Northwestern | RESEARCH

IMPACT REPORT
2020

Eileen Molony

A pandemic year brought historic challenges that dramatically altered our lives. Proving their resilience, inventiveness, and commitment to productivity and partnership, Northwestern faculty, staff, and students nimbly adapted to remote operations, while the on-campus services of essential workers helped ensure the continuity of the University's research enterprise.

That enterprise managed to thrive in fiscal year 2020. The University kept its top-10 national ranking and marked another record-breaking year of sponsored research funding. Investigators attracted support totaling $887.3 million—a 26 percent increase over the past two years—making Northwestern the largest academic research site in Illinois and bringing important economic benefits to the region.

Quickly joining the fight against COVID-19, our scientists pioneered studies of the structural biology of the novel coronavirus, revealing new drug targets. They innovated a self-sanitizing face mask, developed a minimally invasive antibody test, and used synthetic biology to drastically accelerate the production of therapeutics. They advanced artificial intelligence tools for detecting COVID-19 on chest X-rays with high accuracy and for analyzing large numbers of scientific papers—in minutes instead of months—to uncover potential high-value sources. Northwestern conducted a clinical trial on the antiviral capabilities of the drug remdesivir and created a registry used in recruiting thousands of vaccine trial participants. Our researchers also examined how the pandemic exacerbated economic and health disparities.

Unrelated to the pandemic, the launch of the $115 million national quantum science centers at Fermilab and Argonne National Laboratory involved substantial Northwestern thought leadership. Our engineers developed a 3D printer that can output adult-sized objects at unprecedented speed. In another breakthrough, our researchers were able to dialogue with a dreaming person in real time. Northwestern astronomers witnessed the birth of an intermediate-mass black hole, proving the existence of these phenomena. Achievements in the arts also held the spotlight, with several faculty and alumni receiving Grammy Award nominations. Faculty across the University gained the highest distinction, including 8 named to the American Academy of Arts and Sciences and 11 new members of the American Academies of Medicine, Engineering, Education, and Science.

As shown by the examples highlighted here, our work is making a real-world difference. Northwestern's global reputation for research excellence will only continue to grow, propelled by a decade of spectacular ascent in the scale and impact of our investigations.

Milan Mrksich
Vice President for Research

On the cover, clockwise from top left

When the pandemic hit, **Nichole Pinkard** (learning sciences) quickly ramped up a **free digital learning platform** called STEAMville to help parents keep their children engaged in learning at home. Curated by a team of curriculum designers, former teachers, and School of Education and Social Policy–based software developers, the educational content focuses on science, technology, engineering, the arts, and math. Students can learn about coding, digital media, engineering design, and more. Photo by Northwestern University

Jessica Hullman (computer science and journalism) studies how **visualizations and interactive interfaces** can help people make sense of complex information and data under uncertainty. "All data are estimates. Our research asks how data can be presented in ways that help people account for this," says Hullman. She has spoken and written on how her research applies to uncertainty in reporting on COVID-19 models and on election forecasting models, including those used in the last two US presidential elections. Photo by Shane Collins

Observational astronomers led by **Wen-fai Fong** (physics and astronomy) have potentially **seen the birth of a magnetar** for the first time. Believed to be the result of two neutron stars merging, the magnetar produced a brilliant kilonova, the brightest ever seen. "We have never seen evidence of this before, let alone in infrared light, making this discovery special," says Fong, a member of the Center for Interdisciplinary Exploration and Research in Astrophysics at Northwestern. The light was detected by three telescopes, including NASA's Hubble Space Telescope. Photo by NASA, ESA, and D. Player (STScI)

The pandemic spurred **Michael Jewett** (chemical and biological engineering) and his lab to develop scientific innovations related to COVID-19. Jewett is using synthetic biology and cell-free systems to accelerate **COVID-19 therapeutics and diagnostics**. One approach could produce new antiviral therapies more than 10 times faster than current drug-development methods that rely on the use of mammalian cells. Photo by Matthew Allen

School of Communication dean **E. Patrick Johnson** (performance studies and African American studies) is helping lead efforts to strengthen Northwestern's involvement in teaching and researching the history of Black cultural production. One project is the **Black Arts Archive: The Challenge of Translation**, a series of transnational seminars funded by the Andrew W. Mellon Foundation that will focus on archives of African diasporic art forms. Photo by Justin Barbin

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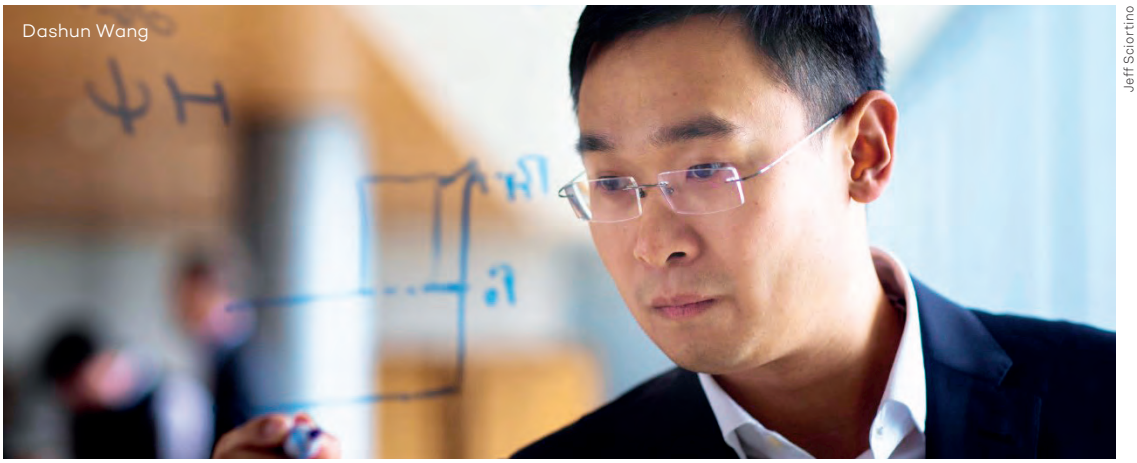
DATA EXPERTS TRACE THE USE OF SCIENCE IN POLICY

Data expert **Dashun Wang** (management) uses the tools of complexity science and artificial intelligence to reveal patterns of innovation, failure, and teamwork. A physicist by training, Wang and an interdisciplinary research team that includes **Ben Jones** (strategy) focused on the COVID-19 pandemic to explore how science and public policy coevolve. Analyzing tens of thousands of international policy documents, they found that while many pandemic-related policies rely on validated science, the tendency to cite research findings directly is mostly concentrated within intergovernmental entities such as the World Health Organization—to a much greater extent than in national governments. Another research focus for Wang is science itself: the science of science. In one study, his team's systematic analysis of millions of academic papers, patents, and software projects compared the contributions of large and small research teams, showing the value of diverse team sizes. Wang is founding director of the Center for Science of Science and Innovation at the Kellogg School of Management.



Jeff Sciortino

QUANTUM EXPERTISE DRIVES BREAKTHROUGH RESEARCH

Northwestern physicists, materials scientists, chemists, and engineers are contributing to three newly established centers dedicated to the study of quantum information science (QIS). The centers—each with five-year, $115 million Department of Energy (DOE) funding—are based at Fermilab, Argonne National Laboratory, and Brookhaven National Laboratory. Seventeen Northwestern faculty are contributing to Fermilab's Superconducting Quantum Materials and Systems Center (SQMS), which is led by physicist **Anna Grassellino**, who holds a joint appointment at Northwestern, and deputy director **James Sauls**, who is codirector of Northwestern's Center for Applied Physics and Superconducting Technologies. SQMS focuses on developing quantum computers based on Fermilab's superconducting microwave cavity technology and various superconducting quantum device technologies advanced in part at Northwestern. **Jens Koch** (physics), coinventor of the transmon qubit, is contributing to SQMS as well as to Brookhaven's Center for Quantum Advantage. Argonne's center, called Q-NEXT, is leveraging Northwestern expertise in chemistry and physics in its work to design custom materials for quantum technologies. All three QIS centers share a mission to help produce a quantum-smart workforce. "The fundamental work is progressing rapidly," says **Michael Wasielewski** (chemistry), a Q-NEXT affiliate and director of Northwestern's Institute for Sustainability and Energy and the new DOE-funded $12.4 million Center for Molecular Quantum Transduction. "Industry is putting more resources into the engineering required to produce practical quantum technology."

Reidar Hahn (Fermilab)

Anna Grassellino and James Sauls

RESEARCH HIGHLIGHTS DISPARITIES IN PANDEMIC'S IMPACT


Courtesy of Beth Redbird

Since the onset of the COVID-19 crisis, **Beth Redbird** (sociology) has led a nationwide survey to assess people's perceptions of the pandemic and its consequences. Called CoronaData U.S., the project involves Northwestern political science, psychology, anthropology, and sociology faculty, including many affiliated with the Institute for Policy Research. The survey results have shown COVID-19's disproportionate impact on the African American and Latinx communities as well as differences in its effects on men and women. In addition, Redbird and **Jaline Gerardin** (preventive medicine), along with collaborators from Stanford University, devised a computer model for identifying so-called superspreader locations in cities. Their work, published in *Nature*, isolated the role of mobility in COVID-19's spread and suggested reasons that some communities have been hit harder than others. "The way low-income neighborhoods are constructed, with smaller establishments that serve more customers, is one of the drivers of racial and economic inequality in infections," says Redbird, who is also a faculty fellow at Northwestern's Center for Native American and Indigenous Research. "By reducing density in these locations, we might reduce this disparity."

BUILDING COMMUNITIES IN THE NEW MEDIA LANDSCAPE

Understanding how people use technology to connect and communicate is a passion for **Nicholas Diakopoulos** and **Darren Gergle** (both communication studies). Diakopoulos is a leading researcher of computational and data journalism, with a focus on the human-centered use of algorithms, automation, and artificial intelligence in news production and consumption. He is the author of the award-winning book *Automating the News: How Algorithms Are Rewriting the Media* and heads Northwestern's Computational Journalism Lab. Gergle works in the field of human-computer interaction, which combines social and cognitive science with information technology and design. Last year, he and colleagues **Elizabeth Gerber** (mechanical engineering) and **Bryan Pardo** (computer science) launched the interdisciplinary Center for Human-Computer

Interaction and Design, whose mission is to study, design, and develop the future of human and computer interaction at home, work, and play. One major goal is to pursue computer models that support revitalizing communities through sustainable democratic participation, leading to a more equitable society.

PIONEERING STUDY TAKES AIM AT COVID-19 PNEUMONIA

An interdisciplinary study led by **Richard Wunderink** (pulmonary and critical care) is yielding new insights about pneumonia, including a distinct type caused by COVID-19. The SCRIPT (Successful Clinical Response in Pneumonia Therapy) study, funded by the National Institutes of Health, involves more than 30 investigators from medicine, biology, computer science, and other fields across three Northwestern schools. The SCRIPT team's findings, published in *Nature*, show that COVID-19 pneumonia gradually establishes itself in small, localized areas of the lung; then, over many days or even weeks, the virus hijacks the lung's immune cells to increase the prevalence and severity of infection, eventually damaging multiple organs. In addition to discovering this unexpected immunopathogenesis, the researchers also identified critical immune cell targets that could be used in treating COVID-19 pneumonia, and an experimental drug based on the SCRIPT study is now being tested.

Northwestern University

BIOTECH DEVICE SPEEDS DETECTION OF WATER POLLUTANTS

Julius Lucks (chemical and biological engineering) has developed an easy-to-use technology that assesses water safety and quality in minutes, using just a single drop. When the handheld device detects a contaminant exceeding safety standards, it glows green. Lucks and his research team at the McCormick School of Engineering built the test using cell-free synthetic biology that repurposes the molecular-level "taste buds" of bacteria. The test can sense 17 different contaminants in water, including toxic metals such as lead and copper, pharmaceuticals, cosmetics, and cleaning products. The technology is so flexible that researchers can continually update it to detect other pollutants. The Lucks Lab is collaborating with **Michael Jewett**, director of Northwestern's Center for Synthetic Biology, on the test's further development.

NEW BIOMATERIAL PROMOTES TISSUE REGENERATION

Chris Strong Photography

Guillermo Ameer

The Food and Drug Administration approved an orthopedic medical device fabricated with CITREGEN, a novel biomaterial from the lab of **Guillermo Ameer** (biomedical engineering and surgery). The CITRELOCK Interference Screw System was cleared for use in surgeries to reattach soft tissue to bone, such as ligament repair and reconstruction. Ameer's new biomaterial takes advantage of citrate, a naturally occurring antimicrobial and anti-inflammatory molecule that plays a crucial role in bone regeneration. "CITREGEN is an unprecedented bioresorbable biomaterial technology developed to support the body's normal healing process and promote tissue regeneration," says Ameer, the founding director of Northwestern's Center for Advanced Regenerative Engineering and a recently named fellow of the National Academy of Inventors and the American Association for the Advancement of Science. CITREGEN is the basis for several orthopedic medical devices that will be commercialized by Acuitive Technologies.

3,428
TOTAL AWARDS IN FY20

$887.3 MILLION
SPONSORED RESEARCH FUNDING
11% INCREASE OVER FY19

40
UNIVERSITY RESEARCH INSTITUTES AND CENTERS

50
CORE FACILITIES
(SHARED LABS AND EXPERT TECHNICAL SUPPORT)

$485M
NIH FUNDING
#15 AMONG PEERS
19% INCREASE OVER FY19

#1
REHABILITATION HOSPITAL
(RYAN ABILITYLAB)*

#8
CANCER CENTER
(LURIE COMPREHENSIVE)*

$69M
SPONSORED FUNDING FOR RESEARCH INSTITUTES AND CENTERS

$357M
GRANTS SUPPORTED BY CORE FACILITIES

#9
RANKING AMONG US UNIVERSITIES*

#10
HOSPITAL
(NORTHWESTERN MEMORIAL)*

512
CLINICAL TRIAL AGREEMENTS

FACULTY RECOGNITION

#17
CLARIVATE HIGHLY CITED RESEARCHERS RANKING
(2014–20)

94
AMERICAN ACADEMY OF ARTS AND SCIENCES MEMBERSHIPS

70
NATIONAL ACADEMY MEMBERSHIPS
(MEDICINE, ENGINEERING, EDUCATION, SCIENCE)

11
FACULTY STARTUPS FOUNDED

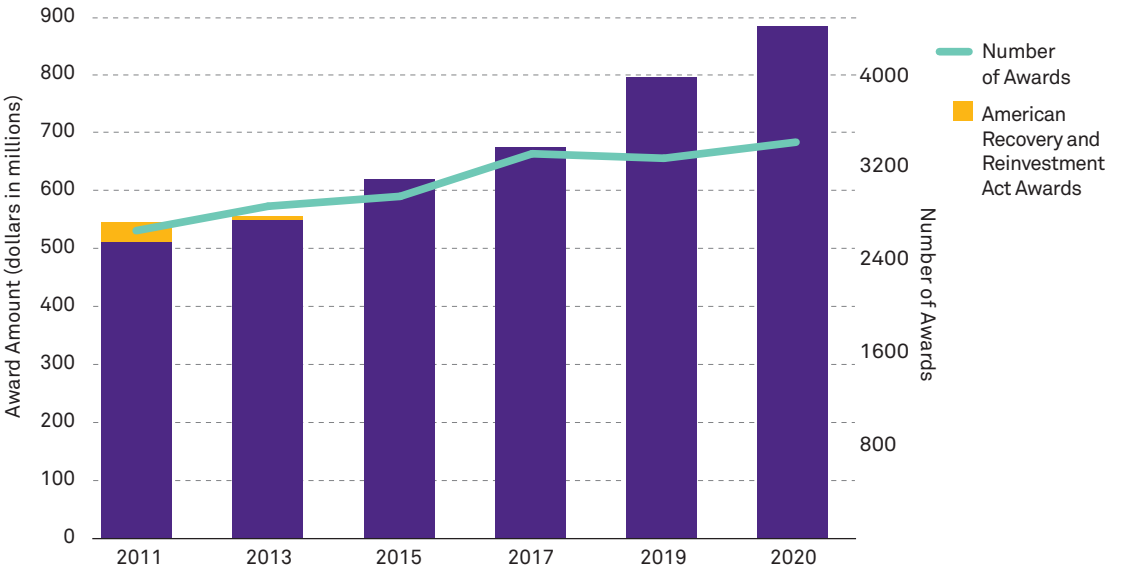
240
INVENTION DISCLOSURES

226
ISSUED PATENTS

$9.2M
LICENSING REVENUES

**U.S. News & World Report*

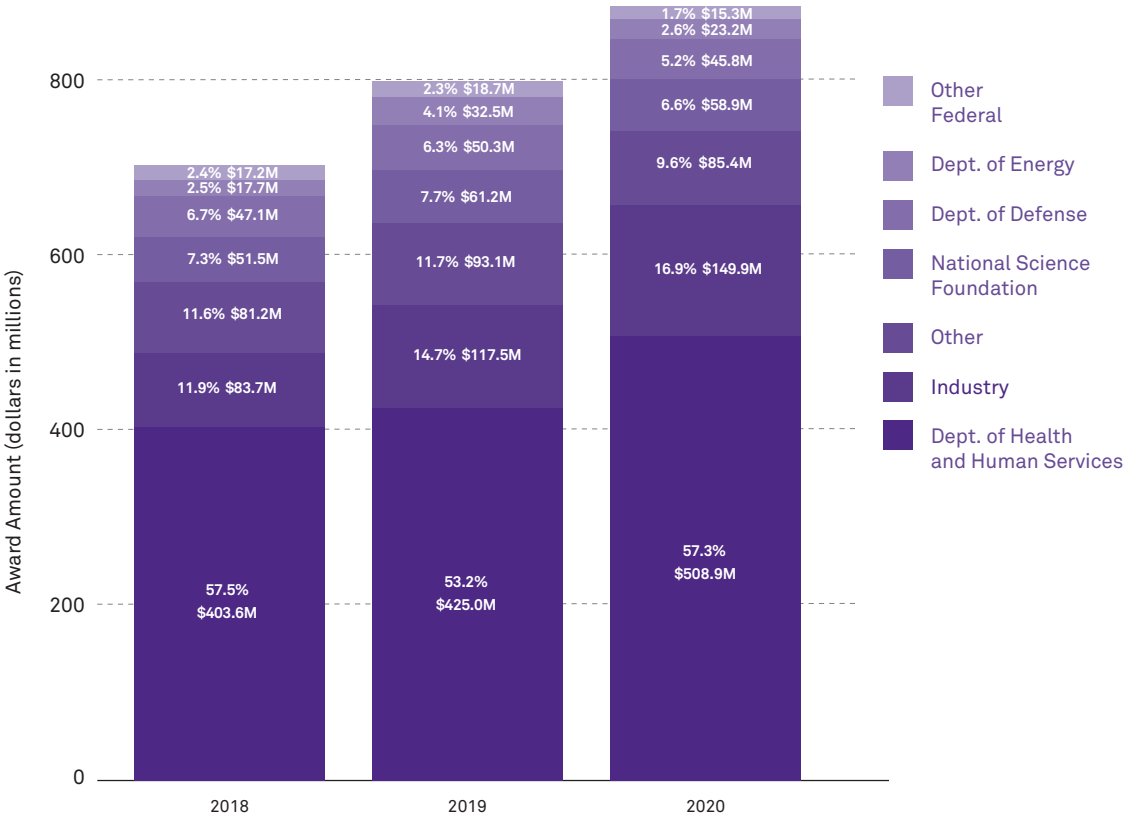
SPONSORED RESEARCH AWARDS



	FY2011	FY2013	FY2015	FY2017	FY2019	FY2020
NUMBER OF AWARDS	2,664	2,875	2,960	3,328	3,289	3,428
AMOUNT (IN MILLIONS)	$511.7	$549.5	$620.9	$676.5	$798.3	$887.3M

73% Funding Increase FY2011–20

AWARDS BY SPONSOR



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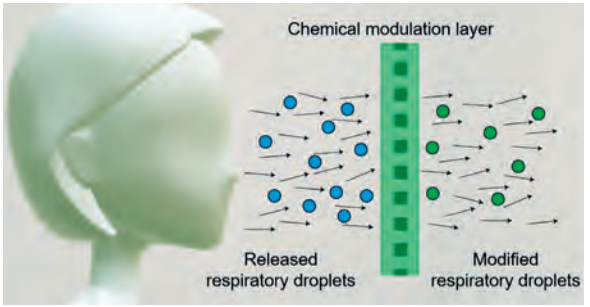

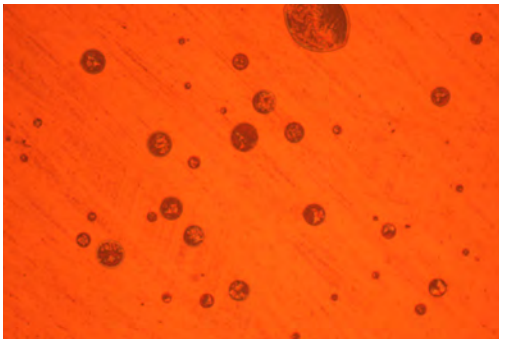

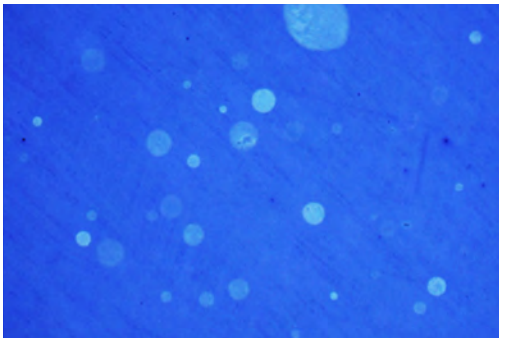

Northwestern researchers are contributing to the **fight against COVID-19** through high-impact studies, drug trials, and innovative technologies. Many of these efforts—such as a modified face mask developed by **Jiaxing Huang** (engineering)—are funded by National Science Foundation RAPID grants. Huang's technology introduces antiviral chemicals into mask fabrics, creating a layer that sanitizes exhaled respiratory droplets.

The images at right depict respiratory droplets before sanitization (orange) and after (blue). Pictured above are postdoctoral fellow **Hun Park** (left) and graduate student **Haiyue Huang**, both members of the Jiaxing Huang Laboratory and co–first authors of the research paper "On-Mask Modulation of Respiratory Droplets," published in the journal *Matter*.

Photos courtesy of Northwestern University