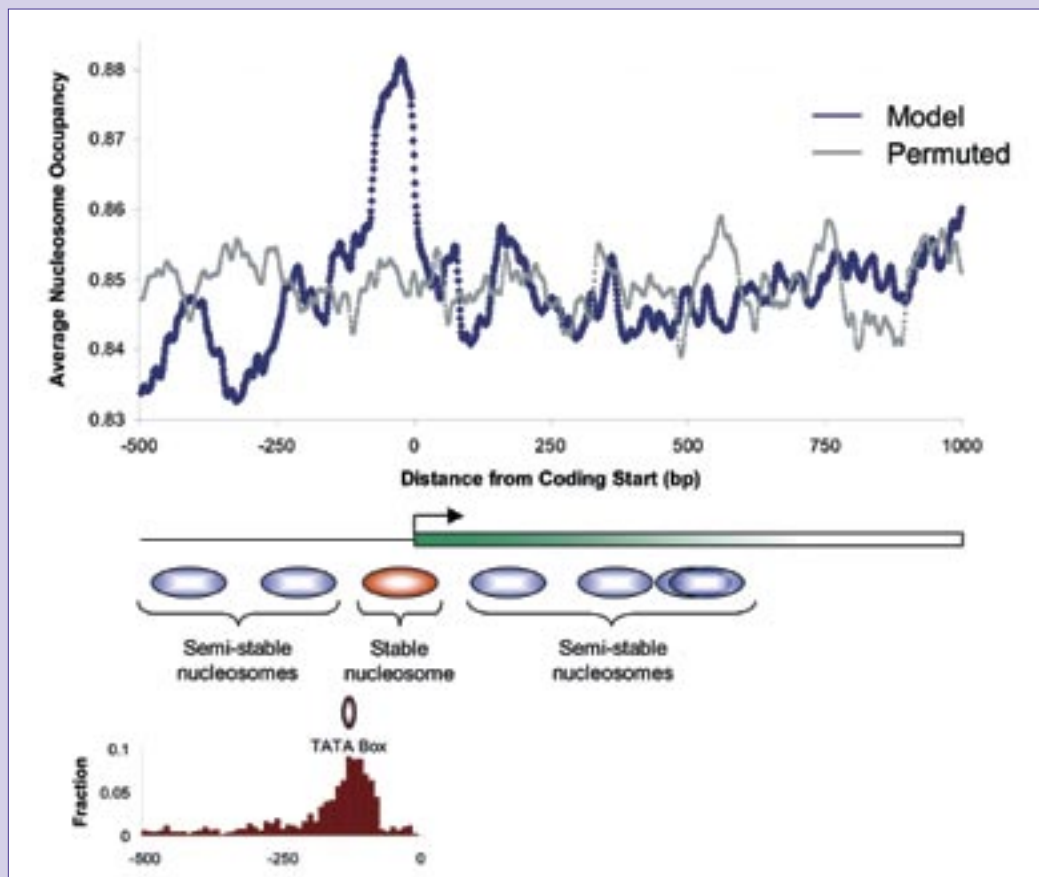


Figure 16

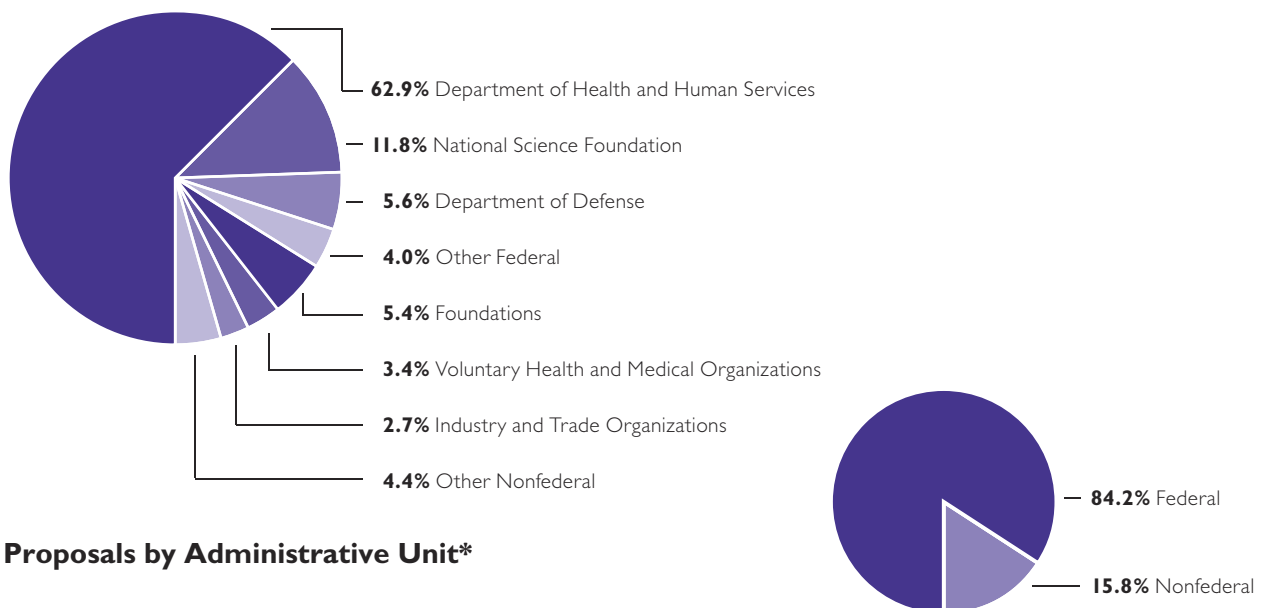
2006 RESEARCH STATISTICS

Sponsored Research Proposals

Proposal volume fluctuates from year to year, often due to opportunities in large program activities like those in cancer research, materials science, and nanotechnology initiatives. The slight decrease of 2.6 percent to \$1.21 billion, down from \$1.25 billion during fiscal year 2005, is not overly alarming. Viewed over two years, there was an increase of 10.6 percent in fiscal year 2006 over fiscal year 2004. The School of Communication (to \$26.7 million) and the Feinberg School of Medicine (to \$728.8 million) both experienced a second year of significant growth. While the Weinberg College of Arts and Sciences grew its proposal volume in fiscal year 2006 (to \$145.1 million), the volume is essentially flat when viewed over two years.

Further analysis is warranted for the McCormick School of Engineering and Applied Science, as its proposal activity has significantly decreased over the past two years, to \$163.9 million from \$217.3 million in fiscal year 2004. Although the School of Education and Social Policy (to \$24.4 million) showed a decline in proposal activity between fiscal years 2005 and 2006, the volume is flat when measured over two years. The volatility in proposal volume is particularly evident in multidisciplinary proposal activities, such as those from the University Research Centers. Their proposal activity is down by 43.5 percent to \$76 million between fiscal years 2005 and 2006; the two-year decrease, while still a matter of concern, is much less at 12.5 percent.

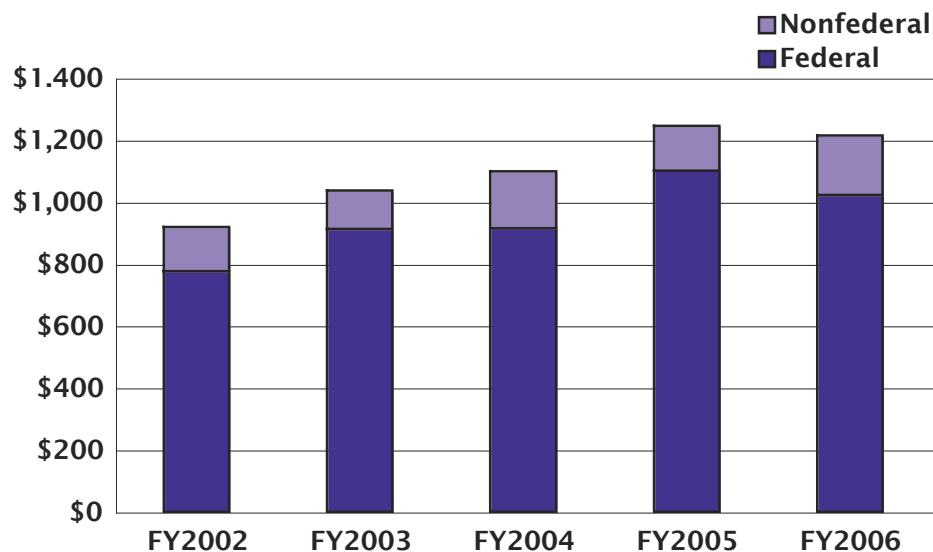
Proposals by Sponsor*



* Percentages do not total 100% because of rounding.

** School of Education and Social Policy, Kellogg School of Management, School of Law, Medill School of Journalism, and School of Music.

Proposals by Fiscal Year (Dollars in Millions)



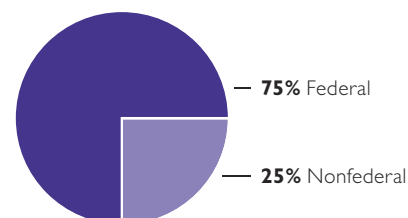
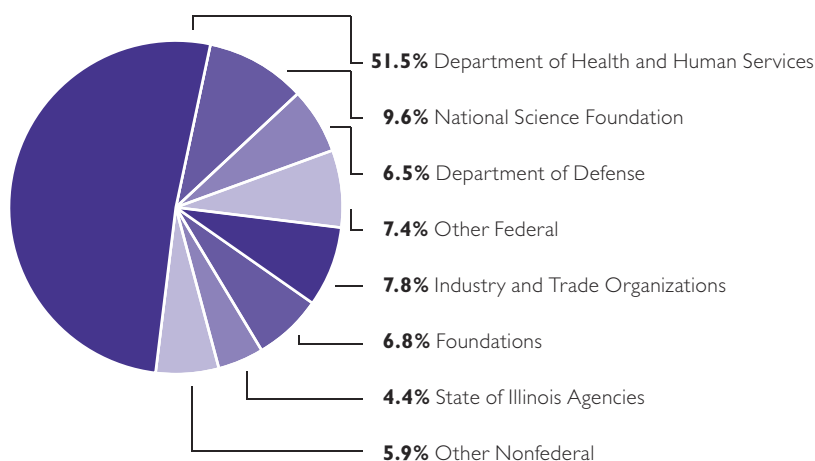
Jill Carlson, Martin Woods Image Consulting, LLC

View on north campus — foreground: Bridge connecting O.T. Hogan Biological Sciences Research Building (1971), left, with the Arthur and Gladys Pancoe–Evanston Northwestern Healthcare Life Sciences Pavilion (2003). The Hogan and Pancoe-ENH buildings include laboratory, office, and teaching space for researchers in the fields of biology and the life sciences. The four-story, 171,000-square-foot Pancoe-ENH facility was designed by Zimmer, Gunsul, Frasca for advanced biomedical research integrating basic science discoveries with clinical investigations. In the far (center) background is William A. and Gayle K. Cook Hall, formerly the Materials and Life Sciences Building (1992). In addition to laboratory and office space for researchers in materials and life sciences, this building houses the Center for Quantum Devices, Center for Structural Biology, Kech Biophysics Facility, the Department of Materials Science and Engineering, and NUANCE Center.

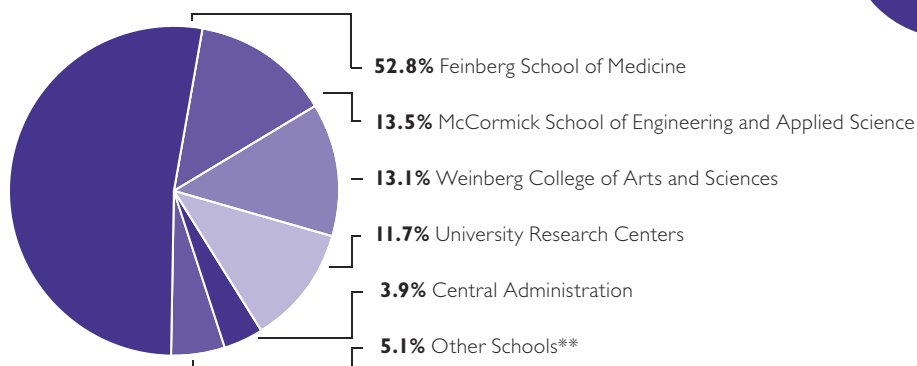
Sponsored Research Awards

As expected, research awards are essentially flat since last year, increasing to \$383.8 million, only 0.8 percent over the \$380.8 million of fiscal year 2005. This is despite a significant drop in federal funding of 4.9 percent (to \$288 million). Major decreases were experienced in awards from the National Science Foundation (minus 13 percent), the Department of Defense (minus 9.9 percent) and the National Institutes of Health (minus 3.2 percent). Offsetting these decreases are the rise in foundation awards of 24.4 percent (to \$26.2 million) and the growth in funding by Illinois agencies of 109.4 percent (to \$16.9 million).

Awards by Sponsor*



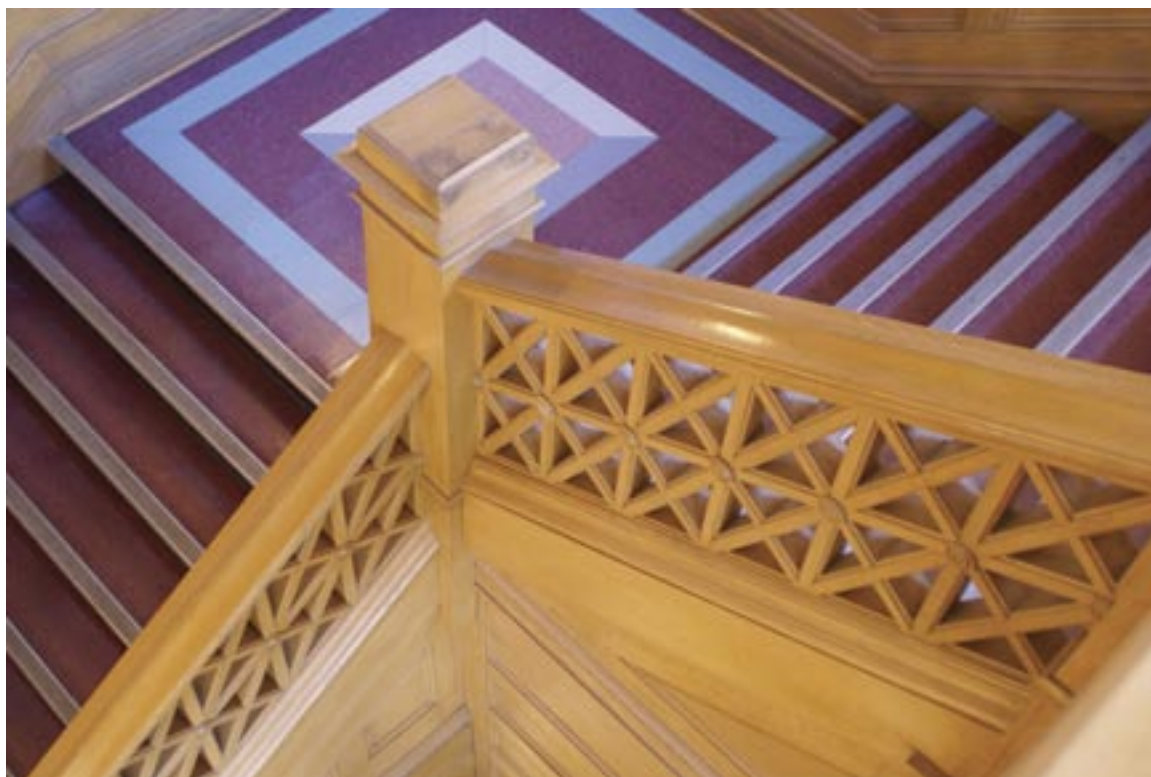
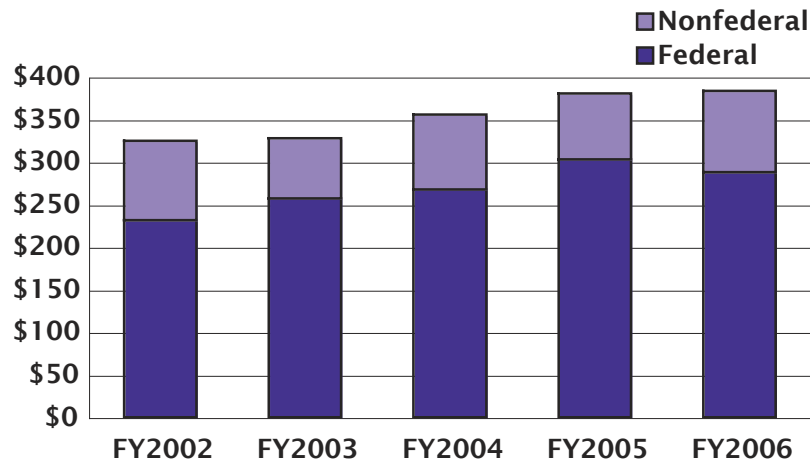
Awards by Administrative Unit*



* Percentages do not total 100 percent because of rounding.

** School of Communication, School of Education and Social Policy, Kellogg School of Management, School of Law, Medill School of Journalism, and School of Music.

Sponsored Research Awards (Dollars in Millions)



Jill Carlson, Martin Woods Image Consulting, LLC

Main staircase in Lunt Hall. Lunt Hall (1894) served as Northwestern's library until Deering Library was built in 1933. Designed by William Augustus Otis, the Italian Renaissance-style building was funded largely by a gift from Orrington Lunt, a prominent Chicago businessman and one of Northwestern's founders. While little of the building's original splendor has survived remodeling efforts, the main entrance foyer and the woodwork on the ceiling of the first-floor library offer a glimpse of the craftsmanship involved in its construction. Lunt Hall served as Northwestern's administration building from 1933 to 1942. During World War II the Naval Training School for radio operators occupied the building. Today Lunt Hall is the third-oldest building on campus and houses the mathematics department.

National Science Foundation Award Summary by Top Institutions* (Dollars in Thousands)

UNIVERSITY	2001	2001 RANK	2002	2003	2004	2005	2005 RANK	% INCREASE 2001-2005
Cornell (Endowed)	72,203	3	78,992	85,814	94,306	90,192	2	24.9%
Columbia	59,607	7	65,700	72,586	70,424	69,901	8	17.3%
MIT	49,116	10	60,468	67,024	69,337	62,011	11	25.6%
Stanford	42,580	16	47,657	54,387	68,203	48,678	15	14.3%
Univ. of Chicago	26,783	35	29,561	38,606	31,990	45,960	18	71.6%
Princeton	25,971	38	29,003	28,881	38,864	38,554	28	48.5%
Duke	19,877	52	31,517	31,166	29,434	33,227	36	58.4%
Harvard	27,442	34	32,592	44,466	46,370	32,394	38	18.0%
Northwestern	30,781	29	28,065	32,170	42,475	29,503	41	-4.2%
Univ. of Pennsylvania	24,962	39	26,667	23,426	33,006	28,300	44	13.4%
Johns Hopkins	24,759	41	33,041	29,396	30,170	27,748	45	12.1%
Yale	13,891	65	21,557	24,469	24,142	27,001	47	94.4%
Rice	18,568	55	19,815	27,656	25,623	20,481	58	10.3%
Washington Univ.	7,792	98	21,867	15,063	10,831	15,254	74	99.2%
Univ. of Rochester	7,869	97	14,277	14,129	10,841	7,703	114	-2.1%
NSF Obligations	4,459,900		4,774,100	5,369,300	5,577,800	5,472,800		28.8%

*Those categorized as "University"

Source: Budget Division, Office of Budget, Finance and Award Management, National Science Foundation, <http://dellweb.bfa.nsf.gov/Top50Inst2/>

National Institutes of Health Awards to Domestic Institutions of Higher Education (Dollars in Thousands)

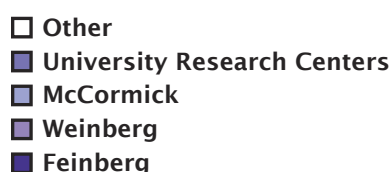
UNIVERSITY	2001	2001 RANK	2002	2003	2004	2005	2005 RANK	% INCREASE 2001-2005
Johns Hopkins	457,362	1	510,005	555,876	599,151	607,223	1	32.8%
Univ. of Pennsylvania	376,032	2	418,547	434,457	464,077	471,350	2	25.3%
Washington Univ.	303,650	5	343,792	383,225	388,308	394,788	5	30.0%
Duke	232,180	13	277,383	345,802	343,825	391,196	6	68.5%
Yale	256,664	10	289,900	303,459	323,614	336,743	10	31.2%
Columbia	248,892	11	269,845	291,304	303,715	330,755	11	32.9%
Harvard	270,226	8	273,148	301,641	325,665	321,224	12	18.9%
Stanford	224,781	14	247,636	271,770	301,734	305,561	14	35.9%
Univ. of Chicago	131,241	27	142,531	192,968	178,566	194,717	23	48.4%
Cornell	152,197	23	161,811	164,648	185,957	192,563	24	26.5%
MIT	79,513	53	87,413	94,152	181,897	172,184	30	116.5%
Northwestern	111,299	37	131,260	153,778	157,346	168,377	32	51.3%
Univ. of Rochester	121,954	32	136,498	151,563	157,549	162,312	34	33.1%
Princeton	33,262	84	36,569	38,766	38,329	37,660	99	13.2%
Rice	5,488	174	6,300	6,181	7,753	10,088	163	83.8%
NIH Total Awards	16,784,682		19,074,465	21,866,798	22,900,577	23,410,118		39.5%

Source: National Institutes of Health, Office of Extramural Research, DSA Pub Files, <http://grants.nih.gov/grants/award/awardtr.htm>

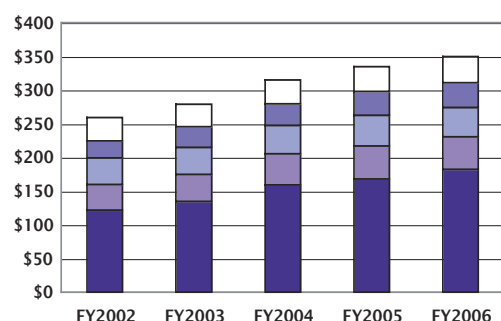
Sponsored Research Expenditures

Research expenditures (an important measure of research activity) reveal another year of solid growth, although the rate of growth has slowed over the past two years. Total expenditures increased by 4.6 percent over fiscal year 2005 to \$349.9 million. Indirect expenditures (generated by “F&A”) increased to \$74.6 million, 6.3 percent more than fiscal year 2005. Feinberg School of Medicine experienced significant growth, both in dollars and by percentage, with \$182.2 million in total expenditures, an increase of 8.4 percent over fiscal year 2005. Although starting from a smaller base, the School of Communication had a very high percentage of increase — 23.4 percent — to \$6.5 million in total expenditures. Both McCormick School of Engineering and Applied Science and Weinberg College of Arts and Sciences experienced small decreases in total expenditures of minus 3.8 percent and minus 1.5 percent, respectively. Total expenditures in the School of Education were flat at \$5.2 million, while those in the University Research Centers increased by 3.2 percent to \$36.8 million.

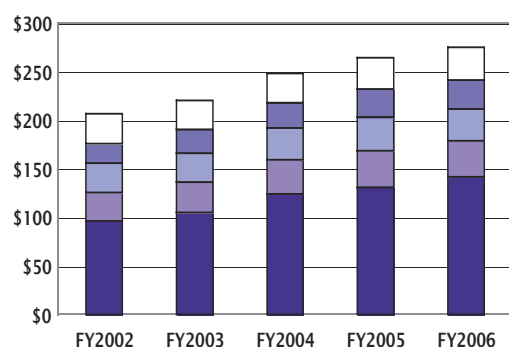
Expenditures by Unit (Dollars in Millions)



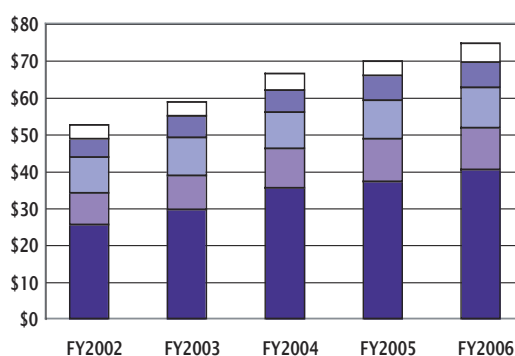
Total Expenditures



Direct Expenditures



Indirect Expenditures



Top Institutions in Total Research and Development Expenditures for Science and Engineering (Dollars in Thousands)

UNIVERSITY	2000	2000 RANK	2001	2002	2003	2004	2004 RANK	% INCREASE 2000-2004
Johns Hopkins	901,156	1	999,246	1,140,235	1,244,132	1,375,014	1	52.6%
Stanford	457,822	8	482,906	538,474	603,227	671,046	8	46.6%
Univ. of Pennsylvania	430,389	9	469,852	522,269	564,635	596,756	10	38.7%
Cornell	410,393	13	443,828	496,123	554,760	575,554	11	40.2%
MIT	426,299	11	435,495	446,786	485,764	543,448	12	27.5%
Duke	356,625	19	375,133	441,533	520,191	520,871	14	46.1%
Washington Univ.	362,216	17	406,642	416,960	474,328	489,565	19	35.2%
Columbia	319,693	24	354,497	405,403	437,669	468,484	23	46.5%
Harvard	341,810	22	372,107	401,367	408,707	454,495	26	33.0%
Yale	296,706	28	321,514	354,243	387,644	422,828	29	42.5%
Northwestern	245,774	36	257,933	282,154	319,722	358,947	34	46.0%
Univ. of Rochester	197,335	47	234,261	261,601	285,768	312,303	45	58.3%
Univ. of Chicago	170,678	58	194,125	225,264	247,332	272,390	54	59.6%
Princeton	134,875	83	149,411	164,408	179,951	188,373	81	39.7%
Rice	41,840	143	42,675	48,169	52,367	60,872	146	45.5%

Source: National Science Foundation, Division of Science Resources Statistics, Academic Research and Development Expenditures: Fiscal Year 2004, NSF 06-323, Project Officer, Ronda Britt (Arlington, VA 20006), www.nsf.gov/statistics/nsf06323/pdf/tables.pdf

Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions (Dollars in Thousands)

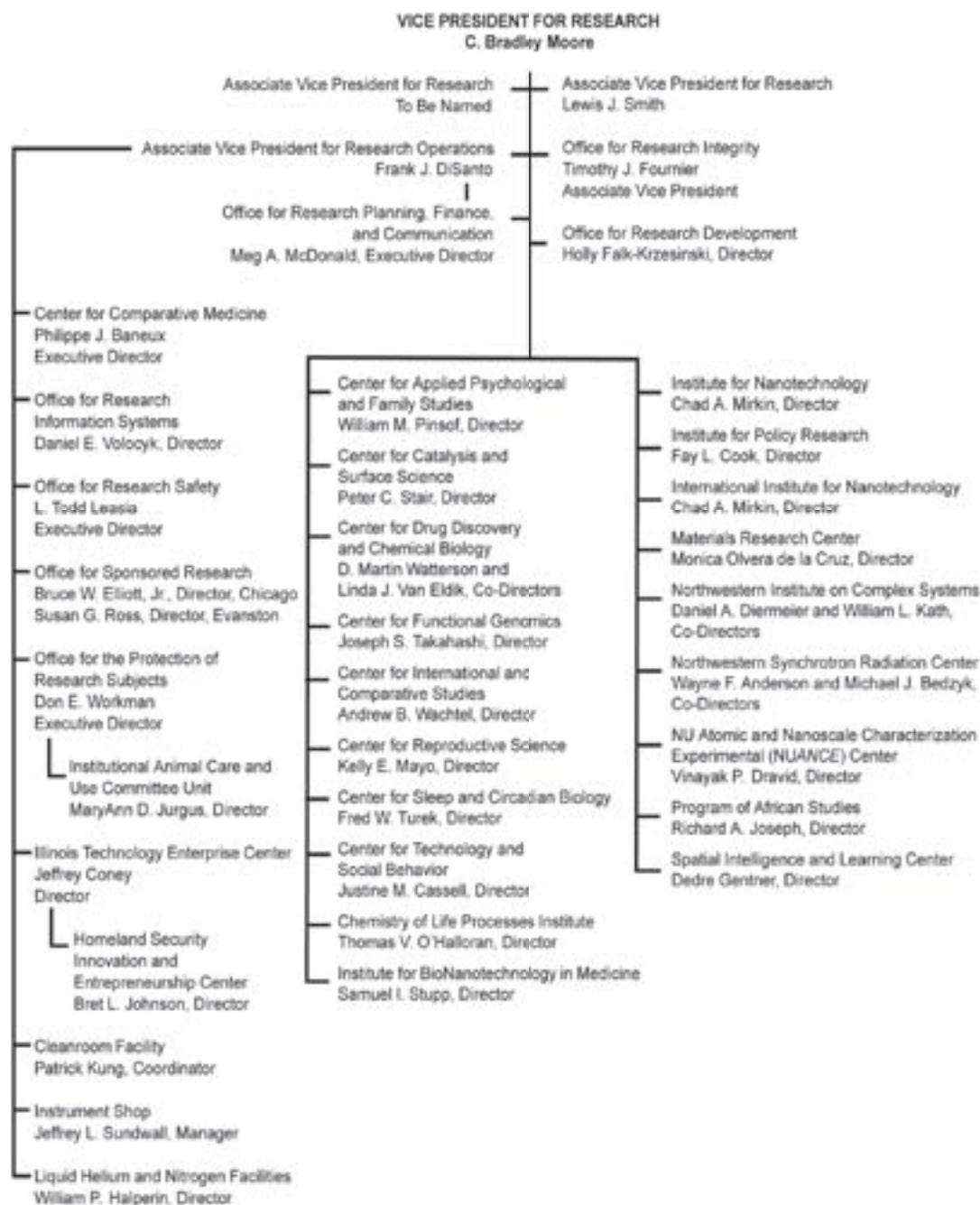
UNIVERSITY	1999	1999 RANK	2000	2001	2002	2003	2003 RANK	% INCREASE 1999-2003
Johns Hopkins	855,678	1	933,245	992,324	1,136,498	1,137,366	1	32.9%
Univ. of Pennsylvania	346,828	4	373,963	438,186	479,852	495,264	4	42.8%
Stanford	346,380	5	377,918	369,715	409,122	467,153	6	34.9%
Washington Univ.	273,051	13	303,684	331,560	381,484	419,014	9	53.5%
Columbia	286,056	9	309,933	348,388	372,920	412,694	10	44.3%
Duke	224,569	20	245,017	288,888	355,278	412,069	11	83.5%
Harvard	294,883	8	330,683	352,230	356,534	384,891	14	30.5%
Yale	268,677	14	279,540	295,710	334,392	349,560	16	30.1%
Cornell	233,741	19	271,564	314,491	327,452	334,108	21	42.9%
MIT	276,811	11	269,030	282,091	291,012	291,879	23	5.4%
Univ. of Rochester	142,939	32	161,689	181,153	203,199	228,985	29	60.2%
Northwestern	149,578	30	160,832	175,962	187,112	213,558	32	42.8%
Univ. of Chicago	168,594	28	157,500	173,911	177,002	208,139	36	23.5%
Princeton	84,021	68	94,086	93,553	98,889	107,933	75	28.5%
Rice	30,292	N/A	27,929	37,131	38,854	51,472	N/A	69.9%

Source: National Science Foundation, Division of Science Resources Statistics, Federal Science and Engineering, Support to Universities, Colleges, and Nonprofit Institutions: Fiscal Year 2003, NSF 06-309, Project Officer, Richard J. Bennof (Arlington, VA 2006), www.nsf.gov/statistics/fedsupport/page8: "To obtain accurate historical data, use only the latest detailed statistical tables (covering FY2003) and not data published earlier. ... references to prior years' data should be restricted to those published in this document."

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Legends for research figures found throughout the *Annual Report*

Figure 1 (Backman, p. 9): An LEBS signal from human colonic tissue. Signals like this one contain information about tissue nano/microarchitecture and how alterations in otherwise colonoscopically and histologically normal tissue are diagnostic for the presence of precancer in the entire colon.

Figure 2 (Cao, p. 11): Scanning electron micrograph of a microcluster of ZnO nanoparticles. The average particle size is about 50 nm. Coherent light is generated from such a cluster under optical pumping.

Figure 3 (Grzybowski, p. 14): (top) Supracrystals of platonic shapes formed from millions of oppositely charged gold and silver nanoparticles; (bottom) light reversible crystals whose electrostatic self-assembly is mediated by photoswitchable surface groups. The totroidal structure on the right forms under special irradiation conditions as a result of a surface instability accompanying self-assembly. These metastable structures form under UV irradiation and fall apart when illuminated by visible light.

Figure 4 (Hartmann, p. 15): Rats have approximately 30 whiskers on each side of the face, each exquisitely sensitive to tactile information. Photo: A.S. Kaloti and M.J. Hartmann.

Figure 5 (Hartmann, p. 15): Extraction of information about an object shape using an artificial whisker array. On the right, the robotic whisker array is shown in front of a small sculpted head (whisker lengths are 2, 3, 4, and 5 cm). As the whiskers sweep over the object, they identify the points at which they make contact with it. The image on the left is constructed by “connecting” the contact points. Figure: J.H. Solomon and M.J. Hartmann.

Figure 6 (Hersam, p. 16): Photograph of a centrifuge tube containing purified carbon nanotubes. Each colored band possesses carbon nanotubes of a different diameter and thus with different electronic and optical properties. Once the purified carbon nanotubes are removed from the centrifuge tube, they can be used in a wide range of applications, including electronics, sensors, and displays.

Figure 7 (Kraus, p. 18): Model for how speech sound structure is represented by brainstem neurons. Neural events (uppercase letters) reflect a direct mapping of stimulus characteristics (lowercase letters). The stimulus waveform has been shifted 6 milliseconds in time to compensate for neural lag in the response. Arrows illustrate the elements of the stimulus corresponding to peaks in the response. The wavelengths between peaks d, e, and f (the fundamental frequency of the stimulus) are similar to those between peaks D, E, and F. Waves C and O correspond to major stimulus feature changes (wave C: transition between onset burst and more periodic portion; wave O: stimulus offset). Figure: N. Kraus and T.G. Nicol.

Figure 8 (Odom, p. 19): High resolution scanning electron microscope image of ordered arrays of gold pyramids supported by etched silicon pillars. These pyramidal shells are of interest not only for their fundamental properties but also for their prospects in treating cancer cells.

Figure 9 (Rowley, p. 21): Multiple cytoplasmic inclusion bodies (brown) in ciliated bronchial epithelium of a child who died of acute Kawasaki disease, visualized by immunohistochemistry using a Kawasaki disease synthetic antibody produced in the Rowley laboratory. Their additional studies indicate that the inclusion bodies are consistent with aggregates of viral proteins and nucleic acids and may derive from the Kawasaki disease etiologic agent.

Figure 10 (Woodruff, Shea, p. 23): Development and differentiation of secondary follicle in alginate scaffold. (A) At day 0, a multilayer secondary follicle with a centrally located immature oocyte and some attached theca cells was isolated and encapsulated in an alginate hydrogel. (B) Follicle maintained its three-dimensional structure and formed an antrum at the end of culture. (C) Follicle displayed an *in vivo* preovulatory phenotype, a spherical shape with a central fluid-filled antral cavity, an oocyte within tightly compacted cumulus cells, and layers of mural granulosa cells outside. (D) Oocytes can be fertilized normally *in vitro* and implanted into the oviduct of a pseudopregnant mouse to produce a live birth.

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Figure 11 (Neurodegenerative Diseases, p. 26): High-magnification confocal microscopic image from the human hippocampus showing an axon from one neuron contacting a spiny dendrite on another neuron. Estrogen increases the number and complexity of these contacts on spines, altering the way hippocampal neurons communicate with one another. Figure: C.S. Woolley.

Figure 12 (Neurodegenerative Diseases, p. 26): 2-photon z-stack of a subthalamic nucleus neuron recorded with somatic (green) and axonal (red) patch pipettes. These experiments suggest that action potentials propagate faithfully along the axons of subthalamic nucleus neurons during high-frequency stimulation. Figure: M. Bevan.

Figure 13 (Neurodegenerative Diseases, p. 26): Microscopic image of an Alzheimer's model mouse brain showing amyloid plaques (blue) surrounded by nerve cells with elevated levels of BACE1 enzyme (red). Immune cells of the brain called astrocytes are shown in green. The increase in BACE1 may play a role in Alzheimer's disease in humans, and understanding this process may lead to novel therapies for this intractable neurodegenerative disorder. Figure: J. Zhao, L. Chew (Cell Imaging Facility, Feinberg School of Medicine), and R. Vassar.

Figure 14 (Neurodegenerative Diseases, p. 26): Ball-and-stick model showing the chemical structure of Minozac, a first-in-class therapeutic drug designed and synthesized by Center for Drug Discovery and Chemical Biology postdoctoral scholars in the laboratory of D. Martin Watterson. Figure: Laura Wing, predoctoral trainee at the center.

Figure 15 (Simon, p. 29): The image shows two cultured myotubes isolated from newt forelimb muscle stained with a muscle marker (red). Live cell imaging of these myotubes *in vitro* allows for the investigation of factors that contribute to regeneration *in vivo*. The muscle cells are multinucleate (blue) but only a subset of the nuclei express factors, which allow them to retain a stem cell-like phenotype (green). Figure: Sarah Calve, postdoctoral fellow in the Simon laboratory.

Figure 16 (Widom, p. 30): Genomes utilize the nucleosome positioning code to create a distinctive arrangement of nucleosomes around a key gene control region at the average gene in baker's yeast. The top graph (blue) shows the distribution of relative nucleosome occupancy that is intrinsically encoded by the yeast genome, plotted as a function of distance

from the start of the protein coding region (ATG signal), at the average yeast gene. The predictions for each of the roughly 6,000 genes in yeast are averaged together. The underlying gray graph shows the result of one random permutation to give a sense of signals attributable to random noise. The ATG signal is at position "0"; sequences in the DNA responsible for controlling gene expression are typically located a couple of hundred basepairs upstream of the gene (to the left, negative numbers, in the figure as plotted). The analysis shows that the genome intrinsically encodes a peak of high nucleosome occupancy a short distance upstream of the ATG signal. This peak represents the center of a high-probability nucleosome; thus, the graph in the top panel of the figure maps to the arrangement of nucleosomes shown schematically (as 147 bp-long ellipses on a linear DNA) at the same scale in the middle panel.

For approximately 1,000 of the ~6,000 genes in yeast, the locations of binding sites for a protein called TBP are known. TBP binding is a critical early event in gene activation, because TBP helps in the subsequent recruitment of RNA polymerase, the enzyme responsible for gene transcription. The bottom graph is a histogram showing where TBP binding sites are located relative to the ATG signals in these 1,000 genes. The graph is plotted on the same scale as the other panels in this figure, to facilitate comparison.

Together, these graphs show that the intrinsic nucleosome organization at the average gene in yeast places the most probable locations of the TBP binding site in a highly accessible linker region, just outside the high-probability nucleosome (brown ellipse); and almost all of the TBP sites are located either in a linker region or only a short distance inside either of the two flanking nucleosomes, where they will still have relatively high accessibility. Thus, the genome is facilitating its own regulation by encoding a particular distribution of nucleosome locations that makes these critical regulatory sites more likely to be accessible, i.e., more easily accessible in a thermodynamic sense.

Independent experiments from several groups show that this predicted intrinsic nucleosome occupancy at the average yeast gene corresponds closely with the actual distribution measured experimentally in populations of living cells. The nucleosome positioning code is expected to apply unchanged to all higher life forms ("eukaryotes"). The Widom group's initial analyses of it have focused on the simple organism, baker's yeast, whose gene regulatory machinery is closely similar to that in people, but is much better understood and far more complete data are available. ■

ON THE BACK COVER

Top, left to right

Picture of a village mosque and library of the Ba family, Paté Gallo, Senegal. Photograph by **Rudolph T. Ware**, professor of history, Weinberg College of Arts and Sciences.

Photograph of **Rudolph T. Ware**. Details of his work may be found on page 22. Photograph by Jill Carlson, Martin Woods Image Consulting, LLC.

Middle, left to right

Photograph of a newt, champion among vertebrate animals because of its ability to completely regenerate lost structures, including limbs and tail. Image by Sarah Calve, postdoctoral fellow in the laboratory of **Hans-Georg Simon**, professor of pediatrics, Feinberg School of Medicine and Children's Memorial Research Center.

Photograph of **Hans-Georg Simon**. He and his group focus on the discovery of genes involved in regenerative processes. Details of his work may be found on page 29. Photograph by Heather Stone.

Image of two cultured myotubes isolated from newt forelimb muscle stained with a muscle marker (red). Live cell imaging of these myotubes *in vitro* allows for the investigation of factors that contribute to regeneration *in vivo*. The muscle cells are multinucleate (blue) but only a subset of the nuclei express factors, which allow them to retain a stem cell-like phenotype (green). Image by Sarah Calve, postdoctoral fellow in the Simon laboratory.

Bottom

Bryna Kra, professor of mathematics, Weinberg College of Arts and Sciences, pictured among the texts she uses most in her work on ergodic theory, a branch of abstract mathematics. Details of her research may be found on page 16. Photographs by Jill Carlson, Martin Woods Image Consulting, LLC.

