Description of document:	National Science Foundation (NSF) Transition Briefing materials for the Incoming Biden Administration 2020
Requested date:	04-January-2021
Release date:	27-January-2021
Posted date:	15-March-2021
Source of document:	National Science Foundation Attn: FOIA Officer 2415 Eisenhower Avenue Alexandria, Virginia 22314 Fax: (703) 292-9041 Email: foia@nsf.gov

NATIONAL SCIENCE FOUNDATION
2415 Eisenhower Avenue
Alexandria, Virginia 22314

OFFICE OF THE
GENERAL COUNSEL

January 27, 2021

Via email

Case #2021-080F

This letter is the final response to your Freedom of Information Act (FOIA) request that the National Science Foundation (NSF) received on January 4, 2021. In your request, you sought a "digital/electronic copy of the transition briefing document(s) (late 2020) prepared by the NSF for the incoming Biden Administration."

After a thorough search, please find all of the records prepared by NSF for the incoming Biden Administration enclosed. Personal information (private mobile phone numbers) has been withheld on page two of the "NSF-Transition-Book-120120" under the privacy protection of Exemption (b)(6) of the FOIA.

Your right of administrative appeal is set forth in Section 612.9 of the NSF FOIA regulation (copy enclosed). Your appeal must be postmarked or electronically transmitted within 90 days of the date of the response to your request.

If you need any further assistance or would like to discuss any aspect of your request, please do not hesitate to contact our FOIA Public Liaison at 703-292-8060. Additionally, you may contact the Office of Government Information Services (OGIS) which was created to offer mediation services to resolve disputes between FOIA requesters and Federal agencies as a non-exclusive alternative to litigation. Using OGIS services does not affect your right to pursue litigation. If you are requesting access to your own records (which is considered a Privacy Act request), you should know that OGIS does not have the authority to handle requests made under the Privacy Act of 1974. You may contact OGIS in any of the following ways:

National Archives and Records Administration
Office of Government Information Services
8601 Adelphi Road - OGIS
College Park, Maryland 20740-6001
E-mail: ogis@nara.gov
Web: https://ogis.archives.gov
Telephone: 202-741-5770
Facsimile: 202-741-5769
Toll-free: 1-877-684-6448

There is no fee for FOIA services in this instance in accordance with 5 U.S.C. § 552(a)(4)(A)(i) et seq. Thank you for your interest in the National Science Foundation.

Sincerely,

/s/

Justin Guz
Government Information Specialist

Enclosures (14 files)

§ 612.9 Appeals.

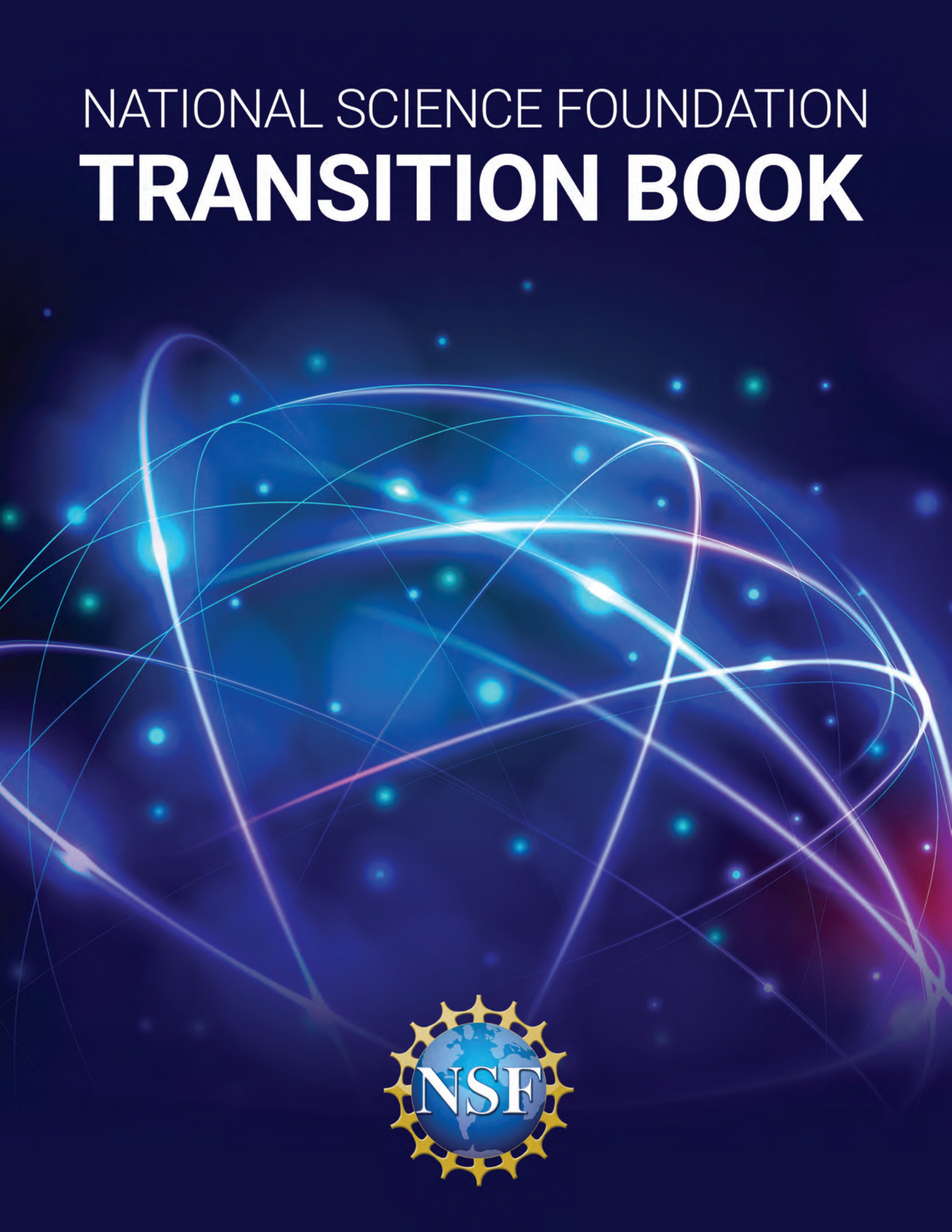
(a) Appeals of denials. You may appeal a denial of your request to the General Counsel, National Science Foundation, 4201 Wilson Boulevard, Suite 1265, Arlington, VA 22230. You must make your appeal in writing and it must be received by the Office of the General Counsel within ninety days of the receipt of the denial (weekends, legal holidays, and the date of receipt excluded). Clearly mark your appeal letter and the envelope "Freedom of Information Act Appeal." Your appeal letter must include a copy of your written request and the denial together with any written argument you wish to submit.

(b) Responses to appeals. A written decision on your appeal will be made by the General Counsel. A decision affirming an adverse determination in whole or in part will contain a statement of the reason(s) for the affirmance, including any FOIA exemption(s) applied, and will inform you of the FOIA provisions for court review of the decision. If the adverse determination is reversed or modified on appeal, in whole or in part, you will be notified in a written decision and your request will be reprocessed in accordance with that appeal decision.

(c) When appeal is required. If you wish to seek review by a court of any denial, you must first appeal it under this section.

NATIONAL SCIENCE FOUNDATION

TRANSITION BOOK



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DR. SETHURAMAN "PANCH" PANCHANATHAN
DIRECTOR
NATIONAL SCIENCE FOUNDATION

The Honorable Sethuraman Panchanathan is a computer scientist and engineer and the 15th director of the U.S. National Science Foundation (NSF). Panchanathan was nominated to this position by the President of the United States in 2019 and subsequently unanimously confirmed by the U.S. Senate on June 18, 2020. NSF is an $8.3B independent federal agency and the only government agency charged with advancing all fields of scientific discovery, technological innovation and STEM education.

Panchanathan is a leader in science, engineering and education with more than three decades of experience. He has a distinguished career in both higher education and government, where he has designed and built knowledge enterprises, which advance research innovation, strategic partnerships, entrepreneurship, global development and economic growth.

Panchanathan previously served as the executive vice president of the Arizona State University (ASU) Knowledge Enterprise, where he was also chief research and innovation officer. He was also the founder and director of the Center for Cognitive Ubiquitous Computing at ASU. Under his leadership, ASU increased research performance fivefold, earning recognition as the fastest growing and most innovative research university in the U.S.

Prior to joining NSF, Panchanathan served on the National Science Board as chair of the Committee on Strategy and as a member of the External Engagement and National Science and Engineering Policy committees. Additionally, he served on the National Advisory Council on Innovation and Entrepreneurship. He was chair of the Council on Research of the Association of Public and Land-grant Universities and co-chair of the Extreme Innovation Taskforce of the Global Federation of Competitiveness Councils. Arizona's Governor appointed Panchanathan as senior advisor for science and technology in 2018. He was the editor-in-chief of the IEEE Multimedia Magazine and editor/associate editor of several international journals.

Panchanathan's scientific contributions have advanced the areas of human-centered multimedia computing, haptic user interfaces, person-centered tools and ubiquitous computing technologies for enhancing the quality of life for individuals with different abilities; machine learning for multimedia applications; medical image processing; and media processor designs. He has published close to 500 articles in refereed journals and conference proceedings, and has mentored more than 150 graduate students, postdocs, research engineers and research scientists, many now occupy leading positions in academia and industry.

For his scientific contributions, Panchanathan has received numerous awards, such as Distinguished Alumnus Awards and the Governor's Innovator of the Year for Academia Award for his development of information technology centric assistive and rehabilitative environments to assist individuals with visual impairments.

Panchanathan is a fellow of the National Academy of Inventors, where he also served as vice president for strategic initiatives. He is also a fellow of the American Association for the Advancement of Science, the Canadian Academy of Engineering, the Institute of Electrical and Electronics Engineers and the Society of Optical Engineering.

Panchanathan is married to Sarada "Soumya" Panchanathan, an academic pediatrician and informatician, who has taught medical students, pediatric residents and informatics fellows. They have two adult children, Amritha and Roshan.

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LEADER OF AI BREAKTHROUGHS, CHAMPION OF INNOVATION AND INCLUSIVITY

Sethuraman Panchanathan, 15th Director of the National Science Foundation Meet Sethuraman Panchanathan, 15th Director of the National Science Foundation

June 23, 2020

He speaks in terms like “inspiration,” “creativity,” “innovation mindset,” and “the science spirit.” Sethuraman Panchanathan grins as he describes himself: “I’m an eternal optimist.”

He goes by “Panch.”

Who is he? By titles and numbers, the 15th Director of the National Science Foundation. Father, husband, Arizona State University Sun Devil, and the first American of Indian origin appointed to the National Science Board. Panchanathan holds four patents, has published more than 485 papers in peer-reviewed journals and conference proceedings and has mentored graduate students, post-docs, research engineers and research scientists —more than 150.

Among piles of accolades and pages of awards, consider one from Arizona State University— early recognition for what would define key pieces of his life’s work and personal mission: Outstanding contributions to improving the lives of individuals with disabilities.

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The way Panchanathan sees it, “When technology is your companion, it frees you up to do creative, artistic things.” That’s why, at ASU, he founded the Center for Cognitive Ubiquitous Computing, where researchers use artificial intelligence and machine learning to “empower people across the entire range of abilities.”

Enabling people across a range of disabilities to better engage in daily life wasn’t the goal, at first. In fact, Panchanathan’s skillset in image processing and computer vision was focused on sight. But as he started working with people who are blind or visually impaired, he realized, “When you work with individuals with disabilities and you understand the hard problems to solve, you are now finding those solutions that actually enable everyone.” For example, an assistive note-taker designed by a visually impaired student offers fellow students with sight an enhanced ability to take better lecture notes.

From focus groups, Panchanathan identified the hard problems. For example, just entering a room and starting a conversation can be problematic for the visually impaired. If you’re blind, you usually wait for others to approach and start a conversation. Panchanathan was adamant: “That’s not acceptable.”

So his team explored the assistive potential of haptics, or how we interact through touch. Haptics can communicate situational awareness cues and information to enable a blind person to engage. An example is the feeling you get when your phone vibrates. Researchers at the center are imagining haptic devices —such as a belt and a glove—that assist the wearer.

Panchanathan maintains that such technology can change conventional thinking about disabilities. The focus is no longer on overcoming an impairment, but on tapping expansive potential, “It gives you an opportunity now to explore the capacities, the capabilities of your brain. We are inherently creative beings. It opens up the creative spirit.”

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Photo credit: Arizona State University

Panchanathan was born and raised in Chennai, on the Bay of Bengal. He earned a doctorate in computer engineering from the University of Ottawa in 1989. He graduated as the information technology revolution was changing nearly everything—commerce, the way people connected and communicated, and the practice of science.

NSF funding helped usher in the information age with networks such as the NSFNET backbone, a bridge to a commercial internet. Panchanathan recalled how this revolution inspired him to move to the U.S.: "I was so taken by the information and technology revolution taking place at the time and wanted so much to be part of and contribute to this revolution."

At ASU in Tempe, Arizona, his contributions enabled machine and human to meet in "synergistic, symbiotic" ways. To get an idea of what this means, think of Stephen Hawking. The renowned physicist was paralyzed and unable to use his vocal cords. Panchanathan points to Hawking's use of assistive technologies to nevertheless express his voice as "a powerful example of how people and machines can work symbiotically to unleash human potential."

As executive vice president of the ASU Knowledge Enterprise and the chief research and innovation officer, Panchanathan's leadership took ASU to the top of U.S News & World Report's "Most Innovative Schools" ranking, five years in a row.

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Photo credit: Arizona State University

In a 2017 talk, Panchanathan explained that in an environment conducive to innovation, you celebrate success. But you also honor failure because if you're trying to innovate, "Chances are that you will try, you will fail. And then you will try, and you will fail. And then you will try, and you will succeed, possibly." The point is that failure is a temporary phase before success. Resilience, Panchanathan explains, is the core of the innovation mindset.

The future of American competitiveness requires such creative and innovative mindsets, Panchanathan testified in the 2019 U.S. Senate hearing "Research and Innovation: Ensuring America's Economic and Strategic Leadership." He also urged inclusivity in STEM as a key to maintaining global leadership. "World-class science requires talented scientists and engineers drawn from every corner of our nation – from remote rural areas to the largest urban centers. The best science is shaped by a wide range of perspectives," Panchanathan explained.

He believes that stronger global partnerships are essential to fostering creative approaches to the big challenges facing society. As an example, Panchanathan pointed to oceans and a sustainable future. "It's not just a science problem, or an engineering problem, or a behavior problem, or a social problem, or a cultural problem, or a policy problem; it is all of the above and more." Big challenges require creative approaches and global cooperation.

June is Oceans Month, read about NSF funded-ocean discoveries here

Beyond titles and numbers, the 15 Director of the National Science Foundation believes, "every human being has raw, untapped potential that can be realized with the right support and opportunity."

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Photo credit: Arizona State University

He believes teachers must inspire students. “It’s a humongous responsibility.” At the recent National Science Board meeting, he spoke in awe of the inspired and inspiring students responding to the pandemic by designing and validating personal protective equipment with NSF-seeded technologies such as 3-D printers.

He believes in “seeding bold, large-scale foundational research with meaningful societal impact.” At a time when emerging technologies such as AI and quantum are creating the industries of the future and the world is confronting the greatest challenges humanity has ever faced, science stands on the brink of new expanses in its endless frontier. Panchanathan believes, “This is an exciting future.”

Written by Trisha Calvarese, Speechwriter in the Office of Legislative and Public Affairs, National Science Foundation / Prime Meridian Media Inc.

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NSF ORGANIZATIONAL CHART

NATIONAL SCIENCE BOARD

OFFICE OF INSPECTOR GENERAL (OIG)

NATIONAL SCIENCE BOARD OFFICE

DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO)

Joanne S. Tornow
Assistant Director
(Career)

Alan D. Tessier
Deputy AD

DIRECTORATE FOR COMPUTER & INFORMATION SCIENCE & ENGINEERING (CISE)

Margaret Martonosi
Assistant Director
(IPA)

Erwin Gianchandani
Deputy AD

DIRECTORATE FOR EDUCATION & HUMAN RESOURCES (EHR)

Karen A. Marrongelle
Assistant Director
(IPA)

Sylvia M. James
Deputy AD

DIRECTORATE FOR ENGINEERING (ENG)

Dawn Tilbury
Assistant Director
(IPA)

Linda G. Blevins
Deputy AD

DIRECTORATE FOR GEOSCIENCES (GEO)

William E. Easterling
Assistant Director
(IPA)

Scott Borg
Deputy AD

DIRECTORATE FOR MATHEMATICAL & PHYSICAL SCIENCES (MPS)

Sean L. Jones
Acting Assistant Director
(Career)

Tie Luo
Acting, Deputy AD

DIRECTORATE FOR SOCIAL, BEHAVIORAL, & ECONOMIC SCIENCES (SBE)

Arthur W. Lupia
Assistant Director
(IPA)

Kellina M. Craig-Henderson
Deputy AD

OFFICE OF BUDGET, FINANCE, & AWARD MANAGEMENT (BFA)

Teresa Grancorvitz
Office Head /Chief Financial Officer (Career)

Janis Coughlin-Piester
Deputy Office Head

OFFICE OF INFORMATION & RESOURCE MANAGEMENT (OIRM)

Wonzie L. Gardner
Office Head /Chief Human Capital Officer (OIRM) / OSDBU Dir.(Career)

Peggy Gartner
Acting Deputy Office Head

OFFICE OF DIVERSITY & INCLUSION (ODI)

Rhonda Davis
Office Head
(Career)

OFFICE OF THE GENERAL COUNSEL (OGC)

Lawrence Rudolph
General Counsel
(Career)

Peggy Hoyle
Deputy General Counsel

OFFICE OF INTEGRATIVE ACTIVITIES (OIA)

Suzanne Iacono
Office Head
(Career)

OFFICE OF INTERNATIONAL SCIENCE & ENGINEERING (OISE)

Rebecca S. Keiser
Office Head
(Career)

Samuel B. Howerton
Deputy Office Head

OFFICE OF LEGISLATIVE & PUBLIC AFFAIRS (OLPA)

Amanda Hallberg Greenwell
Office Head
(Career)

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OMB Organizational Excellent Presentation Slide on COVID

- **NSF received $1M in Supplemental funding from CARES Act**
- **FY 2020 costs incurred for:**
  - Building
  - Information Technology
  - Staff
- **NSF currently in Phase 2**
  - NSF meeting mission
  - Successful use of Zoom
  - ~97% of staff currently working remotely
  - Continuous communication
  - Town Halls, FAQs (staff, research community)

COVID Costs

Building- Personal protective equipment, signage, cleaning staff and cleaning solution, hand sanitizer and stations, plexiglass in high-interaction areas, elevator reprogramming

IT- Zoom licenses, remote IT Help for staff laptops, increased VPN capacity, additional equipment (e.g., monitors)

Staff- move IPA files from paper to electronic, tools for Pulse Surveys (on #4 now).

NSF has successfully demonstrated it could transition to a maximized virtual office/telework environment without negative impact to the agency's mission. The resources that had been spent in the years prior to ensure a robust virtual capability and support enabled the agency to swiftly make this transition. For example, NSF invested significantly in laptops and mobile devices as well as remote access tools, allowing staff to work seamlessly in any location. The agency also had planned for a rollout of Zoom for Government such that rollout was successfully expedited at the outset of the pandemic.

COVID Responses to GAO, Congress and the OIG

NSF Response to COVID

Describe steps the agency took to prepare for continuity of operations as the threat of the COVID-19 pandemic began to emerge.

During February 2020, when the pandemic was emerging as a likely event to impact agency operations, agency senior leadership began discussions and evaluated options. The Office Head, OIRM stood up a Coronavirus Incident Response Team (COV-IRT) comprised of representatives from the business operations and program office organizations involved in implementing the agency's response, which met on a regular basis to discuss issues and provide status updates, which were shared with senior leaders. Telework agreements were reviewed, and all staff were notified to be telework ready. Employees not on a telework agreement were placed on one. Contracts were, likewise, reviewed and the ability of contractors

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to telework was assessed and addressed. The NSF headquarters building is leased through the General Services Administration (GSA). There was significant coordination between GSA and the building management company to ensure adequate cleaning supplies, sanitation equipment, and janitorial staff availability. The agency also expedited the rollout of new Zoom technology to facilitate remote work by providing an agency-wide virtual collaboration platform.

- Describe steps taken to protect personnel during the COVID-19 pandemic, while maintaining agency operations.

Before NSF transitioned to maximum telework, the agency requested more cleaning and sanitizing for high-traffic and high-touch areas on a daily and weekly basis. Non-essential travel was paused, staff were encouraged to conduct merit review panels and other meetings virtually, and social distancing was encouraged.

NSF then quickly restricted building access to mission-essential needs and transitioned to a maximum virtual office environment, which was critical to protecting personnel and maintaining agency operations. New procedures were developed to deliver services remotely to the greatest extent possible. During building population restrictions, NSF continued to evaluate its building safety and took additional steps to evaluate customer service areas and workspaces for viability of physical distancing guidelines. This resulted in installation of plexiglass barriers and procurement of additional sanitation supplies and face masks in accordance with the Centers for Disease Control and Prevention (CDC) guidelines. For workspaces not providing adequate physical distancing, plans to alternate on-site presence of affected staff to maintain physical distancing were developed. Heating, ventilation and air conditioning (HVAC) best practices and standards were implemented in cooperation with the building manager. Facility cleaning protocols and frequency; protocols for shared spaces, such as elevators and pantries; building signage; and common area closures were also addressed during this time and in advance of any regular return to the facility.

- What types of external guidance, if any, did the agency use to inform their response to the COVID-19 pandemic?

Primary guidance utilized includes the criteria outlined in M-20-23, “Aligning Federal Agency Operations with the National Guidelines for Opening Up America Again,” 5 CFR 550.409 authorizing an agency to send employees home or to an alternative telework location without activating a COOP, “Guidelines for Opening Up America Again,” CDC guidance for individuals and for businesses, OPM guidance including “Human Resources Flexibilities and Authorities for the 2019 Novel Coronavirus,” Commonwealth of Virginia guidelines for “Forward Virginia;” and Virginia Department of Health guidance for travelers.

- As required by M-20-23, what is NSF’s process to elevate phasing status and other information to decision-makers, to make decisions at the appropriate level, and to communicate those decisions clearly and expeditiously to Federal employees and contractors?

The Office Head, Office of Information and Resource Management (OIRM) communicates phasing status and other information to the Chief Operating Officer along with recommended agency actions. Once decisions are made, they are communicated to Federal employees and contractors through emails to staff from the Office Head, OIRM. Additional communication occurs through Town Halls, Frequently Asked Questions posted on InsideNSF and announced through the Weekly Wire, and communication from supervisors.

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The Division of Acquisition and Cooperative Support (DACS) works with OIRM and other stakeholders to draft guidance for NSF contractors and their employees. DACS provides this guidance to Contracting Officer Representatives (CORs), who are NSF employees that manage the day-to-day relationship with the contractors. CORs are then able to work with individual contractors to implement the guidance in the manner most appropriate for each contract. For any issues that have a potential impact on price or schedule, CORs coordinate with their Contracting Officers to provide guidance and context to specific contractors. DACS also hosts roundtables for CORs to discuss guidance as needed.

- Describe successes and challenges your agency experienced when implementing continuity of operations during the COVID-19 pandemic. Please provide examples.

The agency successfully demonstrated it could transition to a maximized virtual office/telework environment without negative impact to the agency's mission. The resources that had been spent in the years prior to ensure a robust virtual capability and support enabled the agency to swiftly make this transition. For example, NSF invested significantly in laptops and mobile devices as well as remote access tools, allowing staff to work seamlessly in any location. The agency also had planned for a rollout of Zoom for Government such that rollout was successfully expedited at the outset of the pandemic.

While this was not directly a COOP effort, the agency recognized the closures of schools and senior care centers around the region placed an added burden on employees, who must suddenly and unexpectedly balance dependent care with telework. To assist our workforce in this, supervisors could use their discretion in approving up to 20 hours of weather and safety leave per pay period to employees impacted by dependent care responsibilities resulting from the COVID-19 pandemic.

Due to precautions related to physical proximity at NSF headquarters, the agency implemented discretion to defer the physical presence requirements associated with onboarding of new employees. The agency established a virtual onboarding process for new employees deemed mission-critical and created electronic versions of all signed forms and documents to be provided via e-mail.

The challenges experienced by the agency revolved around pivoting processes that were not electronic to electronic processes. For example, retiring employees could be off-boarded virtually except for wet signatures needed on retirement applications and associated forms. The process was eventually converted to all-electronic, but it posed challenges at the beginning of maximum virtual work.

In order to safely conduct our mission, in-person engagements that would have seen NSF staff travel to conduct on-site reviews or outreach activities and would have brought tens of thousands of panelists to NSF headquarters, have been replaced by various virtual tools. These tools have been invaluable, but NSF leadership and staff look forward to being able to operate with a mix of in-person and virtual settings when it is safe to do so.

Return to the NSF Building

Describe the process the agency used for determining how and when to allow for workforce reentry.
NSF's reopening plan was developed by a working group comprised of executives with broad representation across the agency, including OIRM; the Office of Budget, Finance and Award Management;

the Office of General Counsel; the Office of Diversity and Inclusion; and program offices. Recommendations for operations for Phase Two were developed by a subgroup consisting of subject matter experts from the same organizations and the employee union for the working group's consideration.

The working group developed high-level recommendations for the plan and considered the recommendations from the subgroup. The working group provided their recommendations to the Chief Operating Officer for approval.

- Please describe your agency's plan for reopening. Be sure to include, at minimum: (1) which employees will be asked to return to their duty stations and when; (2) whether leave and telework flexibilities will still be available to employees, for how long, and to what extent; (3) any regionalized or localized plans to account for areas that continue to see an increase in COVID-19 cases; (4) any estimates or timelines of when the agency will return all employees to normal duty stations.

NSF has developed a three-phased plan for returning to on-site facilities that aligns with M-20-23, "Aligning Federal Agency Operations with the National Guidelines for Opening Up America Again" and conforms with Centers for Disease Control and Prevention (CDC) guidelines. NSF entered Phase One on June 8, 2020. In the first step of Phase One, a limited number of staff returned to the NSF building to prepare both the building itself and the agency's IT infrastructure for subsequent re-entry steps. In the second step of Phase One, a limited number of employee-based services that could not be performed off-site began to be provided in the building by appointment only. On July 20, 2020, the agency entered Phase Two of its plan that allows for employees to voluntarily return to on-site facilities. During this phase, telework continues to be encouraged, especially for employees whose schools are closed or whose childcare plans are disrupted, employees who have dependent care responsibilities, employees whose transit options are disrupted due to COVID-19, and employees who are members of vulnerable populations as defined by the CDC. On-site services continue to be by appointment only. All leave and telework flexibilities that were introduced and are described in response to question 17 below continue to be available to employees. In Phase Three of NSF's plan, unrestricted access to the NSF Headquarters building will resume; employee requests for special accommodations, such as telework, will be reviewed by the supervisor on a case-by-case basis; and on-site services will resume without the need for an appointment. NSF does not have an estimated timeline for entering Phase Three.

- What criteria did the agency decision makers use, if any, to determine when and which employees can reenter the workplace?

NSF entered Phase Two of its return to on-site facilities plan on July 20, 2020. During Phase Two, employees may work in the NSF building on a voluntary basis while ensuring social distancing protocols are adhered to at all times. NSF made this determination based on the Commonwealth of Virginia's current status for Northern Virginia in "Forward Virginia" and trends in new COVID-19 cases and deaths in the National Capital Region. NSF also surveyed staff to determine the number of individuals interested in working regularly in the building and used that information to establish an initial allowable maximum daily occupancy for the building of 25%. Offices also developed on-site work schedules for staff in locations that do not comply with CDC physical distancing guidelines to ensure physical distancing guidelines are met.

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- What external guidance, if any, did the agency use to inform decisions surrounding reentry?

In addition to the guidance outlined in M-20-23, "Aligning Federal Agency Operations with the National Guidelines for Opening Up America Again," NSF considered "Guidelines for Opening Up America Again," CDC guidance for individuals and for businesses, OPM guidance including "Human Resources Flexibilities and Authorities for the 2019 Novel Coronavirus," Commonwealth of Virginia guidelines for "Forward Virginia," and Virginia Department of Health guidance for travelers. Trends in new COVID-19 cases and deaths in the National Capital Region were also considered.

- To what extent did your agency consult with its bargaining units or national union representatives when developing its reopening plans? Please describe any such communication your agency had.

Discussions were held with the American Federation of Government Employees (AFGE) Local 3403 union president regarding the agency's plan for Phase One. The union president is a member of the subgroup that developed the recommendations for operations during Phase Two. In addition, the Local 3403 reviews communications sent to all staff regarding agency reopening plans, and the union president has participated in agency and supervisor Town Halls on the topic.

- The July 13th Return to On-site Facilities: Frequently Asked Questions document mentions overall building parameters regarding physical distancing and total population. Please describe the overall building and occupancy parameters. Will there be occupancy limits, or an optimum number of employees on various floors, or in certain rooms, during different phases?

During Phase Two, the initial allowable maximum daily occupancy of the building has been set at 25%. This upper limit will provide flexibility for Directorates and Offices to plan for staff who want to work inside the building as well as accommodate ad hoc visits to the building. Meetings will continue to be held virtually and panel and conference rooms will remain closed. Each Directorate and Office has been provided a floorplan indicating locations where physical distancing requirements cannot be maintained if all staff who normally sit in these areas are present to aid in scheduling staff who volunteer to work in the building. Employees who plan to work inside the building during Phase Two need to coordinate entry with their immediate supervisor or Directorate/Office point of contact.

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UTILIZING NSF-FUNDED RESEARCH IN THE FIGHT AGAINST COVID-19

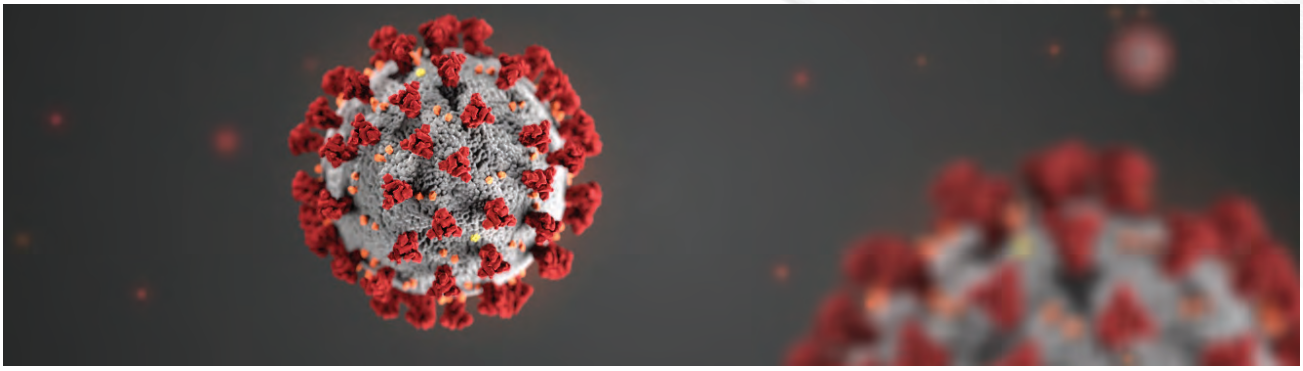

Image credit: CDC

For 70 years, NSF has supported basic research that enhances our economy and national defense, and advances the health, prosperity, and well-being of the nation. As the nation responds to the COVID-19 pandemic, NSF-funded research is playing a crucial role. From the science and engineering behind critical diagnostic tools and medical devices, to novel solutions that help communities, businesses, and individuals navigate the challenges of this difficult time, NSF's investments in science and technology are making a difference.

DECADES OF NSF INVESTMENTS ARE BEING USED IN THE RESPONSE TO COVID-19

3D PRINTED PPE PROTECTS HEALTHCARE WORKERS

NSF's investments in 3D printing and additive manufacturing—going back to the 1980s—are enabling students and educators at community colleges in Tennessee, Kentucky and Connecticut to produce life-saving personal protective equipment (PPE). NSF is continuing to fund research to expand advanced manufacturing capabilities and efficiency, and NSF plays a key role in STEM training that opens these fields up to students and workers across the nation.

UNDERSTANDING THE BIOLOGY OF VIRUSES TO MITIGATE TRANSMISSION

Decades of investments in genetics, cyberinfrastructure and fundamental biology enabled the rapid sequencing and identification of the novel coronavirus weeks after its discovery in late 2019. This finding allowed infectious disease experts to quickly realize its similarity to the 2002 SARS coronavirus and begin work on combatting its spread. Continued work in comparing genetic variation between infected individuals will provide an understanding of how the virus spreads from person to person and between communities.

Since 2002, NSF has partnered with the National Institutes of Health and the U.S. Department of Agriculture to run the Ecology and Evolution of Infectious Diseases (EEID) program. EEID funds research to advance the understanding of pathogen transmission, including human, animal, and plant diseases, in effort to control disease and maintain human, animal, and ecosystem health. Multidisciplinary research funded through EEID has laid essential groundwork for addressing the current and future novel disease outbreaks. An example of EEID's impactful work is the 2013 identification of bats as the source of the 2002 SARS coronavirus outbreak.

NSF-SUPPORTED RESEARCH HUBS ADVANCE THE FIGHT AGAINST COVID-19

The Molecular Sciences Software Institute (MolSSI) has launched a centralized, open repository for sharing resources and expertise related to the molecular properties of the SARS-CoV-2 virus, to help fight the COVID-19 pandemic. Viral

DID YOU KNOW?

NSF funding for social, behavioral, and economic sciences helps us understand and respond to societal dimensions of the pandemic. One example is a project from Stanford University that studied how flu-like diseases spread within schools. The researchers equipped students and school staff with small wireless transmitters that provided real-time data as students and staff encountered each other. The researchers then used that information to simulate strategies to manage the spread of infectious diseases.

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simulations provide a molecular-level understanding of the components that make up the virus, e.g. spike-proteins or proteases, which may uncover pathways to disrupt the virus's ability to replicate or infect human cells. NSF awarded $17 million to Virginia Tech to develop and run MolSSI, a critical molecular sciences computing hub. This infrastructural investment has allowed MolSSI to swiftly respond to the COVID-19 crisis and help contribute to finding essential therapeutics.

HARNESSING THE POWER OF NSF SUPERCOMPUTERS

Eight NSF-funded computing systems are part of the COVID-19 High Power Computing Consortium, a public-private partnership co-led by NSF that is providing researchers with cutting-edge computing power to answer questions critical to the COVID-19 response. More information on how NSF's computing power is being used during the crisis can be found here.

NSF'S RAPID RESPONSE TO THE CRISIS

In March, as the severity of the COVID-19 crisis loomed, NSF responded by calling for Rapid Response Research (RAPID) and Small Business Innovation Research (SBIR) proposals to address the pandemic. As of April 10, 63 RAPID awards totaling $9,862,000 have been made to researchers around the country to support research related to the pandemic.

Recent RAPID awards include:

- Researchers at Northwestern University are developing a self-sanitizing medical facemask insert to protect front line workers from infection.
- Biophysicists from the University of Delaware are building atomic level simulations of the COVID-19 coronavirus to better understand its makeup and how it infects human cells.
- Researchers at the University of Utah are working to understand how different temperatures, drying, and other conditions affect the virus's ability to survive in mucus-like droplets, like those expelled from a cough. Their findings will help shape best practices that individuals can use to protect against spreading the virus, as well as improving models for tracking the spread of the virus as the seasons change.
- Engineers at Purdue University will study how water quality is affected by building closures over time and assess the origin of contaminations so that communities can ensure their infrastructure is safe when people return after the pandemic.

NSF has supported small businesses for more than 40 years. Now in response to the pandemic, several companies are mobilizing their NSF-funded technologies ranging from rapid diagnostics to AI for outbreak monitoring to respond to the COVID-19 crisis.

Up-to-date weekly reports on COVID-19 related funding supported by the CARES Act can be found here.

INVESTING IN A PREPARED FUTURE

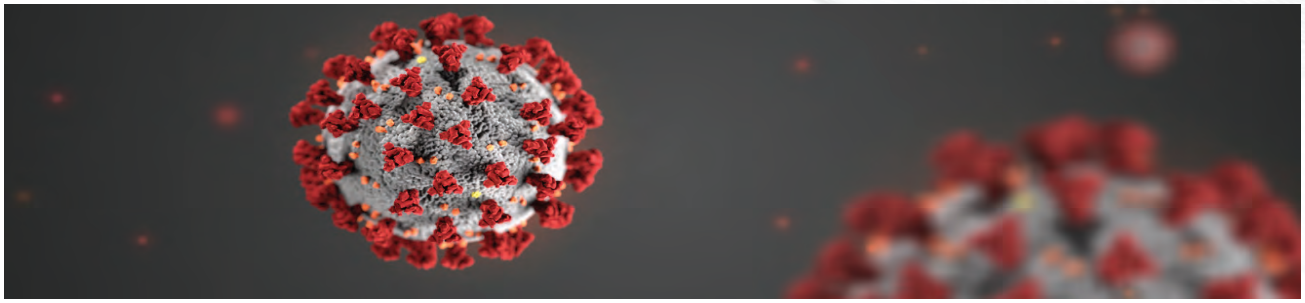
NSF is investing in tools and technology that will help us contend with future pandemics. Advances in artificial intelligence and big data offer the potential to spot hidden patterns and raise the alarm about new diseases before they spread. Advanced manufacturing and cutting-edge engineering will be able to put the right tools in the hands of first responders and medical professionals faster than ever. Programs like the Civic Innovation Challenge are demonstrating how the convergence of technology with local government can give communities and municipalities new tools to help residents and provide services during emergencies. And NSF-supported research will continue to put countless new technologies in people's hands that can enable connectivity, productivity and learning while staying safe at home.

Image credit: iStock.com/MF3d

DID YOU KNOW?

Clinical tests for COVID-19 rely on the genetic identification of the virus, a process made feasible by an NSF-funded discovery of bacteria from thermal pools at Yellowstone National Park. These unique bacteria contained thermostable enzymes that allowed for the rapid copying of genetic material through a process called Polymerase Chain Reaction (PCR). Only a tiny amount of genetic material is retrieved through a nasal swab, far too small an amount to be readily detected, so scientists amplify it to a measurable quantity to confirm whether a patient has been infected with SARS-CoV-2.

Harnessing Computing Power to Fight COVID-19



COVID-19 HIGH PERFORMANCE COMPUTING (HPC) CONSORTIUM

- March 23, 2020 - The White House announced the launch of the COVID-19 High Performance Computing (HPC) Consortium, a unique public-private consortium spearheaded by the White House Office of Science and Technology Policy, IBM, the National Science Foundation (NSF), and the U.S. Department of Energy. The HPC Consortium enables researchers to access the most powerful high-performance computing resources to accelerate understanding of the COVID-19 virus and develop methods for combating it.
- For over four decades, NSF has been at the forefront of advanced computing capabilities, providing researchers across the country access to computing systems that are key to keeping the U.S. a global leader in research and education.

Providing access to **30 supercomputing systems, 402 petaflops, 105,334 nodes, 3,539,044 CPU cores, 41,286 GPUs,** and counting...

- NSF-supported computing systems powering the HPC Consortium include: the leadership-class computing resource, Frontera, at the Texas Advanced Computing Center (TACC); Bridges at the Pittsburgh Supercomputing Center (PSC); Cheyenne at the NCAR-Wyoming Supercomputing Center; Comet at the San Diego Supercomputer Center (SDSC); Jetstream at the Indiana University Pervasive Technology Institute (PTI); and Stampede2 at TACC.
- NSF-supported services, the Extreme Science and Engineering Discovery Environment (XSEDE) and the Open Science Grid (OSG), are also working to integrate and coordinate resources available to the HPC Consortium.

MAPPING NSF'S COMPUTING POWER

NSF-funded advanced computing systems and services enabling the COVID-19 HPC Consortium.
*XSEDE is a collaborative partnership of 19 institutions, and OSG has more than 100 active virtual organizations worldwide.

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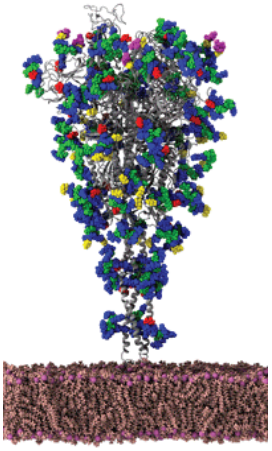
- Powerful data analytics, machine learning, artificial intelligence, and other advanced computing capabilities available through NSF-supported computing resources are giving rise to new knowledge and discovery not otherwise possible. These systems contribute to the Nation's economic competitiveness and security, and in the current environment, they are critical to advancing researchers' understanding of COVID-19.

SIMULATIONS TO UNDERSTAND TRANSMISSIBILITY

- NSF-funded advanced computing systems have been supporting University of California-San Diego Chemistry and Biochemistry Professor Dr. Rommie Amaro's work to understand the transmissibility of influenza viral infections since 2014.
- As recently as February 2020, the Dr. Amaro's research has advanced our understanding of the transmissibility of the H1N1 Influenza virus, enabled by simulations on the Blue Waters supercomputer at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. This research was instrumental in allowing a quick response to the COVID-19 crisis.
- The Frontera team at TACC provided considerable support in March 2020 in terms of expertise in benchmarking, porting, and scaling the code to enable large-scale runs on the Frontera system. The simulations utilized 4,000 nodes, or about 250,000 processing cores, which amounts to half the total computation capability available on the system.
- Dr. Amaro's lab built on experimental cryogenic electron microscopy (cryoEM) research from University of Texas at Austin that illuminated the near-atomic resolution structure of the SARS-CoV-2 spike proteins, the most important viral protein involved in infecting host cells. Through her simulations on Frontera, Dr. Amaro is leading the effort to build the first complete all-atom model of the SARS-CoV-2 envelope. This effort is critically important to understanding the viral protein used by COVID-19 to infect host cells and crucial to understanding how best to react to this new threat.

#1 Frontera is the most powerful academic supercomputer in the world.

#5 Frontera is the fifth most powerful supercomputer in the world.



SARS-CoV-2 spike protein of the coronavirus as simulated by the Amaro Lab on the Frontera system.

SUPPORTING COLLABORATIVE RESEARCH

- Dr. Amaro's work in response to the COVID-19 crisis is also a demonstration of the national collaborative research enterprise between NSF and the National Institutes of Health (NIH). The Amaro lab's scientific research in developing and applying state-of-the-art computational and theoretical techniques to the investigation of biological systems is funded by NIH. Access to the Frontera supercomputer and the development of the system itself was made possible by NSF's investment in leadership-class computing resources.

DID YOU KNOW?

According to *Encyclopedia Britannica*, the term "supercomputer" is commonly applied to the fastest high-performance systems available at any given time. Such computers have been used primarily for scientific and engineering work requiring exceedingly high-speed computations. Frontera was named the #5 top supercomputer in the world and #1 academic supercomputer in the June 2019 rankings of the Top500 organization.

Coronavirus.gov **Coronavirus Disease 2019 (COVID-19)** **What the U.S. Government is Doing**

Image credits: Page 1 Centers for Disease Control and Prevention (CDC) Page 2 (top to bottom) TACC; TACC and Rommie Amaro, UC San Diego

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NSF AT A GLANCE

The National Science Foundation promotes the progress of science; advances the national health, prosperity, and welfare; and secures the national defense. It is the only federal agency that supports fundamental research in all fields of science and engineering, from mathematics and the geosciences to the biological, behavioral and computer sciences — and more. NSF also helps researchers and small businesses develop their discoveries into products and services through technology development, entrepreneurship training and industrial partnerships.

FAST FACTS

1950
Year Congress created NSF

$8.3B
NSF's approximate annual budget

93%
Percent of budget committed to research, education and related activities

11,000
Number of awards NSF funds each year

$200M
Amount NSF awards annually to small business to move discoveries into the marketplace

$1.2B
NSF spending each year on STEM education and workforce development

242
Number of Nobel Prize winners who received NSF funding

WHO WE ARE

The **NSF Director**, who is appointed by the President and confirmed by the Senate, **leads a workforce** driven to improve the world through research, discovery and innovation. The workforce consists of 200 rotating scientists and engineers, 1,400 career employees and 450 contract employees.

In addition, a 24-member **National Science Board**, also presidentially appointed, establishes the overall policies of the foundation. Board members and the NSF director serve six-year terms.

WHAT WE DO

Discovery
NSF supports research and people that explore the unknown, seek to demystify nature and advance the frontiers of science and engineering. NSF funds researchers who generate new knowledge and discoveries that provide a greater understanding of the world around us. Situated at the intersection of all science and engineering disciplines, NSF is uniquely positioned to identify and guide investments toward new, cutting-edge research areas.

Research Infrastructure
NSF funds supercomputers, ground-based telescopes, the world's largest and highest-powered magnet lab, long-term ecological sites, engineering centers and other infrastructure and state-of-the-art tools to sustain the nation's scientific enterprise. NSF also supports research stations in the Arctic and other locales, and manages the nation's entire Antarctic program. These NSF-supported facilities drive discoveries and serve as training grounds for the next generation of scientists and engineers.

Learning
NSF programs support science, technology, engineering and mathematics (STEM) education and training that attract individuals from every sector and group in society, ensuring a pipeline of diverse people and ideas ready to solve pressing global challenges in STEM.

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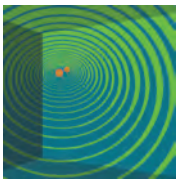
FUELING THE U.S. ECONOMY

NSF's commitment to fund high-risk, high-reward ideas strengthens the U.S. economy by producing discoveries that lead to emerging industries and jobs. NSF programs like Innovation Corps and the Small Business Innovation Research program expand and sustain the nation's innovation ecosystem. NSF also upholds America's competitive edge by training and preparing a 21st century STEM workforce and funding research that leads to new technologies, from Google's page-ranking algorithm and the internet to Qualcomm and magnetic resonance imaging, also referred to as MRI.

ENHANCING THE NATION'S SECURITY

Within 24 hours of the September 11 terrorist attacks, rapid-response researchers funded by NSF arrived at ground zero to help locate survivors with shoebox-sized robots, study how building structures failed and collect other critical data. The nation's scientists and engineers have responded similarly to other catastrophes, from hurricanes and oil spills to cyberattacks in support of the nation's defense. In addition, NSF-funded researchers help support the U.S. military by developing everything from lighter, more flexible bulletproof vests to next generation prosthetics and new methods for treating post-traumatic stress disorder.

SUSTAINING GLOBAL LEADERSHIP



NSF's support for cutting-edge research has positioned the U.S. as a global leader in science and technology. We advance the frontiers of knowledge across the smallest and grandest of scales, from atoms and black holes to tissue engineering, artificial intelligence and quantum mechanics. NSF's long-term support for research conducted at U.S. colleges and universities has helped transform these institutions into global centers of discovery and innovation, able to attract talent from around the world.

NSF RESEARCH AREAS

- BIOLOGICAL SCIENCES
- COMPUTER & INFORMATION SCIENCE & ENGINEERING
- EDUCATION & HUMAN RESOURCES
- ENGINEERING
- GEOSCIENCES
- MATHEMATICAL & PHYSICAL SCIENCES
- SOCIAL, BEHAVIORAL & ECONOMIC SCIENCES
- OFFICE OF INTEGRATIVE ACTIVITIES
- OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING

DID YOU KNOW?

With NSF support, future Google co-founders Sergey Brin and Larry Page created the page-ranking algorithm that would become the basis for their groundbreaking search engine.

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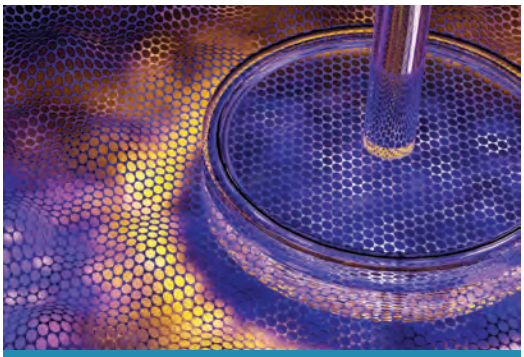
NSF BY THE NUMBERS

ADVANCING SCIENCE AND ENGINEERING RESEARCH IN THE U.S. AND ABROAD

- NSF was created by Congress in **1950** to continue the U.S. science and technology enterprise begun during World War II.
- NSF allocates **93 percent** of its approximately **$8.3 billion** budget for grants and awards to support research projects, facilities and STEM education.
- NSF funds research in **all 50 states** and U.S. territories.
- NSF fosters international scientific collaboration on **all 7 continents** around the globe.
- About **2,000 academic and other private and public institutions** across the U.S. conduct NSF-funded research.
- NSF supports **25 percent of all federally funded academic fundamental research** at U.S. colleges and universities.
- In 2018, NSF received approximately **48,000 research proposals** from scientists and engineers and funded about 12,000.
- **248** NSF-funded researchers have received Nobel Prizes.



25% of all federally funded academic fundamental research comes from NSF

SUPPORTING WORLD-CLASS RESEARCH FACILITIES AND INFRASTRUCTURE

- NSF supports almost **60 centers** focused on interdisciplinary research in areas such as chemistry, engineering, materials, nanotechnology, energy and biology.
- NSF has **4 oceanographic research vessels** and provides support to all **18 ships** and **3 submersibles** in the U.S. Academic Research Fleet.
- NSF owns **2 aircraft** that provide unique research capabilities to probe the Earth's atmosphere.
- NSF supports **19 ground-based telescopes or observatories** in the U.S. and around the world.
- NSF funds **7 of the world's supercomputers**.
- NSF supports **8 facilities** to study and mitigate powerful natural forces including a shake table for **earthquakes**, a large wave basin for **tsunamis**, and wind facilities for **hurricanes and tornados.**

19 NSF-supported, ground-based telescopes and observatories around the world

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- NSF supports **50 biological field stations and marine laboratories** across the U.S. and overseas.
- NSF funds **28 Long-Term Ecological Research sites** to achieve an understanding of how components of ecosystems interact.
- NSF's **National Ecological Observatory Network comprises 81 sites across the United States** and provides open data to researchers to understand how our ecosystems are changing.
- NSF manages all U.S. logistics and research for **3 permanent stations in Antarctica**: McMurdo, Amundsen-Scott South Pole and Palmer.

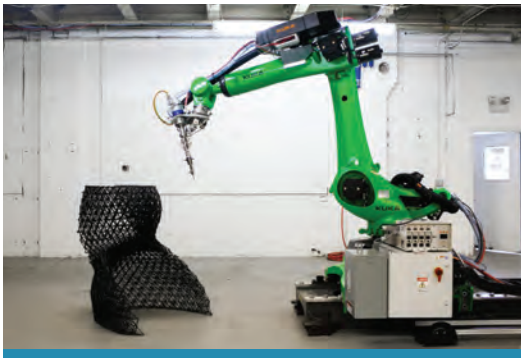
EXPANDING THE SCIENCE AND ENGINEERING WORKFORCE

- Annually, NSF funding **directly impacts 386,000** researchers, technical professionals, post-doctoral students, graduate students, undergraduates, K-12 teachers and students.
- **Since 1952**, NSF has supported **more than 57,000 students** through its flagship Graduate Research Fellowship Program.
- In FY 2018, approximately **42,000 graduate students** received funding through NSF programs as part of research and education grants.
- NSF Advanced Technological Education program supports **35 centers across the U.S.**, preparing students for jobs in high-tech industries.
- The **NSF INCLUDES national network** broadens participation in STEM by creating access and opportunities for all U.S. residents through public, private and academic partnerships.

386K people directly involved in NSF activities annually

ACCELERATING THE EXCHANGE BETWEEN LAB AND MARKET

- **NSF created the Small Business Innovation Research program** in 1977, which has expanded across government and spends approximately **$3 billion annually** on research and development.
- NSF established the **Small Business Technology Transfer Program** in 1992 to encourage the translation of research from lab to marketplace; through small business and technology transfer programs, the federal government sets aside **$2.5 billion annually** and produces about **10 patents per day**.
- In FY 2018, NSF awarded more than **$200 million** in R&D funding through its small business programs.
- Each year, NSF funds about **400 companies** across nearly all technology and market sectors.
- NSF established Innovation Corps, or I-Corps™, which offers entrepreneurship training to scientists and engineers; the program has resulted in **645 startup companies**.



400 companies receive NSF small business funding each year

DID YOU KNOW?

Since 1992, NSF's Louis Stokes Alliances for Minority Participation program has helped more than **650,000 students from groups historically underrepresented in STEM** – African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians and Native Pacific Islanders – attain a bachelor's degree in a science or engineering discipline.

Image credits: Page 1 (top to bottom) Andis Rea/Shutterstock.com; Philip Krantz, Columbia University; Dave Finley, NRAO/AUI/NSF; Page 2 (top to bottom) Photo from ATE Centers Impact 2011 (www.atecenters.org); Branch Technology

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AMERICAN LEADERSHIP IN ARTIFICIAL INTELLIGENCE

Artificial intelligence is impacting our everyday lives. It is the power behind smart household devices, personalized search results on Google, and digital assistants like Alexa and Siri. AI technologies are transforming how we optimize energy usage, deliver health care and respond to roadway congestion in real time. As an industry of the future, AI will greatly enhance business productivity, transforming the American workforce and the global economy. The U.S. National Science Foundation is the leading federal funder of AI research to expand our understanding of AI concepts and techniques, use-inspired studies to drive AI innovations, computing resources to empower AI researchers, and training to prepare an AI-savvy workforce.

FAST FACTS

2016
Year the federal government published its first "National AI R&D Strategic Plan."

About $500 million
Amount NSF invests annually in AI research.

7
Number of NSF-led AI Institutes funded in 2020 in conjunction with agency partners.

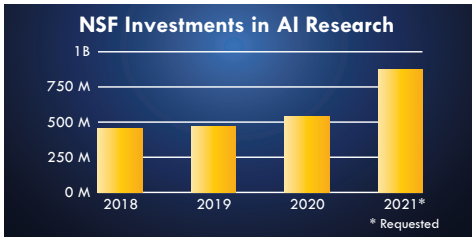
5th
Ranking of NSF's Frontera among the 500 fastest supercomputers in the world.

2019
Year the White House announced the "American AI Initiative," which identified the need for fundamental research in AI.

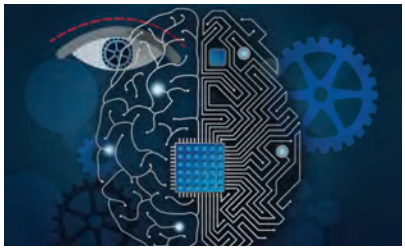
3,130
Number of cybersecurity experts placed at government entities across the U.S, thanks to NSF's CyberCorps program.

MAINTAINING THE AI EDGE

Global investments in AI research are on the rise, with China and the European Union having the largest AI investments abroad. Aligned with administration and congressional priorities, NSF's portfolio is part of a coordinated federal strategy to secure America's competitiveness in AI.



NSF SUPPORTING THE FOUNDATIONS OF AI



NSF has long supported transformational research that has helped form the knowledge base of AI. These investments over the last several decades helped pave the way for AI innovations in the commercial sector today.

- In the 1980s and 1990s, NSF-funded researchers developed the foundations of modern artificial neural networks, probabilistic reasoning with uncertain information, and automated machine learning. These technologies underlie all AI technology today, from the speech recognition on your smart phone to the systems used to discover patterns in medical data.

NSF AI RESEARCH AGENDA

GIVING RISE TO TRANSFORMATIVE AI TECHNOLOGIES

Today, NSF supports a variety of foundational research in AI spanning planning, perception, knowledge representation, reasoning, learning, natural language, computer vision, human-machine interfaces, safety and security, and fairness and transparency.

AI is also a powerful tool in the fight to protect endangered wildlife. NSF funds AI research to help rangers patrol wildlife parks and to predict where and when wildlife crimes may occur.

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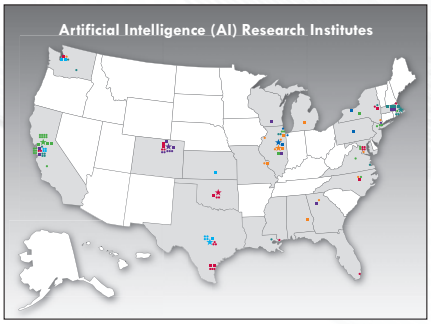
The agency also champions use-inspired research in areas such as materials discovery and design, environmental monitoring and prediction, infrastructure resilience, and health care. These efforts link AI innovation with the economy along with all fields of science and engineering.



- NSF AI Institutes program is funding multidisciplinary center-scale projects that serve as national nexus points for universities, federal agencies, industry and nonprofits to develop the foundational tools and workforce necessary for the next decade of AI innovation and innovators.
- Fairness in AI in Collaboration with Amazon supports computational research focused on fairness in AI, with the goal of developing trustworthy AI systems ready to tackle societal challenges.
- NSF-Simons Research Collaborations on the Mathematical and Scientific Foundations of Deep Learning supports two collaborative research projects exploring the theoretical foundation of deep learning.
- NSF partners with Intel on Machine Learning for Wireless Networking Systems to accelerate fundamental, broad-based research on machine learning techniques for future wireless systems that offer higher capacity, more security and greater efficiency. This partnership demonstrates the interplay between two industries of the future, AI and advanced wireless.
- NSF partners with the Defense Advanced Research Projects Agency to explore high-performance, energy-efficient hardware and machine learning architectures through the Real-Time Machine Learning initiative.

NURTURING THE NEXT GENERATION OF AI USERS AND INNOVATORS

- Advanced Technical Education provides offerings at community colleges and Computing in Undergraduate Education develops new approaches for handling the soaring numbers of students interested in computer science at the undergraduate level.
- Graduate Research Fellowships Program supports students pursuing research-based master's and doctoral degrees in STEM disciplines.
- Innovative Technology Experiences for Students and Teachers supports new approaches to motivate and prepare preK-12 learners for the industries of the future, including AI.

100,000 strong! Thanks to NSF's Computer Science for All program, more than three times as many Black/African American, Hispanic/Latino and women took an Advanced Placement (AP®) computer science exam in 2019 compared to 2016 – the largest and most diverse class ever.

EXPANDING COMPUTING RESOURCES THAT POWER AI INNOVATIONS

- The NSF Frontera supercomputer is the fastest supercomputer at any university campus in the US and fifth most powerful system in the world. Frontera is specifically equipped to accelerate AI and machine learning research.
- CloudBank enhances the research and education community's access to commercial cloud computing resources. This initiative builds on previous collaborations with Amazon Web Services, Google Cloud Platform, IBM Cloud and Microsoft Azure.

DID YOU KNOW?

NSF-funded researchers helped develop the technology that now fuels the recommender engines ("you might like this") of Netflix, Amazon and other websites.

Image Credits: Ryzhi/Shutterstock; Adrian Apodaca, National Science Foundation; Christine Daniloff/MIT (CC BY-NC-ND 3.0); Photo by Andrew Kelly/NY Hall of Science; ArtHeart/Shutterstock.com; Anatolir/Shutterstock.com; Liz Krage, National Science Foundation; Courtesy of Dr. Calvin Lin, Professor of Computer Science, University of Texas, Austin; Texas Advanced Computing Center; CoreDESIGN/Shutterstock

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NSF ADVANCES ARTIFICIAL INTELLIGENCE RESEARCH WITH NEW NATIONWIDE INSTITUTES

Photo credit: David Steadman/Santhosh Ramakrishnan/University of Texas at Austin

A new AI agent developed by researchers at the University of Texas at Austin takes a few "glimpses" of its surroundings, representing less than 20 percent of the full 360 degree view, and infers the rest of the whole environment. What makes this system so effective is that it's not just taking pictures in random directions but, after each glimpse, choosing the next shot that it predicts will add the most new information about the whole scene.

Read more

August 26, 2020

WASHINGTON — The U.S. National Science Foundation is establishing new artificial intelligence institutes to accelerate research, expand America's workforce, and transform society in the decades to come. Enabled by sustained federal investment and channeled toward issues of national importance, continued advancement in AI research holds the potential for further economic impact and improvements in quality of life.

With an investment of over $100 million over the next five years, NSF's Artificial Intelligence Institutes represent the nation's most significant federal investment in AI research and workforce development to date. The $20 million investment in each of five NSF AI institutes is just the beginning, with more institute announcements anticipated in the coming years.

"NSF's long history of investment in AI research and workforce development paved the way for many of the breakthrough commercial technologies permeating and driving society today," said NSF Director Sethuraman Panchanathan. "NSF invests more than $500 million in AI research annually. We are supporting five NSF AI Institutes this year, with more to follow, creating hubs for academia, industry, and government to collaborate on profound discoveries and develop new capabilities to advance American competitiveness for decades to come."

Led by NSF, and in partnership with the U.S. Department of Agriculture's National Institute of Food and Agriculture, the U.S. Department of Homeland's Security Science and Technology Directorate, and the U.S. Department of Transportation's Federal Highway Administration, these institutes will serve as nodes in a broader nationwide network that will pursue transformational advances in sectors of societal impact, from extreme weather preparedness to K-12 education. In addition to the five new NSF AI Institutes, USDA is announcing two of its first institutes today supported through this joint program, providing an additional $40 million over the next five years.

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- **NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography,** led by a team at the University of Oklahoma, Norman, assembles researchers in AI, atmospheric and ocean science, and risk communication to develop user-driven trustworthy AI that addresses pressing concerns in weather, climate, and coastal hazards prediction. With AI certificate programs aimed at workforce skills, the institute is providing the research and training necessary for the future workforce to deliver the advances needed to deal with forecasting and prediction challenges.

- **NSF AI Institute for Foundations of Machine Learning,** led by a team at the University of Texas, Austin, focuses on major theoretical challenges in AI, including next-generation algorithms for deep learning, neural architecture optimization, and efficient robust statistics. The institute's partners include large industrial technology companies and the city of Austin. Major online coursework and research initiatives will bring current AI tools to thousands of students and professionals across the country.

- **NSF AI Institute for Student-AI Teaming,** led by a team at the University of Colorado, Boulder, develops groundbreaking AI that helps both students and teachers to work and learn together more effectively, and equitably, while helping educators focus on what they do best: inspiring and teaching students. The vision is to develop engaging "AI partners" that will observe, participate in, and facilitate collaborative STEM learning conversations by interacting naturally through speech, gesture, gaze, and facial expression in real-world classrooms and remote learning settings.

- **NSF AI Institute for Artificial Intelligence and Fundamental Interactions,** led by a team at the Massachusetts Institute of Technology, incorporates workforce development, digital learning, outreach, and knowledge transfer programs to develop AI methods that integrate the laws of physics as a guiding framework to advance our knowledge — from the smallest building blocks of nature to the largest structures in the universe — and galvanize AI research innovation to broaden societal impacts.

- **USDA-NIFA AI Institute for Next Generation Food Systems,** led by a team at the University of California, Davis, integrates a holistic view of the food system with AI and bioinformatics to understand biological data and processes, addressing issues of molecular breeding to optimize traits for yield, crop quality, and pest/disease resistance; agricultural production, food processing and distribution, and nutrition. Major emphasis is on inclusive education and outreach approaches to build a diverse, next-generation workforce.

- **USDA-NIFA AI Institute for Future Agricultural Resilience, Management, and Sustainability,** led by a team at the University of Illinois at Urbana-Champaign, advances AI research in computer vision, machine learning, soft object manipulation and intuitive human-robot interaction to solve major agricultural challenges including labor shortages, efficiency and welfare in animal agriculture, environmental resilience of crops, and the need to safeguard soil health. The institute features a new joint Computer Science + Agriculture degree and global clearinghouse to foster collaboration in AI-driven agriculture research.

"The National AI Institutes being awarded today comprise large, multi-disciplinary, and multi-sector collaborations: they bring together consortia of dozens of universities and other organizations, ultimately spanning academia, government, and industry," said Michael Kratsios, U.S. Chief Technology Officer. "In effect, over the next five years, some of the best minds in the country will be tackling some of the grandest challenges that we face, both in terms of new AI techniques as well as breakthroughs in fields of science and engineering and sectors of our economy. And along the way, they will nurture the future American workforce in AI research and practice."

Learn more about the NSF AI Institutes and artificial intelligence research by visiting nsf.gov.

For more on NSF's investments in AI, see our fact sheet, "American Leadership in Artificial Intelligence" and the NSF Science Matters article "New NSF AI Research Institutes Push Forward the Frontiers of Artificial Intelligence".

Media Contacts
Media Affairs, NSF, (703) 292-7090, media@nsf.gov

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AMERICAN LEADERSHIP IN QUANTUM

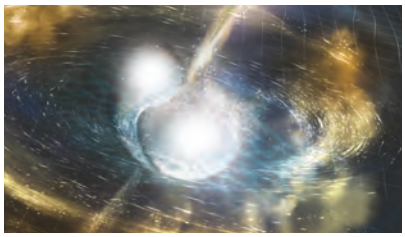
GPS systems, MRI technology, and lasers that enable today's internet are a few examples of quantum-based technologies that have already transformed society and the American economy. The future of quantum information science promises to be even more impactful, enabling a new era in sensing, computing, modeling, and communication that is more secure, accurate, and efficient than ever before. As a leading federal funder of quantum research, the U.S. National Science Foundation is at the forefront of quantum discovery, exploring the fundamental research questions that have enabled the quantum innovations of today and will drive the quantum revolution of tomorrow.

GLOBAL R&D IN QUANTUM

Nations worldwide are accelerating quantum research, as new quantum-based methods for computing, communicating, and encrypting data could have global, economic and security implications.

NSF's portfolio is closely aligned with the Administration's **National Strategic Overview for Quantum Information Science** and the **National Quantum Initiative Act**, which provide a coordinated federal approach for securing America's world-leading position in quantum research.

NSF AND THE HISTORY OF QUANTUM RESEARCH



NSF has been supporting research in quantum information science since the field's inception in the early 1980s, building on earlier quantum investments that helped make QIS possible. Early NSF studies in quantum mechanics and information theory laid the groundwork for several concepts and tools that are being explored today.

For example, a 1979 NSF grant to Kip Thorne employed a new approach to quantum measurement that is being implemented at the Advanced Laser Interferometer Gravitational-Wave Observatory, also known as Advanced LIGO. This approach, developed by his student Carleton Caves, is expanding LIGO's already revolutionary ability to detect gravitational waves and changing our understanding of the universe.

NSF'S QUANTUM RESEARCH AGENDA

NSF targets key fundamental research challenges that must be overcome to advance America's quantum capabilities.

FAST FACTS

1982
Approximate year NSF began supporting research in the newly developed field of quantum information science.

31
Number of NSF-supported Nobel Laureates honored for quantum studies.

2017
Year NSF designated Quantum Leap as one of its 10 Big Ideas, investing $180M for convergent research.

2018
Year the National Quantum Initiative Act was signed into law.

2023
Year NSF-funded projects expect to deliver a practical quantum computer.

$75M
NSF investment to establish three Quantum Leap Challenge Institutes.

22
Number of industry partners supporting NSF's first three Quantum Leap Challenge Institutes.

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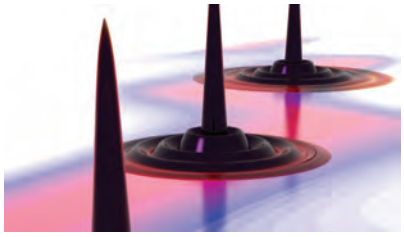

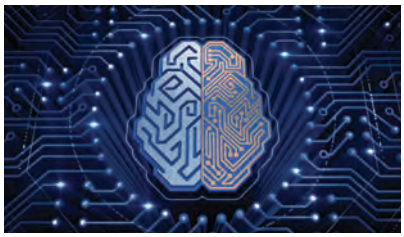

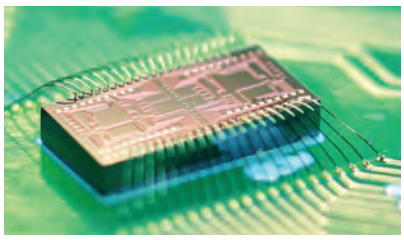

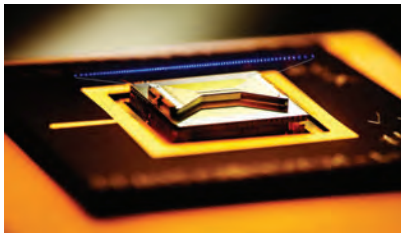

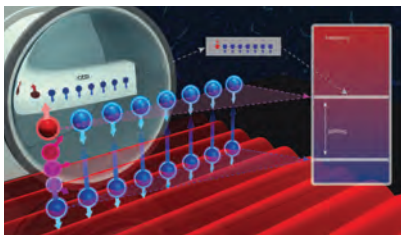

MULTIDISCIPLINARY COLLABORATION

NSF is uniquely positioned to build bridges across all quantum-related disciplines and to nurture partnerships with academia, industry, and international allies – all of which are vital to advancing quantum discoveries.

NSF Quantum Leap Challenge Institutes provide large-scale interdisciplinary research centers designed to leverage expertise from various disciplines, research institutions, and industry to address research and workforce development challenges across all areas of quantum information science.

NSF Quantum Idea Incubator for Transformational Advances in Quantum Systems enables bold and collaborative research approaches by supporting small interdisciplinary teams that come together to imagine original ideas in quantum science, computing, and engineering.

NSF Convergent Accelerated Discovery Foundries for Quantum Materials Science, Engineering, and Information accelerate the translation of fundamental materials engineering and information research for quantum applications.

NSF partners in quantum research with private and public organizations from Amazon to Department of Energy and from Microsoft and IBM to National Institutes of Standards and Technology.

CREATING NEXT-GENERATION TECHNOLOGIES

NSF is accelerating the development of advanced quantum-based applications, including new materials and circuits, more precise sensors and detectors, and new algorithms that fuel powerful computers and more secure communications.

Seeking Secure Quantum Communications
To advance the technology necessary for practical quantum communication, NSF is supporting Advancing Communication Quantum Information Research in Engineering to engineer systems that use entangled photons in pre-determined quantum states as a way to encrypt data.

Building a More Advanced Quantum Computer
To accelerate the development of a practical quantum computer that will one day answer currently unsolvable research questions, NSF is investing in the multi-institution Software-Tailored Architecture for Quantum co-design project. By bringing together experts who have outlined a path to a practical quantum computer and supporting its development, NSF is working to take the quantum revolution from theory to reality.

NURTURING QUANTUM INNOVATORS

NSF is working to empower a diverse, quantum-literate workforce that will drive and implement quantum innovations well into the future.

NSF Building "Triplets" to Bridge Academia and Industry initiative links the talents and resources of academia and industry, by creating three-person teams of university faculty, industrial researchers, and graduate students who will work together on quantum challenges.

NSF Quantum Computing & Information Science Faculty Fellows program supports the hiring of academic faculty specializing in quantum computing and/or communication to departments of computer and information science and engineering at U.S. institutions of higher education.

DID YOU KNOW?

Five of the researchers behind Google's groundbreaking quantum computer were supported by NSF early in their careers.

Image Credits: (In order) P. Roushan/Martinis lab/UC Santa Barbara; Trinka Kensill/NSF; NSF/LIGO/Sonoma State University/A. Simonnet; Baxley/JILA; Sergey Tarasov/Shutterstock; Shayan Mookherjea, UC San Diego; K. Hudek, Ion Q&E/E. Edwards, JQI; David Awschalom, University of Chicago; S. Kelley/Joint Quantum Institute, University of Maryland

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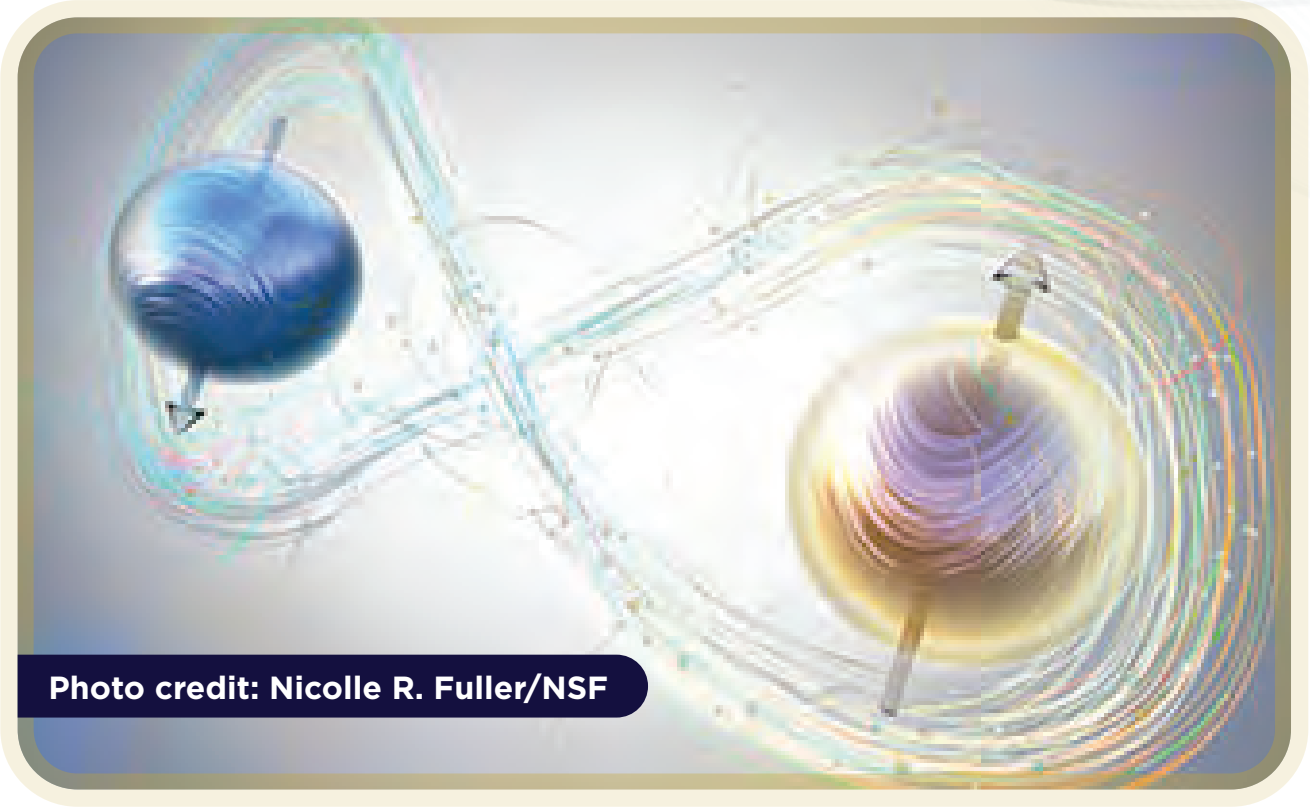
NSF ESTABLISHES 3 NEW INSTITUTES TO ADDRESS CRITICAL CHALLENGES IN QUANTUM INFORMATION SCIENCE



Artist's rendition of quantum entanglement.

July 21, 2020

Quantum phenomena have puzzled and delighted scientists for over a century, revealing unique, counter-intuitive characteristics of matter like superposition and entanglement. For four decades, the U.S. National Science Foundation has worked to enable breakthroughs in quantum information science and engineering that harness what researchers have learned about quantum phenomena to develop technologies like quantum computers, sensors, and communications. These quantum technologies will have enormous consequences for the national and global economy. To unleash that potential, researchers must overcome several major, fundamental challenges in quantum information science and engineering.

With these unresolved questions in mind, NSF launched the Quantum Leap Challenges Institutes program. And today, NSF, in partnership with the White House Office of Science and Technology Policy, is announcing $75 million for three new institutes designed to have a tangible impact in solving these problems over the next five years.

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These institutes are a central piece of NSF's response to key federal initiatives to advance quantum information science, including the National Quantum Initiative Act of 2018 and the White House's ongoing focus on American leadership in emerging technologies. Quantum Leap Challenge Institutes also form the centerpiece of NSF's Quantum Leap, an ongoing, agency-wide effort to enable quantum systems research and development.

"Quantum information science has the potential to change the world. But to realize that potential, we must first answer some fundamental research questions," said NSF Director Sethuraman Panchanathan. "Through the Quantum Leap Challenge Institutes, NSF is making targeted investments. Within five years, we are confident these institutes can make tangible advances to help carry us into a true quantum revolution."

"America's future depends on our continued leadership in the most cutting-edge industries of tomorrow. With the announcement of three new quantum institutes, the Trump Administration is making a bold statement that the United States will remain the global home for QIS research. Our new Quantum Leap Challenge Institutes will advance America's long history of breakthrough discoveries and generate critical advancements for years to come," said Michael Kratsios, U.S. Chief Technology Officer.

NSF is establishing three institutes:

- **NSF Quantum Leap Challenge Institute for Enhanced Sensing and Distribution Using Correlated Quantum States.** Quantum sensors that can measure everything from radiation levels to the effects of gravity will be more sensitive and accurate than classical sensors. This institute, led by the University of Colorado, will design, build, and employ quantum sensing technology for a wide variety of applications in precision measurement.

- **NSF Quantum Leap Challenge Institute for Hybrid Quantum Architectures and Networks.** Developing more robust quantum processors is a significant challenge in quantum information science and engineering. This institute, led by the University of Illinois, Urbana-Champaign, will build interconnected networks of small-scale quantum processors and test their functionality for practical applications.

- **NSF Quantum Leap Challenge Institute for Present and Future Quantum Computing.** Today's quantum computing prototypes are rudimentary, error-prone, and small-scale. This institute, led by the University of California, Berkeley, plans to learn from these to design advanced, large-scale quantum computers, develop efficient algorithms for current and future quantum computing platforms, and ultimately demonstrate that quantum computers outperform even the best conceivable classical computers.

The institutes comprise an interconnected community of 16 core academic institutions, 8 national laboratories, and 22 industry partners. Through integrating the perspectives and resources of multiple disciplines and sectors, they promote a sustainable ecosystem for innovation. In addition to their research, these centers will also make strides in training and educating a diverse, quantum-ready U.S. workforce. They will develop new in-person and online curricula for students and teachers at all educational levels, from primary school to professionals.

More information on NSF-supported quantum information science and engineering research can be found here.

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NSF GLOBAL FACILITIES WITH VIRTUAL ACCESS

The National Science Foundation invests in world-class scientific facilities that explore everything from the subatomic to black holes. These facilities support the entire science and engineering enterprise as shared-use infrastructure, instrumentation and equipment that are accessible to a broad community of researchers, educators and students. Located around the globe, NSF has supported such diverse projects as particle accelerators, optical and radio telescopes, research stations in the Arctic and Antarctic, research vessels, aircraft and a continental-scale ecological observatory.

This fact sheet offers a glimpse into several NSF global facilities. The sites profiled below provide virtual tours or webcams to allow students and researchers around the globe to see science at work without leaving home. For more information:

- Comprehensive map of NSF facilities
- Additional NSF resources

Antarctic Facilities and Operations

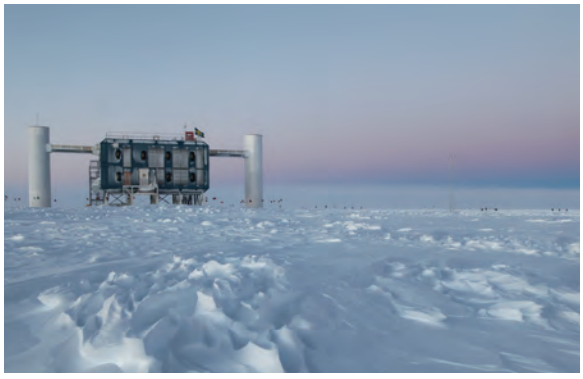
The U.S. Antarctic Program provides the infrastructure needed to support all U.S. research conducted in Antarctica. This includes research funded by NSF and by U.S. mission agencies; for year-round work at three U.S. stations; on two research ships; and at a variety of remote field camps. The research stations are located on Ross Island (McMurdo Station), at the geographic South Pole (Amundsen-Scott South Pole Station), and on Anvers Island in the Antarctic Peninsula region (Palmer Station). Explore USAP:

- McMurdo Station webcams
- Amundsen-Scott South Pole Station webcams
- Palmer Station webcam

IceCube Neutrino Observatory

The IceCube Neutrino Observatory is the world's first high-energy neutrino observatory and is located deep within the ice under Amundsen-Scott South Pole Station in Antarctica. The observatory represents a new window on the universe, providing unique data on the engines that power active galactic nuclei; the origin of high-energy cosmic rays; the nature of gamma-ray bursts; the activities surrounding supermassive black holes; and other violent and energetic astrophysical phenomena. ICNO is presently led by the University of Wisconsin, Madison, and was constructed with support from four countries: the U.S., Belgium, Germany and Sweden. Explore IceCube:

- IceCube explained



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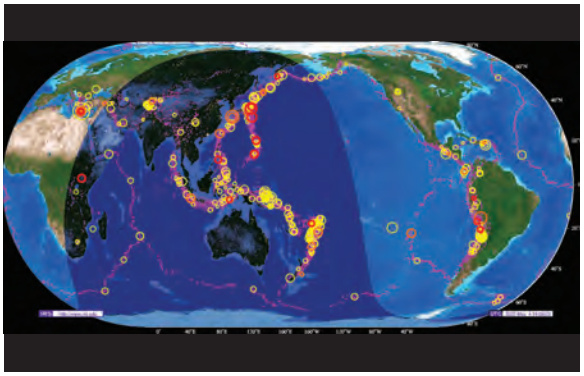
International Ocean Discovery Program

The International Ocean Discovery Program is an international marine research collaboration made up of scientists, research institutions and funding organizations from 23 nations that explores the evolution, structure and behavior of Earth, as recorded in the ocean basins. The research vessel *JOIDES Resolution* is a 143-meter drillship in the IODP fleet funded by NSF and run through a cooperative agreement with Texas A&M University. Explore the *JOIDES Resolution*:

- Virtual tour of the *JOIDES Resolution*



Seismological Facility for the Advancement of Geoscience

The Seismological Facility for the Advancement of Geoscience is a distributed, multi-user national facility for the support of modern digital seismic instrumentation and serves national goals in basic research and education in the earth sciences, earthquake research, global real-time earthquake monitoring, and nuclear test ban verification. The facility is managed and operated for NSF by the Incorporated Research Institutions for Seismology, a consortium of 125 U.S. universities and nonprofit institutions with research and teaching programs in seismology, 21 educational affiliates, three U.S. affiliates and 128 foreign affiliates. Explore SAGE:

- IRIS Global Seismic Monitor

National Ecological Observatory Network

The most persistent challenges facing the ecological sciences today result from a limited understanding of the complex interactions between living and non-living systems operating over large spatial and temporal scales. A lack of long-term and large-scale infrastructure has hindered a thorough assessment of complex ecological issues. The National Ecological Observatory Network was designed to address this issue, as well as revolutionize ecological research and promote the use of open data. NEON consists of 81 strategically located field sites (47 terrestrial and 34 aquatic) across 20 eco-climatic domains. Construction of NEON was completed in May 2019. Explore NEON:

- NEON field sites interactive map
- NEON YouTube page

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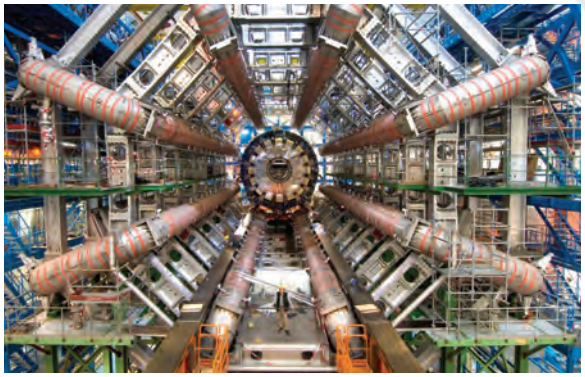
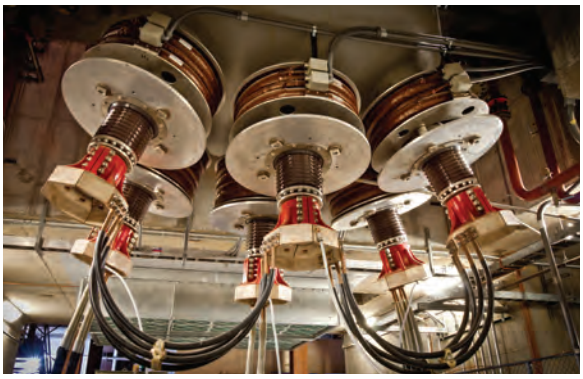


Large Hadron Collider

The Large Hadron Collider, an international project at the European Organization for Nuclear Research, or CERN, a laboratory in Geneva, Switzerland, is the most powerful particle accelerator ever constructed. It produces the highest energy particle beams ever created at a laboratory, making it the premier facility in the world for research in elementary particle physics. More than 45 international funding agencies provide support for scientists to participate in experiments at LHC. The U.S., through a partnership between the U.S. Department of Energy and NSF, made major contributions to the construction and operation of the A Toroidal LHC ApparatuS and Compact Muon Solenoid detectors, two large, general purpose particle detectors at LHC. NSF also supports operation of the LHC beauty experiment, a special purpose detector that investigates matter/antimatter differences by studying "beauty quark" particles. Explore LHC:

- CERN virtual tour



National High Magnetic Field Laboratory

The National High Magnetic Field Laboratory, or MagLab, develops and operates high magnetic field facilities that scientists and engineers use for research in condensed matter and material physics, materials science and engineering, chemistry, biology, biochemistry, neuroscience, energy and the environment. The laboratory is managed by Florida State University and consists of facilities at FSU, the University of Florida and Los Alamos National Laboratory. It is the world's premier high magnetic field laboratory with a comprehensive collection of high-performing magnet systems and extensive support services. MagLab is an internationally recognized leader in magnet design, development and construction. It is also a key player in the development of new superconducting materials. Approximately 2,000 users use the MagLab every year for crucial research experiments. Explore the MagLab:

- MagLab virtual tour

National Radio Astronomy Observatory

The National Radio Astronomy Observatory conceives, designs, builds, operates and maintains state-of-the-art radio telescopes used by scientists from around the world. This essential infrastructure enables modern astrophysicists to make discoveries that reach from within our solar system to the most distant galaxies in the universe. As a Federally Funded Research and Development Center, headquartered in Charlottesville, Virginia, NRAO operates the Karl G. Jansky Very Large Array near Socorro, New Mexico; the Very Long Baseline Array, with 10 sites throughout the continental U.S., Hawaii and the U.S. Virgin Islands; and is the North American implementing organization for the international Atacama Large Millimeter/submillimeter Array in Chile. In support of these radio telescopes, NRAO also operates the Central Development Laboratory in Charlottesville, which develops next generation electronics and detectors for radio astronomy. Explore NRAO:

- NRAO Explore
- VLA virtual tour

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National Optical-Infrared Astronomy Research Laboratory
At the start of fiscal year 2020, NSF launched the National Optical-Infrared Astronomy Research Laboratory, a Federally Funded Research and Development Center that will be the foundational hub of U.S. ground-based, optical-infrared astronomy in the era of the Vera Rubin Observatory, multi-messenger astrophysics, data intensive science and extremely large telescopes. Over the last two decades, NSF has been a leading partner in operations of the two 8.1-meter Gemini Telescopes, located on Maunakea in Hawaii at an altitude of 4,200 meters and on the 2,700-meter summit of Cerro Pachón in Chile. Technological advances incorporated into the design of the twin Gemini Telescopes optimize their imaging capabilities and infrared performance, as well as their ability to quickly swap instruments in response to changing atmospheric conditions. Explore Gemini:

- Virtual tour of Gemini Observatory

The Vera Rubin Observatory, which is under construction until 2022 on Cerro Pachón in Chile, is an 8-meter-class telescope coupled to a 3.2-gigapixel camera – the world's largest digital camera ever fabricated for optical astronomy. Explore the Vera Rubin Observatory:

- Vera Rubin gallery and YouTube page

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NSF PARTNERSHIP OPPORTUNITIES

NSF embraces partnership opportunities to enhance research and innovation, increase access to research infrastructure and strengthen workforce development. Partnering can accelerate scientific discovery as well as the translation of research into products and services that benefit society.

POTENTIAL NSF PARTNERS

- Private industry
- Foundations
- Non-profits
- Federal agencies
- International organizations
- State and local governments
- Individuals

The NSF/Air Force partnership is advancing areas of mutual interest in the geosciences and other areas.

PARTNERSHIP HIGHLIGHTS

A partnership with NSF can take many forms. The following are a few examples of NSF partnership agreements.

LETTER OF INTENT

NSF deepened ties with the **U.S. Air Force**, a longtime provider of critical logistical support for polar research, through a letter of intent. Together, we are working to advance national security research in areas of common interest, such as space operations and geosciences, advanced materials sciences, information and data sciences, and workforce development.

MEMORANDUM OF UNDERSTANDING

NSF and the **National Institute of Food and Agriculture** are advancing initiatives aimed at critical resources such as digital agriculture, food security, energy and water quality through a memorandum of understanding. The partnership encourages information sharing about project activities and joint support in areas of mutual interest.

LETTER OF COLLABORATION

Through the **Graduate Research Internship Program**, NSF partners with nine federal agencies providing additional research options for NSF Graduate Research Fellows at federal facilities and national laboratories in areas of national priority. Opportunities have included positions in astrophysics at the Smithsonian Institution, natural resource management at the U.S. Department of Agriculture and mineral studies at the U.S. Geological Survey.

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INTERAGENCY AGREEMENT
NSF and multiple federal agencies support the **National Center for Atmospheric Research,** a research and development center that advances worldclass research in the atmospheric and related earth system sciences. The center has expanded understanding of many atmospheric occurrences, including geohazards such as hurricanes, geomagnetic storms and wildfires. Federal partners include the U.S. Army, Air Force, Army Corps of Engineers, the Defense Advanced Research Projects Agency and the National Oceanic and Atmospheric Administration.

JOINT SOLICITATION
Intel Corporation and NSF partnered to develop and jointly fund five solicitations to advance research, innovation and workforce development in cybersecurity and privacy, visual and experiential computing, computer-assisted programming, wireless edge networks and microarchitecture. NSF and Intel provide equal support for the program.

The NSF/Intel partnership is enhancing the security and privacy of cyber-physical systems.

INDUSTRY/UNIVERSITY COOPERATIVE RESEARCH CENTERS
The **Center for Biophotonic Sensors and Systems** is a national resource for development of biophotonic sensors and systems using light-based technologies to create devices and systems for early disease detection and more effective personalized care options. The center was established by Boston University and the University of California Davis and supported by NSF's Industry/University Cooperative Research Centers program. The center includes nearly 20 members from government, industry and academia who leverage research funds to address pressing industry needs.

A GIFT TO NSF
Through a collaboration to strengthen the needs of the future workforce, **The Boeing Company** made a gift to NSF that is supporting the design and deployment of online curricula to accelerate training in critical skill areas such as robotics, data science and artificial intelligence. NSF will fund research focused on re-skilling and improving the technical abilities of the nation's STEM workforce.

For more information on partnering with NSF, contact partnership@nsf.gov

$2.5B
Amount federal government invests annually in small business and technology transfer firms, resulting in about 10 patents per day.

34%
NSF Industry-University Cooperative Research Centers that reported an invention in FY18

DID YOU KNOW?

NSF and NASA have partnered on several research projects in Antarctica, including a study to prepare astronauts to cope with months of isolation, confinement and life in an extreme environment.

Image credits: Page 1 (top to bottom) Liu zishan/Shutterstock.com; Scott Springer, Earth & Space Research; Page 2 (c)iStock.com/Andrey Prokhorov

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NSF STRENGTHENS THE U.S. WORKFORCE

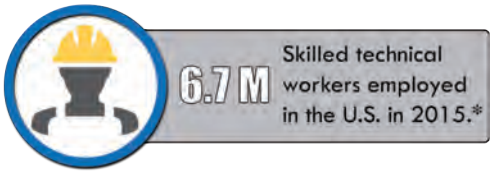
NSF supports initiatives that build the STEM-capable U.S. workforce of the future and ensure Americans are prepared to meet evolving workplace demands. NSF partners with academia, government and industry to develop and leverage education and training opportunities, which result in increased levels of STEM employment and job creation. The following are just a few examples of NSF's varied workforce development portfolio.

SHAPING THE FUTURE OF WORK AND WORKPLACES

The Future of Work at the Human-Technology Frontier, one of NSF's 10 Big Ideas, supports fundamental research to advance understanding of how people and technology interact, distribute tasks, cooperate and complement each other in various work contexts. This research will develop new technologies to augment human performance, explore the risks and benefits of these technologies, examine the impact of artificial intelligence on workers and work, and discern the influence of human-technology partnerships on society. New approaches to training and education will yield new information on how adults adapt to emerging technologies and changing work environments.

CONNECTING WITH STUDENTS

NSF's **Advanced Technological Education** program improves education of technicians for high-technology industries important to the nation's economy and security. Most often, these technicians, whose highest level of education is either high school or some college, are prepared for their jobs through associate degree programs in community colleges and related technology programs in secondary schools. In 2016, out of nearly 1.1 million associate's degrees awarded in the U.S., 9% were in science and engineering and 13% in science and engineering technologies.



The **Innovative Technology Experiences for Students and Teachers** supports projects to encourage preK-12 students to participate in the STEM and information and communications technology workforce of the future. Programs heighten awareness of STEM occupations, motivate students to pursue education pathways leading to STEM careers, and develop the reasoning and communications skills to enter the STEM workforce.

BROADENING PARTICIPATION

A number of NSF-supported programs focus on increasing opportunities for underrepresented populations to pursue STEM careers. Among these programs: **NSF INCLUDES**, the agency's comprehensive initiative to broaden STEM participation; the **Established Program to Stimulate Competitive Research**, also known as EPSCoR, which fosters STEM training, professional development and research competitiveness in underserved regions of the country; and the **Scholarships in Science, Technology, Engineering and Mathematics** program, which provides scholarships for low-income, academically talented students who are pursuing two-year, four-year or graduate degrees in STEM fields. The program also provides support to institutions and their partners for activities that encourage student recruitment, retention and career advancement.

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PARTNERING WITH INDUSTRY

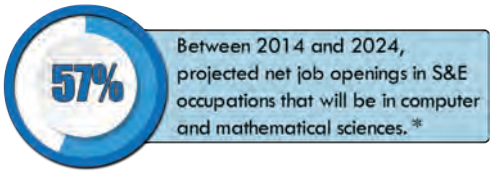
NSF supports a variety of world-class research centers across multiple fields of science and engineering. Many of the centers foster partnerships with industry to expand opportunities for research and training in areas of critical importance such as manufacturing, natural hazards mitigation, communications and biotechnology.

Examples include **NSF Engineering Research Centers**, which engage students of diverse backgrounds in real-world engineering environments; **Industry-University Cooperative Research Centers**, which train students in emerging technology areas that impact multiple industry sectors; and **NSF Science and Technology Centers**, which provide a rich environment for encouraging future scientists, engineers and educators to take risks in pursuing discoveries and new knowledge. Graduate students in **NSF's INTERN** program also gain practical experience working with Fortune 500 companies, small businesses, government labs and think tanks.

DEVELOPING SKILLS IN CRITICAL FIELDS

The number of degrees in computer sciences has been on the rise at the bachelor's, master's and doctoral levels since the late 2000s. NSF's commitment to building the computer science knowledge base extends to funding R&D for rigorous and engaging computer science programs in schools across the United States. For example, NSF and the Department of Education, in partnership with other federal agencies, are leading a national effort called **CS for All** to ensure computer science education is available to all students.

NSF funds **CyberCorps: Scholarship for Service** to strengthen the cadre of cybersecurity professionals who protect the government's critical infrastructure. The program provides tuition and a stipend to students in exchange for a commitment to serve in a cybersecurity role in the U.S. government for up to three years after graduation.



REPORTING WORKFORCE TRENDS

To inform policy discussions related to the U.S. STEM workforce, NSF's **National Center for Science and Engineering Statistics** (NCSES) leads multiple activities to measure workforce characteristics including STEM diversity; U.S. competitiveness in science, engineering, technology and research and development; and the condition and progress of U.S. STEM education. The National Science Board, NSF's governing body, presents the data to Congress in a biennial report, the *Science and Engineering Indicators*, which comprises high-quality quantitative data on the U.S. and international science and engineering enterprise. NCSES also produces for Congress the biennial report, *Women, Minorities, and Persons with Disabilities in Science and Engineering* that provides statistical information about the participation of these groups in science and engineering education and employment.

11%
Rate of increase for total employment in S&E occupations between 2014 and 2024; compared to 7% rate of increase for all occupations.*

$84K
Median annual salary in S&E occupations in 2016, more than double the median ($37,040) for all U.S. workers. *

DID YOU KNOW?

Over the last 25 years, NSF has invested $1.1 billion to advance technician training in a range of high-tech fields.

* Science and Engineering Indicators 2018 | January 2018

Image Credit: txieyuliang/Shutterstock.com

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ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCOR)

Building Research Infrastructure to Advance Science and Engineering Research and Education Across America since 1979

The National Science Foundation recognizes the inherent value of a truly national science and engineering (S&E) research enterprise that trains students and engages researchers throughout the country. The Established Program to Stimulate Competitive Research (EPSCoR) was created to provide deliberate investments in S&E research and capacity-building in U.S. states and territories receiving a disproportionate share of NSF funds. This program has continuously invested in EPSCoR jurisdictions across the country totaling over $2.55 billion invested since 1979.

INVESTMENT STRATEGIES

EPSCoR investments are made through three major investment strategies that infuse support for cutting-edge research and education programs. Each funding mechanism is designed to support a unique facet of research and training to holistically stimulate an environment for discovery, innovation, and STEM workforce training in a jurisdiction.

I. Research Infrastructure Improvement (RII) Program

   a) Track-1 awards are up to $20 million over 5 years that is invested in research infrastructure in an area critical to the jurisdiction's science and technology plan.

   b) Track-2 awards stimulate collaborations between EPSCoR jurisdictions in scientific focus areas consistent with NSF and National priorities.

   c) Track-3 awards provide up to $750,000 for up to five years to support broadening participation of underrepresented groups in STEM fields including but not limited to African Americans, Hispanics, Native Americans, women, persons with disabilities and those in underserved rural regions of the country.

   d) Track-4 awards, also called EPSCoR Research Fellows, directly support non-tenured researchers for key collaborations with industry, government, or academic research centers that enhance the research capacity of the researcher, institution, and jurisdiction.

II. EPSCoR funds are also used to provide co-funding support for competitive proposals from individual investigators, groups, and centers in EPSCoR jurisdictions.

III. Workshops, conferences, and other community-based activities are eligible for EPSCoR funding.

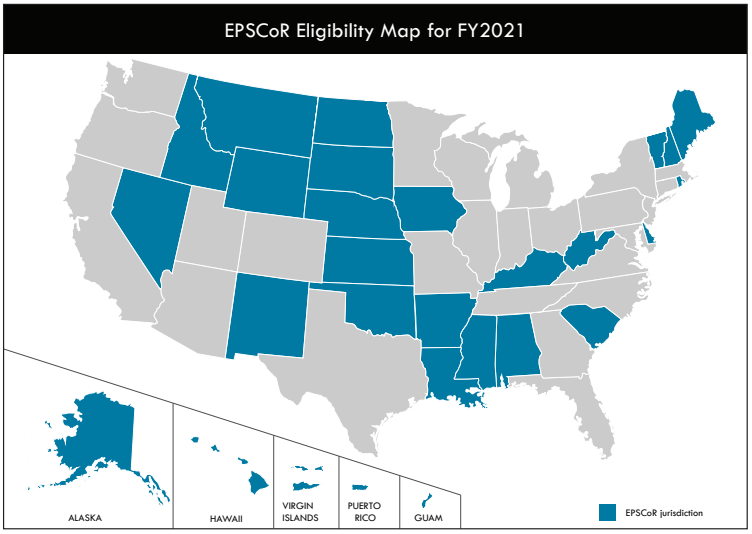
EPSCOR ELIGIBILITY

Eligibility to participate in EPSCoR program activities is based on two primary considerations:

- A jurisdiction's demonstrated commitment to develop its research capacity and to improve the quality of science, technology, engineering, and mathematics (STEM) research conducted at its universities and colleges, and
- A jurisdiction's most recent five-year history of research funds awarded by NSF relative to the Foundation's total research budget for that same period.

Updating eligibility for sustained investments

- Effective starting in FY2021, the eligibility criteria have been updated to allow for continued investments in EPSCoR jurisdictions on the cusp of eligibility. This effort will help to eliminate year-to-year



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eligibility fluctuation and provide a buffer for those jurisdictions on an upward funding trajectory. The new rules determine EPSCoR competition based on a five-year average with an expanded definition of NSF investments with an updated announcement each year on October 1. These rules were designed as best practice for building sustainable STEM research and education capacities.

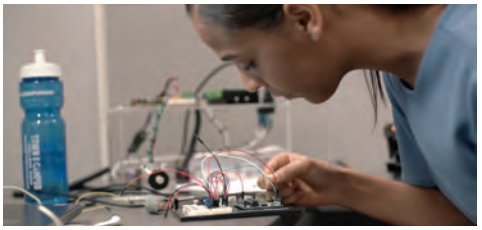
Link to FY2021 Eligibility Table.

EPSCOR HIGHLIGHTS

Alabama
A team of researchers led by Gary Zank at the University of Alabama in Huntsville have invented a novel process to grow nanostructured diamond films. This finding opens the possibility to make electrically conducting diamond film surfaces that could someday lead to breakthroughs in machining or extend the lifetime of existing equipment.

Kansas
Kristin Bowman-James and her team at the University of Kansas are working to understand the multitudes of microbes that naturally inhabit Kansas' soil and water. Understanding the interconnections of this microbiome can aid ecosystem management to increase plant, root, and soil productivity while maintaining water quality of streams and lakes.

New Hampshire
3D-printed skin grafts sound straight out of a science fiction novel but a team of researchers at the University of New Hampshire led by Brad Kinsey is working to bring it into reality. This team has developed biocompatible materials of varying size that can be 3D printed to create a scaffold that stimulates tissue regrowth.



Find information about specific EPSCoR jurisdictions here.

EPSCOR OUTCOMES

Catalyze the development of research capabilities and the creation of new knowledge
- EPSCoR projects supported over **6,500** faculty researchers and **13,200** students over the past five years.

Broaden direct participation of diverse individuals, institutions and organizations
- In the past five years, **486** underrepresented minority graduate and undergraduate students involved in EPSCoR projects attained their degrees.

Establish sustainable STEM education, training, and professional development pathways
- EPSCoR has co-funded **152** Faculty Early Career Development (CAREER) awards in the past five years, helping to spark the research careers of junior faculty.

Effect engagement at the academic, government and private-sector levels
- In the past five years, EPSCoR-supported outreach engaged over **16,000** faculty in academic institutions, more than **27,000** K-12 teachers, and over **475,000** K-12 students.

Impact research, education and economic development
- EPSCoR jurisdictions have received **69** new patents and leveraged over **$1.5 billion** in new awards in the past five years.

Image Credits: Trinka Kensill, National Science Foundation; Walter Dodds; Zachary Sar, Loading Dock NH

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EXPLORING THE DEEP

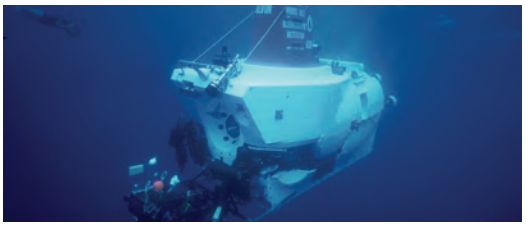
The ocean covers the majority of the Earth's surface, yet more than 80% of it remains unexplored. The National Science Foundation is committed to enhancing our understanding of the ocean, which plays a role in everything from regulating the global climate and supporting life on Earth to global trade and sustaining a prosperous ocean economy. NSF-supported researchers investigate the ocean system, from beneath the sea floor and from the deepest waters to the ocean surface. NSF also **supports ocean research vessels**, deep sea submersibles, autonomous gliders and other ocean-faring vessels that allow researchers to probe the ocean's mysteries in different ways.

FLOATING LABS

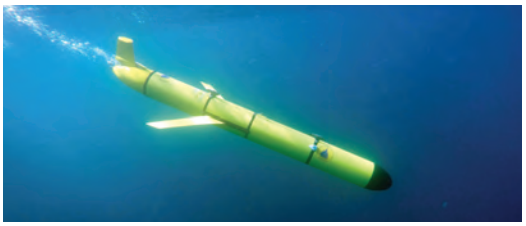
Researchers use different types of vessels to study the ocean system and at different depths.

R/V Sikuliaq
An ice-capable research vessel, the ***Sikuliaq*** allows researchers in the Arctic Ocean to collect sediment samples directly from the seafloor, host remotely operated vehicles and conduct surveys throughout the water column and sea bottom and below using state-of-the-art instrumentation.

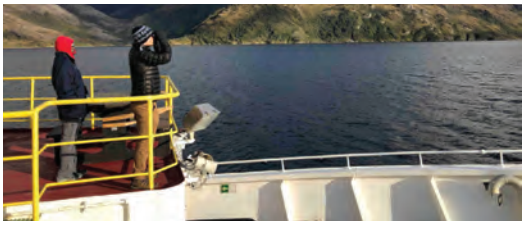
Alvin
The ***Alvin***, a human-occupied submersible, can carry two scientists and a pilot to a depth of nearly 15,000 feet. The *Alvin* allows researchers to observe and collect data for more than two-thirds of the ocean floor. It is one of only five deep-sea research submersibles in the world.



Polar Sentinel
Researchers are developing robotic technologies such as this autonomous underwater glider to be used for long-term, unattended under-ice observation and data collection in vast regions like the Arctic and Antarctic.



JOIDES Resolution
The ***JOIDES Resolution*** is a scientific ocean drilling vessel that recovers core samples and collects measurements from under the ocean floor, giving scientists a glimpse into Earth's geologic and climatic history. It is the primary vessel of the International Ocean Discovery Program, an international marine research collaboration.



FAST FACTS

60
Number of years NSF has been supporting scientific discoveries in the ocean.

18
Number of ships NSF supports in the U.S. Academic Research Fleet.

8,000
Approximate number of scientists the U.S. Academic Research Fleet supports annually.

15,000 ft
Depth at which the submersible *Alvin* can descend below the ocean's surface.

6 miles
The depth at which the *JOIDES Resolution* can drill from the ocean surface into the seafloor.

830
Number of instruments aboard 83 ocean platforms comprising the NSF-funded Ocean Observatories Initiative.

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NSF OCEAN RESEARCH HIGHLIGHTS

Mapping coastlines
NSF-supported marine geology geophysics is helping map new coastlines formed when lava enters the ocean. When lava seeps into the sea, as it did in the 2018 Kilauea eruption, it creates new areas capable of collapse. Mapping these areas helps researchers identify areas vulnerable to undersea landslides and tsunamis.

Understanding a hurricane's aftermath
NSF-supported chemical oceanography research is helping communities manage coastal areas after major hurricanes. When Hurricane Harvey's massive rains fell over a Texas estuary, researchers needed to know how it changed water quality. As they rescued their docks and sensors from the storm, they also collected samples of water and mud to measure how the hurricane affected nutrients and salinity.

Monitoring dead zones
NSF-supported scientists use underwater robotic gliders to collect continuous oceanographic data for weeks to months at a time, without human assistance. Scientists monitoring low-oxygen "dead zones" use gliders to navigate the rugged and tumultuous Pacific coastline. Gliders can take many measurements over long periods of time to identify why these dead zones form. Scientists identified one dead zone the size of Rhode Island!

Next generation ocean scientists
Early career research cruises prepare the next generation of scientists to effectively supervise and organize their own research voyages. Students form about 20% of sea-going science parties.

DID YOU KNOW?

The seafloor and rocks beneath it are humming with microbial life, causing scientists to wonder how long life may have thrived there – and what percent of Earth's biosphere it ultimately makes up.

Image Credits: (In order) IODP; Kim Kenny; WHOI; Richard Camilli/WHOI; JOIDES; Allen.G/Shutterstock.com; Cire notrevo/Shutterstock.com; Andrew Thompson/Caltech; WHOI

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ADVANCING THE AMERICAN BIOECONOMY

A strong American bioeconomy -- the biology-derived infrastructure, innovation, products, technology and data that stimulate economic growth -- is key to future U.S. leadership in biotechnology and global competitiveness. The National Science Foundation (NSF) is driving fundamental research that is advancing future industries; accelerating innovation; improving health; and building a sustainable U.S. economy.

10 BIG IDEAS: UNDERSTANDING THE RULES OF LIFE

It has taken 3.5 billion years of evolutionary innovation to discover diverse solutions to life's toughest challenges, from harnessing quantum phenomena for energy and sensing to finding ways to thrive in even the most extreme environments. With a new suite of investments within the Understanding the Rules of Life Big Idea, NSF is strengthening U.S. leadership in the global bioeconomy through integrative research to understand and manipulate those evolutionary innovations.

Understanding the Rules of Life projects will uncover new tools to describe and manipulate genomes; new means of sensing processes at multiple biological scales simultaneously; and new data and computational approaches, including artificial intelligence, in bioinformatics and modeling to unveil the regulation of complex living systems. These advances vastly improve the ability to understand life's deepest mysteries, while enabling new capabilities to create innovative biotechnologies for societal benefit and economic prosperity.

PROVIDING THE RESOURCES FOR U.S. INNOVATION

NSF invests in both information and instrumentation resources needed to push the frontiers of scientific knowledge and innovation. Notably, growing the bioeconomy increasingly depends on easy access to and manipulation of diverse, distributed and very large datasets. NSF investments in cyberinfrastructure -- including data, software, networking, computing and people -- are improving data capture, storage, security and access, and enabling data processing and analysis at unprecedented scales.

NSF provides resources that are critical to basic scientific and technological innovations across scales and scientific disciplines, including:

- Access to databases, such as via the Protein Data Bank.
- Physical and digital biological collections like iDigBio and living biological collections through the Collections in Support of Biological Research program.
- Computational capacity for research, such as access to Frontera, the world's fastest academic supercomputer; cloud computing; and other emerging computing platforms.
- Center-scale research efforts to protect the growing social and economic benefits of cyber systems and data, through the Secure and Trustworthy Cyberspace program.
- Major facilities, like NSF's National High Magnetic Field Laboratory (MagLab), and major instrumentation, like the newly funded 1.2 gigahertz Nuclear Magnetic Resonance spectrometer, supported by NSF's Mid-Scale Research Infrastructure program.
- Resources to develop and disseminate new research and computational tools, such as the Infrastructure Innovation for Biological Research program.

TRAINING FOR THE INDUSTRIES OF TOMORROW

A strong bioeconomy requires investment in a new generation of scientists trained to pursue questions beyond the traditional scientific disciplines and biological sub-disciplines. NSF is investing in new modes of training -- from K-12 through graduate education and beyond -- that develop skill sets in cutting-edge technologies; promote highly collaborative team science; and foster greater diversity in the workforce, which is essential to advance the frontiers of what is possible through research and development.

For example, through Non-Academic Research for Internships for Graduate Students (INTERN), graduate students develop skills that prepare them for success in a broad range of career paths, from innovation and entrepreneurship to leadership and management. NSF also seeks to broaden participation in STEM fields during precollege years and at the undergraduate level to ensure a diverse pool of future STEM degree holders through funding opportunities like S-STEM, Computer Science for All (CSforAll) and Research Assistantships for High School Students (RAHSS).

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ADVANCING THE BIOECONOMY ACROSS THE RESEARCH AND INNOVATION CONTINUUM

The research and innovation enterprise is a continuum spanning from basic science to translation, product development, commercialization and sustainability. A leader in the U.S. basic science enterprise, NSF also supports research and innovation across this continuum to advance American bioeconomic leadership.

Fundamental Research

Fundamental biological research to discover basic scientific principles -- without necessarily a clear application in view -- is the engine that drives innovation leading to growth across all bioeconomic sectors, including health care, pharmaceuticals, manufacturing and agriculture.

NSF's convergent approach spans disciplines and scales, making critical advances at the frontiers between life and physical sciences. For example, the NSF-Simons Research Centers for Mathematics of Complex Biological Systems bridge biology and mathematics to uncover the complex rules guiding fundamental biological processes, providing valuable insight for the development and successful implementation of future biotechnologies and applications.

Future Manufacturing to Advance the Bioeconomy

NSF investments in fundamental research will unlock scientific and technological advances to drive the future of advanced manufacturing, from new materials, processes and design methods to innovative new machines and technologies. NSF supports biomanufacturing, cybermanufacturing and ecomanufacturing research to enable emergence of new industries that don't exist today; meet growing societal needs and challenges; and reinforce U.S. manufacturing competitiveness far into the future.

For example, for more than three decades, NSF has supported Engineering Research Centers (ERCs) in biomanufacturing, biotechnology and health care. ERCs promote collaboration among researchers in different scientific disciplines and partnerships between industry and universities to produce both technological innovations that strengthen the competitive position of industry and engineering graduates who will be creative innovators in a global economy.

Clearing the Path to Commercialization

NSF helps American researchers advance their discoveries from innovation to application. For example, the NSF Innovation Corps™ (I-Corps™) program prepares scientists and engineers to extend their focus beyond the university laboratory and accelerates the economic and societal benefits of NSF-funded basic research projects that are ready to move toward commercialization. I-Corps links NSF grantees with established entrepreneurs, helping them transform their ideas into marketable products and services. The Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) programs similarly help to commercialize high-risk, high-impact technologies, awarding $200 million annually to startups and small businesses across the country.

AMPLIFYING INVESTMENTS THROUGH PARTNERSHIP

Collaboration with other government agencies, industry and private foundations is essential to the development of a strong American bioeconomy. NSF leverages partnerships with key stakeholders across sectors in several ways. For example, NSF program officers act as liaisons to the Manufacturing USA Institutes, which consist of agency, industry and academic partners working to bridge the gap between academic and industry practice. NSF also invites proposals for basic research that have the potential to translate to the institutes or to use infrastructure at the institutes. NSF also catalyzes partnerships to leverage expertise, inspire research questions, drive innovation and provide critical workforce development opportunities, such as through the Industry-University Cooperative Research Centers (IUCRC) program and Grant Opportunities for Academic Liaison with Industry (GOALI) proposals.

ENSURING A SOCIALLY RESPONSIBLE BIOECONOMY

To better accelerate biotechnology product adoption and socially responsible use, NSF supports research on ethical questions and impacts arising from innovative new technologies and their integration into society. For example:

- Societal and Ethical Impacts of Innovation: NSF's Science and Technology Studies program and Ethical and Responsible Research program fund workshops and studies investing in a range of topics, including societal and social justice issues in synthetic biology; ethics and responsible innovation in genome engineering; and possible governance challenges that may arise in the current era of rapid scientific, technological and economic change.
- Predicting Future Risks and Impacts: NSF investment in ecoforecasting improves the ability to predict environmental consequences of major advances related to the bioeconomy. These advancements in predictive modeling capabilities are critical to measuring risks related to genomic manipulation of organisms; reducing uncertainty in developing regulations around new biotechnologies; and to aspects of biosecurity such as identifying and predicting the impact of biothreats.

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Videos about NSF for your use

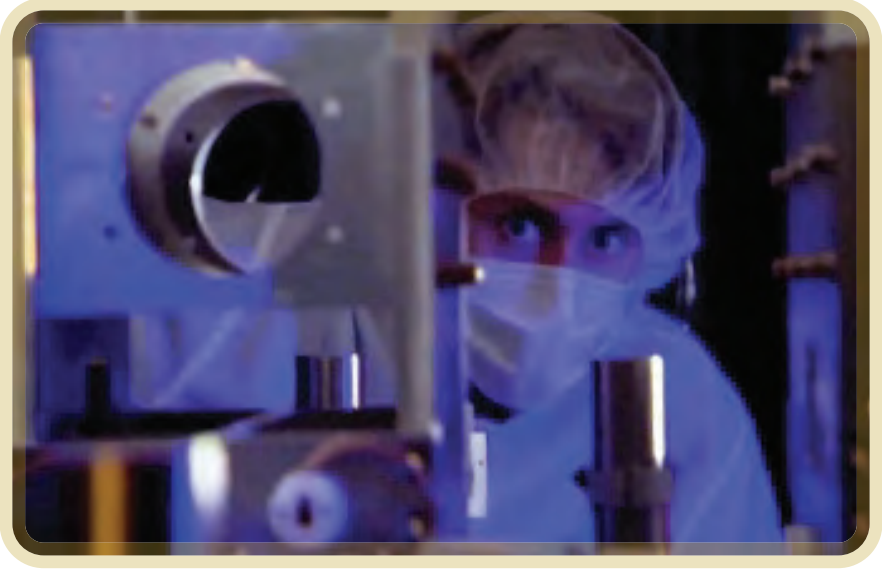
To download, click the play button on your selected video. When controls appear at the bottom of the video window, click on the downward arrow.

NSF's 10 Big Ideas

Ten research and process "big ideas" that are driving important aspects of NSF's long-term research agenda, pushing forward the frontiers of U.S. science and engineering research, and lead-ing to new discoveries and innovations. Runtime: 4:00. **View online**

Who is NSF?

A brief, inspiring video about NSF, designed for use in presentations, events and more. Runtime: 1:45. **View online**



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NSF: Everywhere in your world

A fast-paced look at the impact of NSF-funded research in our daily lives. Runtime: 1:29.

View online

How NSF helps make and keep America a global leader

A look at how NSF's support of early stage, basic research helps enable discoveries and innovations that keep America a global leader. Runtime: 2:30. **View online**

The importance of NSF Funding

WPast and present NSF grantees attest to the importance of NSF support to their research and to innovation. Runtime: 1:18. **View online**

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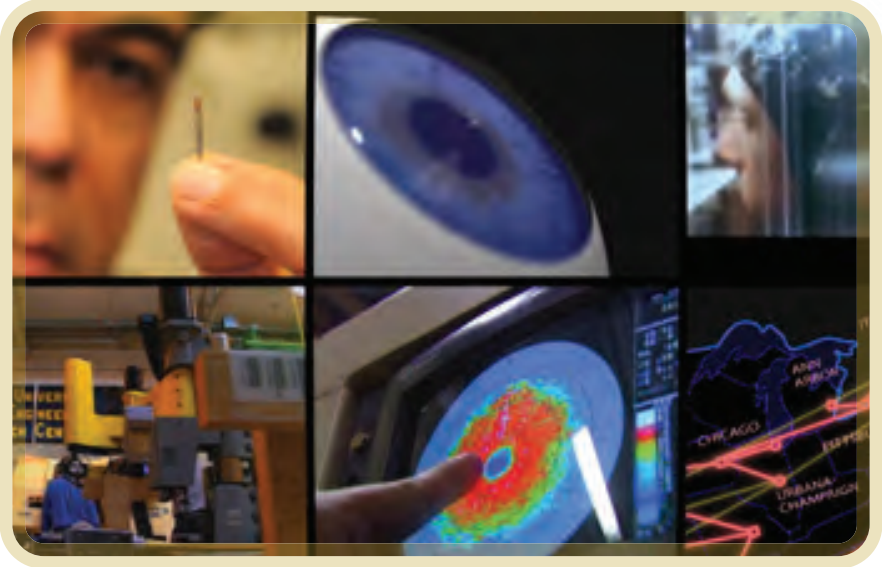
Why NSF is vital to our nation's defense

William McRaven, University of Texas System Chancellor and a retired four-star Navy admiral, describes NSF's critical importance to the Department of Defense and our nation's security. McRaven is former commander of the U.S. Special Operations Command and is considered one of the country's top foreign policy experts. Runtime: 0:55. **View online**

How NSF helps drive our nation's economy

A brief look at how NSF-supported fundamental research helps drive our nation's economy, enhance our security, advance our knowledge to sustain global leadership, and transform our future. Runtime: 1:27. View online or download video Extended version with additional information about the agency's mission, budget and merit review process. Runtime: 2:25. **View online**



NSF INCLUDES: Empowering diversity in STEM

NSF is working to increase female and minority representation in STEM education and careers. NSF INCLUDES supports programs, networks and partnerships that empower women and minority students to pursue STEM education and careers, while broadening access to a greater range of opportunities. Runtime: 4:23. **View**

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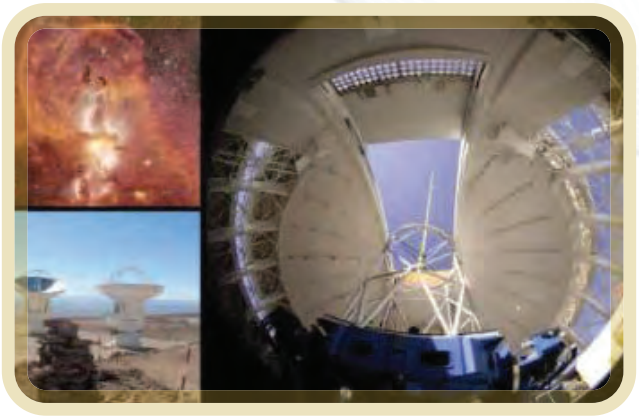
Foundation for Innovation

How NSF support for fundamental research is critical to discovery, innovation and economic growth. Runtime: 4:17. **View online**

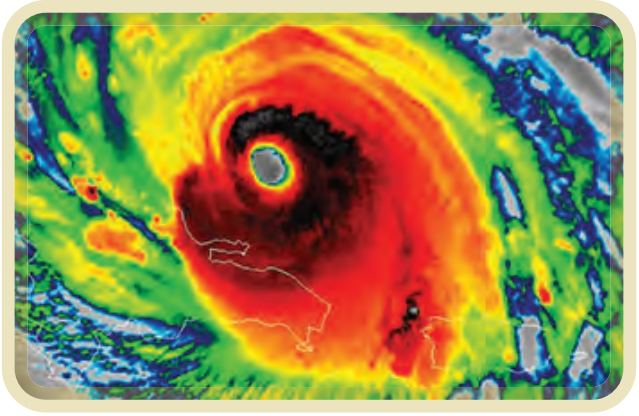


The value of social, behavioral and economic sciences

How NSF's SBE directorate supports a wide range of research in the social, behavioral and economic sciences. This research helps improve our nation's security, bolster our economy, and maintain our global leadership. Runtime: 2:51. **View online**

Social Science: Essential when the storm strikes

How NSF-funded research in the social, behavioral and economic sciences improves hurricane risk communication, evacuation and recovery processes. Runtime: 1:17. **View online**



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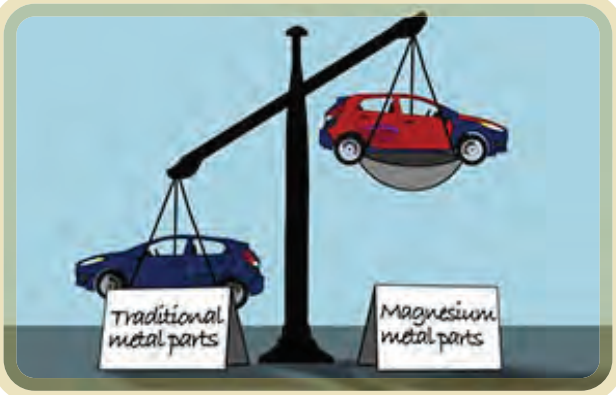
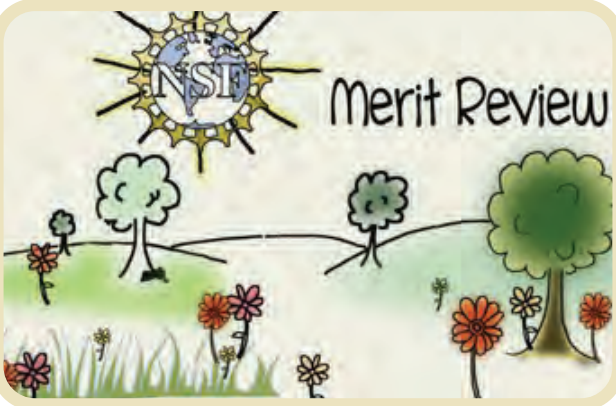
More Distance, Less Fuel

One example of how NSF funding holds the promise of significant economic impact and knowledge to sustain global leadership. Runtime: 1:22. **View online**



NSF's Merit Review Process

How NSF determines which research has the greatest potential and would be the most impactful investment of taxpayer dollars. Runtime: 6:16. **View online**



NSF Proposal Review Panels

What really happens in a proposal review panel? Audiences will get a good sense from this mock review session as panelists discuss the strengths and weaknesses of a CAREER Award proposal. Runtime: 6:16. **View online**

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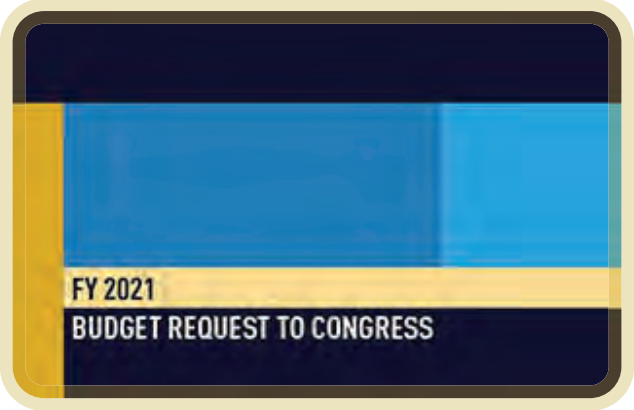
COVID-19 Response Funding Updates

View updates

FY 2021 Budget Request to Congress

NSF Fiscal Year 2021 budget to advance innovation, infrastructure **View previous budget requests**



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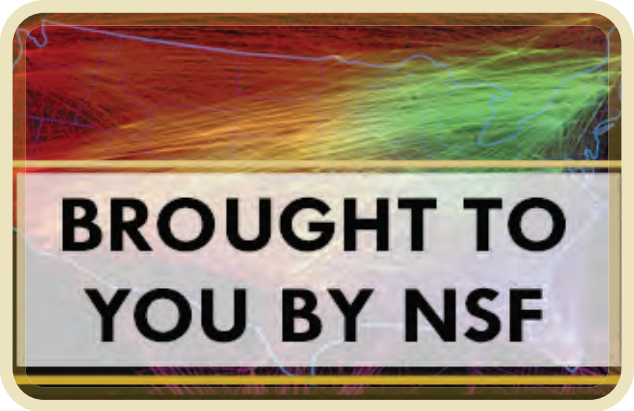
Special Report **Download report**



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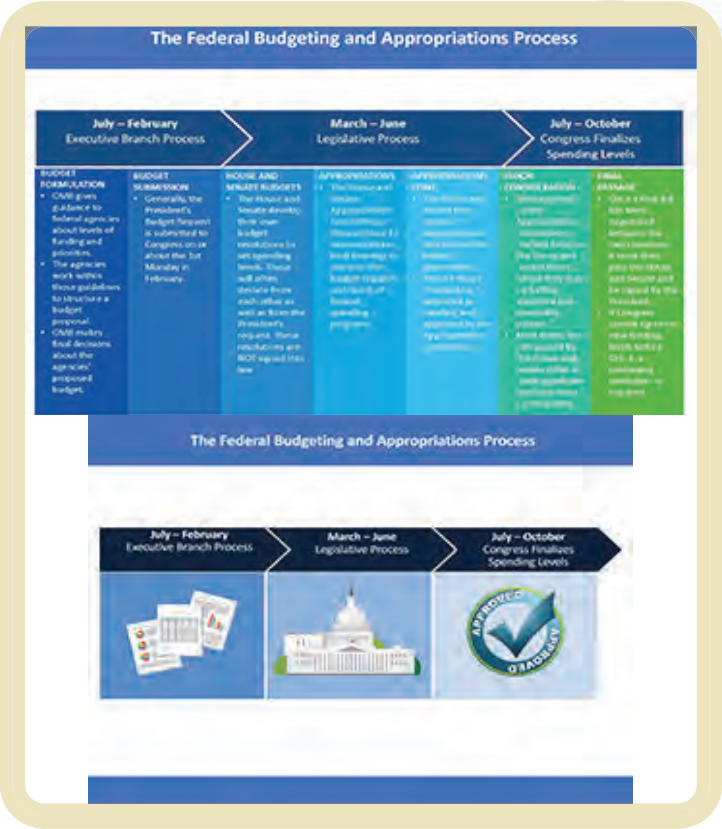
The Federal Budgeting and Appropriations Process

Infographics showing the Federal budgeting and appropriations process, divided in three segments.

Download chart 1 (PDF, 1.0MB)

Download image chart (PDF, 1.0MB)

Text version (Accessible)



Transforming the World Through Science (2nd Edition)

This is the fiscal year 2019 version of "Transforming the World Through Science (2nd Edition)."

Download (PDF, 10MB)

Download the FY 2018 edition (PDF, 4.6MB)

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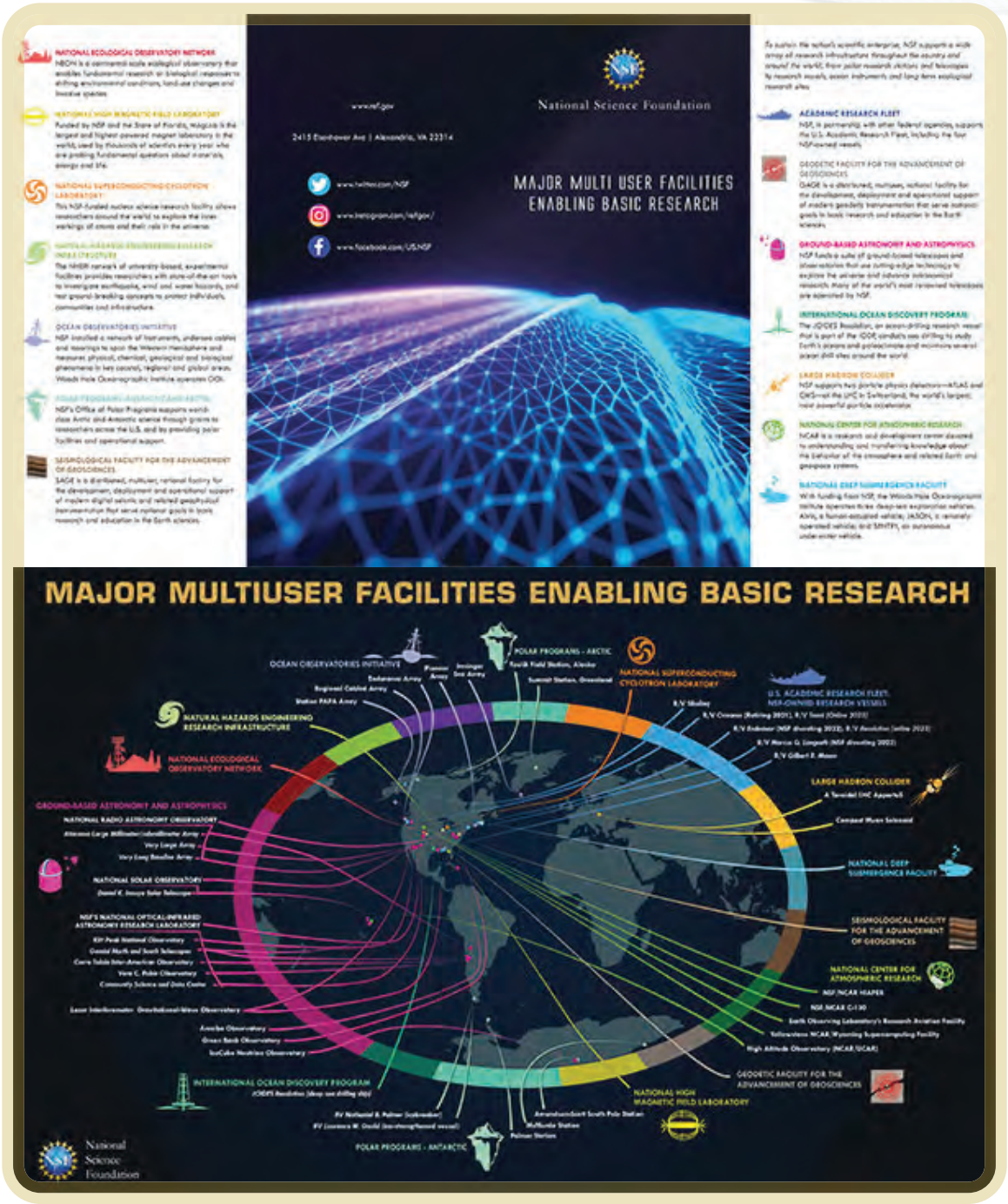
Major Multi User Facilities Enabling Basic Research

To sustain the nation's scientific enterprise, NSF supports a wide array of research infrastructure throughout the country and around the world, from polar research stations and telescopes to research vessels, ocean instruments and long-term ecological research sites.

Download brochure (PDF, 10,435KB)

Download poster (PDF, 4,219KB)



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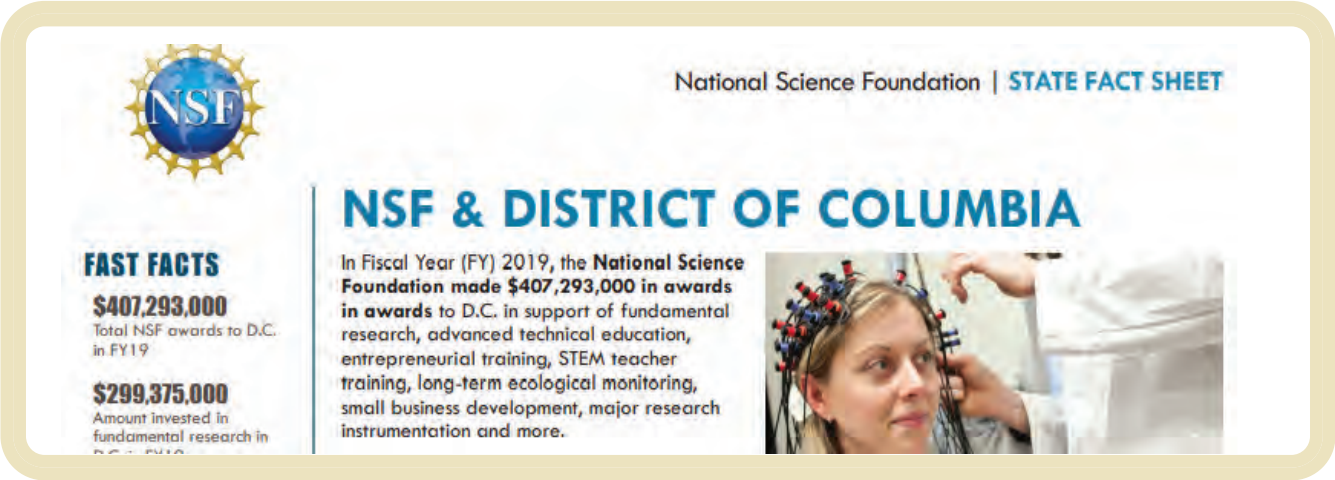
10 Big Ideas for Future NSF Investments

As we look ahead to the coming decades, we must envision bold questions that will drive NSF'slong-term research agenda -- questions that will ensure future generations continue to reap the benefits of fundamental science and engineering research. This is the reason behind these 10 "big ideas." Special Report **Download report**

NSF IN YOUR STATE

NSF's Budget Internet Information System allows you to view the number of NSF awards made to your state, for any given fiscal year. You can also see the number of awards, and the individual award abstracts, for specific institutions in your state.

NSF "State Fact Sheets" provide information on NSF-funded discoveries, STEM workforce development, student support, research facilities, and science and engineering employment data by state. Click on the individual State Fact Sheets to learn about how NSF supports discoveries and discoverers in your state. **View state fact sheets**



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Presidential Transition Documentation - 5 year trend analysis

Data for each FY is as of the end of the FY (9/30/xxxx) and excludes NSB and OIG

		FY16	FY17	FY18	FY19	FY20
	Headcount	1,531	1,535	1,548	1,575	1,592
Appointment Type	PERMANENT	1,104	1,144	1,152	1,165	1,180
		72%	75%	74%	74%	74%
	TEMP	168	141	137	149	141
		11%	9%	9%	9%	9%
	VSEE	39	40	46	38	39
		3%	3%	3%	2%	2%
	IPA	175	162	177	182	195
		11%	11%	11%	12%	12%
	OTHER	45	48	36	41	37
		3%	3%	2%	3%	2%
Education Level	1. HIGH SCHOOL, SOME COLLEGE, AND ASSOCIATES	296	292	280	293	279
		19%	19%	18%	19%	18%
	2. BACHELORS DEGREE	297	301	301	287	279
		19%	20%	19%	18%	18%
	3. MASTERS, POST MASTERS, AND PROFESSIONAL	274	291	298	301	318
		18%	19%	19%	19%	20%
	4. PHD AND POST DOCTORATE	662	651	669	688	714
		43%	42%	43%	44%	45%
	NOT REPORTED	2			6	2
		0%			0%	0%
Pay Plan Average Salary (excludes IPAs)	GS	98,528	101,979	106,259	108,281	113,841
	AD	153,401	160,682	164,900	168,708	174,451
	ES	179,000	180,541	182,264	182,379	188,878

		2015	2016	2017	2018	2019
FEVS Index-level results	OPM New Inclusion Quotient ("New IQ")	63%	65%	68%	69%	70%
	OPM Global Satisfaction Index	67%	70%	74%	74%	76%
	OPM Employee Engagement Index	69%	73%	75%	76%	77%
	NSF Career Development Index	60%	62%	65%	66%	67%
	NSF Workload Index	53%	53%	55%	59%	58%
	NSF Performance Management & Recognition Index	61%	63%	64%	65%	66%

		FY16	FY17	FY18	FY19	FY20
Gender	Female	894	893	904	909	904
		58%	58%	58%	58%	57%
	Male	637	642	644	666	688
		42%	42%	42%	42%	43%
Veteran Status (excludes IPAs)	Not a Veteran	1,131	1,155	1,163	1,188	1,208
		83%	84%	85%	85%	86%
	Veteran	225	218	208	205	189
		17%	16%	15%	15%	14%
Disability Status (excludes IPAs)	Disabled	88	62	62	83	79
		6%	5%	5%	6%	6%
	Not Disabled	1,208	1,219	1,214	1,196	1,192
		89%	89%	89%	86%	85%
	Not Reported	60	92	95	114	126
		4%	7%	7%	8%	9%
Race & National Origin	AMERICAN INDIAN or ALASKA NATIVE	11	14	15	13	13
		1%	1%	1%	1%	1%
	ASIAN	157	152	172	174	180
		10%	10%	11%	11%	11%
	BLACK or AFRICAN AMERICAN	399	408	410	405	409
		26%	27%	27%	26%	26%
	HISPANIC or LATINO	47	54	58	65	74
		3%	4%	4%	4%	5%
	None	3	4	4	4	5
		0%	0%	0%	0%	0%
	WHITE	911	900	886	911	909
		60%	59%	57%	58%	57%

2020 NSF Workforce and Employee Engagement

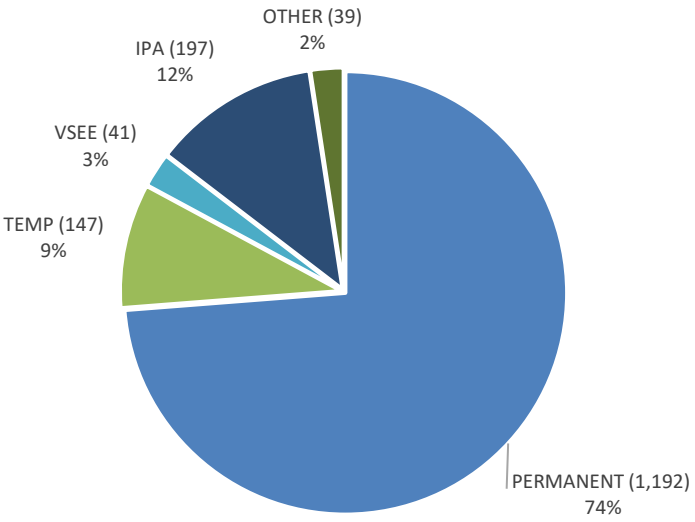
NSF Workforce at a Glance

- NSF is divided into twelve component organizations:
  - Seven directorates that support science and engineering research and education (Biological Sciences; Computer and Information Science and Engineering; Engineering; Geosciences; Education and Human Resources; Mathematical and Physical Sciences; and Social, Behavioral and Economic Sciences)
  - Two administrative offices (Office of Budget, Finance, and Award Management and Office of Information and Resource Management)
  - The Office of the Director (OD), which houses two programmatic offices – Office of International Science and Engineering (OISE) and Office of Integrative Activities (OIA) – as well as the Office of Legislative & Public Affairs (OLPA), Office of Diversity & Inclusion (ODI), and Office of General Counsel (OGC).
  - Two independent offices (Office of the Inspector General and the National Science Board Office).
- NSF has a total staff of 1,616 currently[1] (excluding OIG and NSB/NSBO):
  - 1,192 permanent federal employees on General Schedule (GS), Administratively Determined (AD), and Senior Executive Services (SES) appointments.
  - 424 non-permanent staff consisting of 197 staff members serving on the IPA (Intergovernmental Personnel Act) assignments, 41 in the VSEE (Visiting Scientist, Engineer, and Educator) program, 147 temporary staff, and 39 other appointments
- 84 employees are in SES positions; 30 are in executive-level IPA assignments
- There are 22 National Science Board (NSB) members (of a total 24 positions) appointed by the President.
- The NSF Director and NSF Deputy Director are Presidential appointments.
- 65% of employees have advanced degrees (masters, professional, doctorate, or post-doctorate) and 18% have bachelor's degrees; 47% work in STEM-related positions
- 57% of employees are White; 26% are African American/Black; 11% are Asian American/Asian; 5% are Hispanic or Latino; 1% are American Indian or Alaska Native
- 57% of employees are female
- 13% of employees have veteran status (excluding IPAs)
- 6% of employees reported having a disability (excluding IPAs)
- 17% of employees are currently eligible for retirement (as of the end of FY20)
- The average GS salary is $99,833; the average AD salary is $170,403; the average SES salary is $184,581
- In the wake of COVID-19, 100% of NSF staff have been approved to fully telework (starting March 16).

[1] NSF workforce counts as of 11/30/20.

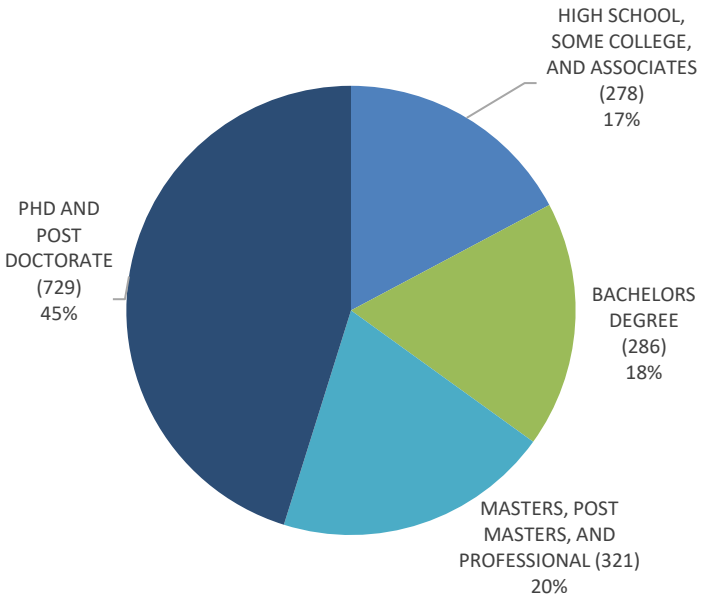
Appointment Type

NSF Staff (Excludes NSB/NSBO & OIG)



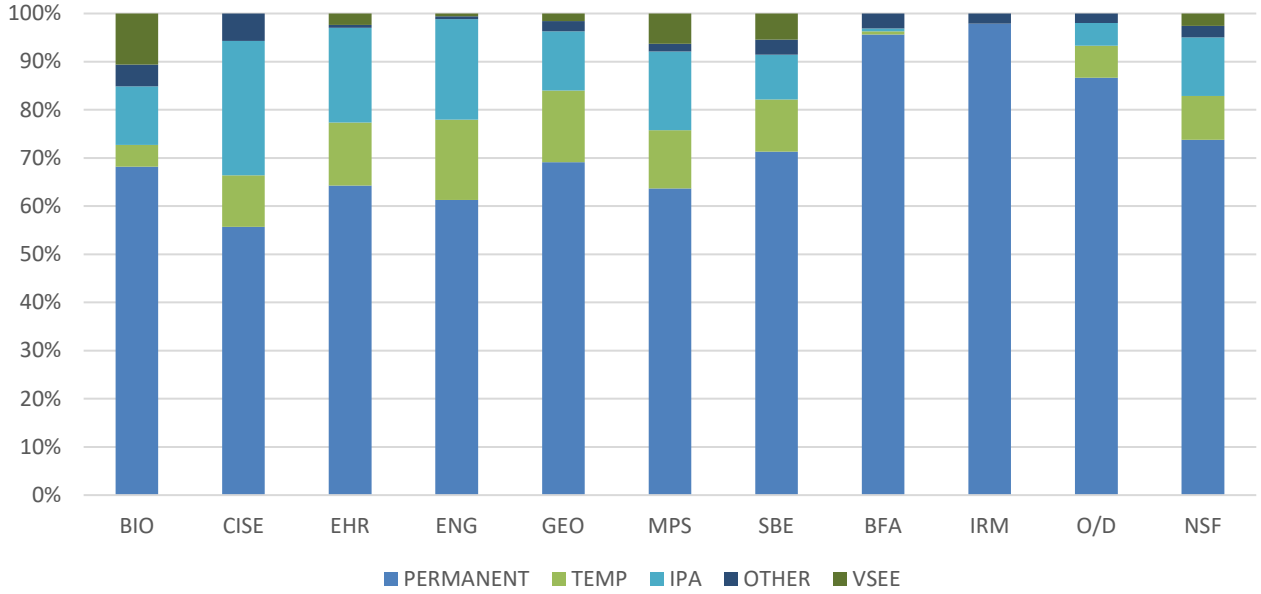
Education Level

NSF Staff (Excludes NSB/NSBO & OIG)



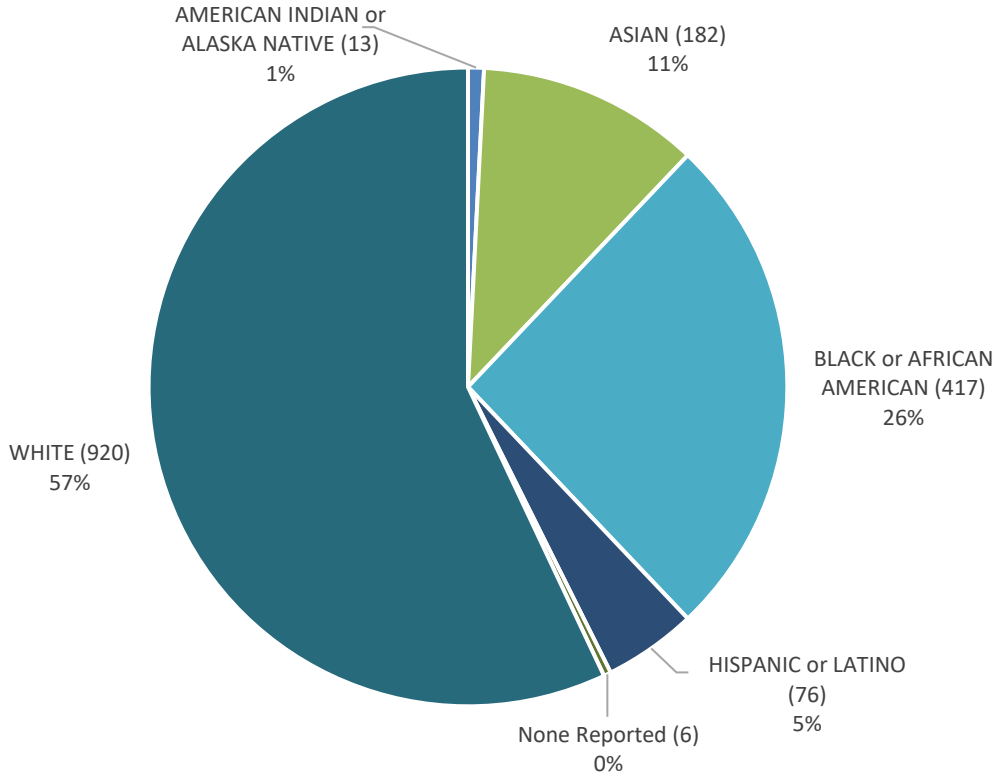
Appointment Type by Directorate/Office

NSF Staff (Excludes NSB/NSBO & OIG)



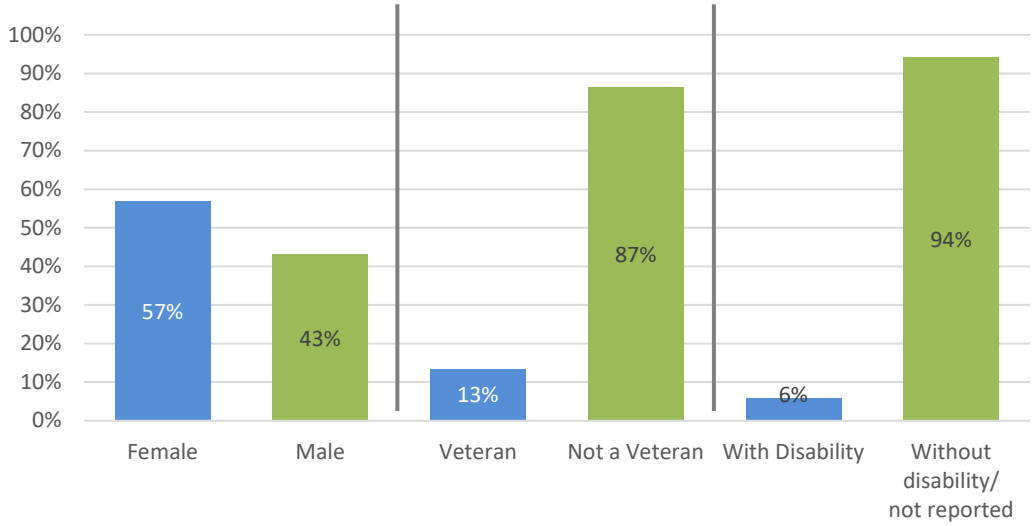
Race & National Origin

NSF Staff (Excludes NSB/NSBO & OIG)



Gender, Veteran Status, & Disability Status

NSF Staff (Excludes NSB/NSBO & OIG)



Note: Counts are as of 11/30/20. Veteran and disability status are not available for IPA appointments.

NSF Employee Engagement

NSF has consistently had high employee engagement scores from the Federal Employee Viewpoint Survey (FEVS). Recent improvements in employee engagement scores are attributable to concerted efforts to make NSF one of the best places to work in the Federal government.

Highlights of NSF's 2019 FEVS results include:

- NSF had a 71% response rate, 28 percentage points higher than the government average.
- NSF ranks third for Employee Engagement, third for Global Satisfaction, and third for New IQ among medium-sized agencies
- 2019 Employee Engagement Index score: 77
    - NSF's 2019 score is up eight points since 2015; up one point from 2018
    - NSF's 2019 score is nine points higher than the government-wide average
- 2019 Global Satisfaction Index score: 76
    - NSF's 2019 score is up nine points since 2015; up two points from 2018
    - NSF's 2019 score is eleven points higher than the government-wide average
- 2019 NEW IQ Index score: 70
    - NSF's 2019 score is up seven points since 2015; up one point from 2018
    - NSF's 2019 score is eight points higher than the government-wide average
- 2019 Career Development Index (index created by NSF): 67
    - NSF's 2019 score is up seven points since 2015; up one point from 2018
    - NSF's 2019 score is eight points higher than the government-wide average
- 2019 Performance Management & Recognition Index (index created by NSF): 66
    - NSF's 2019 score is up five points since 2015; up one point from 2018
    - NSF's 2019 score is eight points higher than the government-wide average
- 2019 Workload Index (index created by NSF): 58
    - NSF's 2019 score is up five points since 2015; down one point from 2018
    - NSF's 2019 score is four points higher than the government-wide average

Link to 2019 FEVS Government-wide Management Report: https://www.fedview.opm.gov/

**2020 FEVS Reports will be made available in January 2021*

NSF Contributions to Climate Research

as one of the 13 members of the US Global Change Research Program (USGCRP)

Summary: NSF supports a broad range of climate research across disciplines and the development of the STEM workforce needed to understand and mitigate the consequences of climate change. These investments, totaling $241 M in FY 2019,[1] advance the frontiers of knowledge, provide state-of-the-art instrumentation and facilities, develop new analytical methods, and enable cross-disciplinary collaborations. NSF also supports the development of educational resources needed for an informed citizenry while its research and fellowship programs cultivate a diverse, highly trained workforce. Major areas of support include:

- Research and related activities to advance the fundamental understanding of physical, chemical, biological, and human systems, and the interactions among them, including the critical controls the carbon cycle plays in global climate change.
- Interdisciplinary approaches to studying Earth system processes and the consequences of change, including how humans respond to changing environments and the impacts on ecosystems and the essential services they provide.
- The development and enhancement of qualitative and quantitative modeling to improve understanding of integrated Earth system processes and to advance predictive capabilities.
- Fundamental research on the processes used by organizations and decision makers to identify and evaluate policies for mitigation, adaptation, and other responses to the challenge of a changing and variable environment.
- Research instrumentation networks capable of long-term, continuous, and consistent records of environmental conditions that function as part of a global network of climate observing systems in conjunction with those maintained by other agencies.

NSF regularly collaborates with other USGCRP agencies to provide support for a range of multi-disciplinary research projects and is actively engaged in several international partnerships. NSF investments are also advancing the fundamental research needed for the development of critical clean energy technologies and infrastructure, from the nanoscale to grid-scale.

Current Plans and/or Issues for First 100 Days:

- Through April 2021, additional climate science-related FY 2021 solicitations will be released and many solicitations already accepting proposals will begin the review process for awards.
- The operation of many NSF-supported facilities important to climate science, including those supporting Polar Programs, have been interrupted due to local COVID-19 conditions, with significant impacts on data collection both domestically and internationally.

Key Interagency, International, and Partnership Activities:

- NSF actively participates in the National Windstorm Impact Reduction Program, the NSTC Interagency Arctic Research Subcommittee (IARPC), and the NSTC subcommittees on Global Change Research, Ocean Science (co-chair), U.S. Group on Earth Observations, Resilience S&T, International S&T (co-chair), R&D Infrastructure (co-chair), and Biological Sciences (co-chair).

[1] https://www.nsf.gov/about/budget/fy2021/pdf/12_fy2021.pdf. All budget totals provided are for FY 2019, the most current year for which actual investments are publicly available.

- NSF coordinates research under the USGCRP in three areas: Science of Adaptation and Science to Inform Adaptation Decisions; Multidisciplinary Earth and Human System Understanding; and Integrated Modeling.
- NSF is the Principal US member of the Belmont Forum, a partnership of funding organizations, international science councils, and regional consortia committed to the advancement of transdisciplinary research providing knowledge for understanding, mitigating, and adapting to global environmental change.
- NSF plays a key role in coordinating Federal research activities in the Arctic and is designated as the lead agency for managing Federal investments in Antarctic research. Through these roles, NSF supports a number of projects with significant international collaborations, through the programs listed below, notably including the international MOSAiC research expedition studying the processes that couple the Arctic atmosphere, sea ice, ocean, and ecosystem; and the International Thwaites Glacier Collaboration investigating one of the most unstable glaciers in Antarctica.

Targeted Programs and Facilities:

National Center for Atmospheric Research (NCAR). NCAR, an FFRDC sponsored by NSF, is a focal point for research in the field of atmospheric sciences. The facilities at NCAR serve the entire atmospheric sciences research community and part of the ocean sciences community studying large-scale atmospheric and ocean dynamics that contribute to an understanding of climate processes and global change; global and regional atmospheric chemistry including geochemical and biogeochemical cycles; the variable nature of the Sun and the physics of the corona; the physics of clouds, thunderstorms, precipitation formation, and the interactions and effects on larger-scale weather; and the examination of human society's impact on and response to global environmental change. (GEO, $152 M[2])

National Ecological Observatory Network (NEON), the first continental-scale platform for ecological research, is gathering long-term data to enable fundamental research on biological responses to shifting environmental conditions, climate change, land-use changes, and invasive species. (BIO, $74 M)

Long-Term Ecological Research (LTER) is significantly advancing understanding of the long-term dynamics of populations, communities, and ecosystems in a diversity of habitats including coral reefs, arid grasslands, estuaries, lakes, prairies, forests, alpine and Arctic tundra, the Antarctic, urban areas, and agroecosystems. LTER supports a coordinated network of 28 field sites that focus on understanding ecological phenomena that occur over long temporal and broad spatial scales; creating a legacy of well-designed, long-term ecological experiments; and providing information to identify and to address environmental challenges. (BIO, GEO, SBE, $33 M)

Coastlines and People (CoPe) is supporting diverse, innovative, multi-institution projects investigating critically important interactions between coastlines and people that is integrated with broadening participation goals. CoPe Research Hubs are structured using a convergent science approach, at the nexus between coastal sustainability, human dimensions, and coastal processes to transform understanding of interactions among natural, human-built, and social systems in coastal, populated environments, all of which are significantly affected by climate change. (GEO, $6 M)

[2]FY 2019 Actual obligations include $17.80 million for continuity of operations into FY 2020 as well as $30.94 million in funds reobligated from prior award.

Critical Zone Observatories and the associated Collaborative Network aims to understand the Earth's surface from tree canopy to bedrock—the realm where water, air, soil, rock and life interact. Through a network of nine US observatories from Puerto Rico to California, NSF supports a community of researchers working to understand how components of the Critical Zone interact, shape Earth's surface, and support life, including how such zones recover from disturbances such as fire and flooding and how coastal critical zones are changing due to rising sea levels. (GEO)

Critical Aspects of Sustainability (CAS) supports fundamental research aimed at improving the sustainability of resources through the design, manufacture, and use of efficient, effective, safe and more environmentally benign products and processes. It also supports research to better understand how communication between the environment and living systems can confer resilience and/or could foster adaptability of living systems subject to changing environments. (MPS)

Sustainable Regional Systems Research Networks (SRS RNs) will develop and support interdisciplinary, multi-organizational teams of investigators and stakeholders working collaboratively to produce cutting-edge convergent research, education, and outreach that addresses grand challenges in sustainable regional systems. Sustainable regional systems are connected urban and rural systems that are transforming their structures and processes collaboratively with the goal of measurably and equitably advancing the well-being of people and the planet. (NSF-wide)

Navigating the New Arctic (NNA)—one of NSF's "Big Ideas"—NNA seeks innovations in Arctic observational networks and fundamental convergence research that address the intersection of natural, social, and built systems to inform decisions regarding the economy, security, and resilience of the Arctic region. It is supporting initiatives empowering new research communities; diversifying the next generation of Arctic researchers; integrating the co-production of knowledge; and engaging partnerships, particularly among international stakeholders. (NSF-wide, $44 M)

Core and other Related Programs and Facilities:

Mid-scale Research Infrastructure (Mid-scale RI-1 and Mid-scale RI-2) is transforming individual scientific and engineering research fields with new infrastructure ($6 M to $100 M), while simultaneously training early-career researchers in the development, design, construction, and use of cutting-edge infra-structure. Infrastructure projects under construction include a state-of-the-art, aircraft-based airborne laboratory for atmospheric research and a global ocean biogeochemistry array that will release a network of 500 robotic floats into the ocean to collect chemistry and biology data to a depth of 2 km to improve and expand monitoring of the ocean's health, including ocean life and fisheries. (NSF-wide)

National Artificial Intelligence (AI) Research Institutes focus on the advancement of multidisciplinary, multi-stakeholder research on large-scale, long-time-horizon challenges in AI research to accelerate the development of transformational technologies, including the new AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography. (BIO, CISE, EHR, ENG, GEO, MPS, SBE)

The NSF-funded National High Magnetic Field Laboratory (MagLab) is a global destination for groundbreaking research across scientific disciplines, leveraging the power of high magnetic fields to overcome energy challenges, among other focus areas. Researchers use MagLab's Ion Cyclotron Resonance Facility to better understand existing energy sources and to explore new ones, including those from natural alternatives to fossil fuel and cleaner ways to use lower-quality crude oil. (MPS)

Ecosystem Studies (ES) supports investigations of ecosystem structure and function across a diversity of spatial and temporal (including paleo) scales to advance understanding of: 1) material and energy fluxes and transformations within and among ecosystems; 2) roles and relationships of ecosystem components in whole-system structure and function; 3) ecosystem dynamics, resilience, and trajectories of ecosystem change through time; and 4) linkages among ecosystems in space, time, and across spatial and temporal scales. (BIO)

Long Term Research in Environmental Biology (LTREB) supports the generation of extended time series of data to address important questions in evolution, ecology, and ecosystem science. Research areas include, but are not limited to, the effects of natural selection on populations, communities, or ecosystems; population or community dynamics for organisms that have extended life spans and long turnover times; feedbacks between ecological and evolutionary processes; pools of materials such as nutrients in soils that turn over at intermediate to longer time scales; and external forcing functions such as climatic cycles that operate over long return intervals. (BIO)

NSF's Advisory Committee for ERE (AC-ERE) provides advice recommendations and oversight concerning support for the NSF's environmental research and education portfolio, among other functions. The Committee has recently reported on the importance of sustainability for urban areas, which contribute to more than 70% of global greenhouse gas emissions, articulating a vision and a compelling research agenda for developing the next generation of sustainable urban systems science (which informed the SRS RNs program discussed above). (NSF-wide)

Macrosystems Biology and NEON-Enabled Science (MSB-NES) supports quantitative, interdisciplinary, systems-oriented research on biosphere processes and their complex interactions with climate, land use, and changes in species distribution at regional to continental scales as well as training activities to broaden participation of researchers in this field. (BIO)

Environmental Chemical Sciences (ECS) supports experimental and computational research on the fundamental chemistry of processes in the environment. (MPS)

Chemical Catalysis (CAT) supports experimental and computational research directed towards the fundamental understanding of the chemistry of catalytic processes, including processes fundamental to understanding clean energy, carbon cycling, approaches for carbon sequestration, and for harnessing visible light and electricity to drive chemistry. (MPS)

Centers for Chemical Innovation (CCI) supports research centers focused on major, long-term fundamental chemical research challenges, including the Center for Aerosol Impacts on Chemistry of the Environment (CAICE). CAICE focuses on improving the understanding of how aerosol particles impact the environment, air quality, and climate. Through strong international and national collaborations, it also provides an innovative education program to future workforce development tackling complex environmental problems related to the ocean, atmosphere, and climate. (MPS)

The GEO Office of Polar Programs (OPP) supports world-class arctic and antarctic science through research grants and by providing polar facilities and operational support. Arctic Research Opportunities support research advances in fundamental, process, and/or systems-level understanding of the Arctic's rapidly changing natural environment, social and cultural systems, and, where appropriate, to improve our capacity to project future change. Research also focuses on the Arctic region and its connectivity with lower latitudes. Antarctic Research supports cutting-edge research to expand fundamental

knowledge of Antarctic systems, biota, and processes; improve understanding of interactions among the Antarctic region and global systems; and utilize the unique characteristics of the Antarctic region as a science observing platform. The U.S. Antarctic Program supports scientific research in Antarctica and the Southern Ocean. At both poles, critical research is supported to understand the physical processes controlling land ice loss and its contribution to global sea-level rise. (GEO)

Core programs of the GEO Division of Ocean Science support research, infrastructure, and education to advance understanding of all aspects of the global oceans and ocean basins, including their interactions with people and the integrated Earth system. These activities provide knowledge critical to addressing many of our nation's most pressing challenges involving earth processes, including climate change—for example, by improving the understanding of ocean water mass temperature changes that contribute to global sea level rise or that affect the health of commercial fisheries. (GEO)

Core programs in the GEO Division of Earth Sciences support research geared toward improving the understanding of the structure, composition, and evolution of the Earth, the life it supports, and the processes that govern the formation and behavior of the Earth's materials. The results of this research will create a better understanding of the Earth's changing environments, and the natural distribution of its mineral, water, biota, and energy resources and provide methods for predicting and mitigating the effects of geologic hazards such as earthquakes, volcanic eruptions, floods, landslides. (GEO)

Signals in the Soil supports convergent research to transform existing capabilities in understanding dynamic soil processes, including soil formation, through advances in sensor systems and modeling. (BIO, CISE, ENG, GEO, MPS)

Human-Environment and Geographical Sciences (HEGS) supports basic scientific research about the nature, causes, and/or consequences of the spatial distribution of human activity and/or environmental processes across a range of scales. (SBE)

Decision, Risk and Management Sciences (DRMS) supports research on improving decision making by individuals, groups, organizations, and society with particular emphasis on improving responses in disaster contexts. (SBE)

Humans, Disasters, and the Built Environment (HDBE) supports fundamental, multidisciplinary research on the interactions between humans and the built environment within and among communities exposed to natural, technological, and other types of hazards and disasters. (ENG)

Dynamics of Integrated Socio-Environmental System (DISES) supports research projects that advance basic scientific understanding of integrated socio-environmental systems and the complex interactions within and among the environmental and human components of such a system. (BIO, GEO, SBE)

Computer and Information Science and Engineering (CISE) Core supports research and education projects that develop new knowledge in all aspects of computing, communications, and information science and engineering, as well as advanced cyberinfrastructure. CISE core includes support for areas such as computer networking, graphics, and visualization that advance telepresence and distributed collaboration and therefore offset the need to travel, leading to carbon footprint savings. (CISE)

NSF Support for an Equitable and Inclusive COVID-19 Recovery

for the Academic Research Community

Summary: The National Science Foundation (NSF) plays a major role in supporting the nation's academic research enterprise and the development of the STEM workforce, making it a critical partner in the recovery process. NSF does not have the resources to return the entire enterprise to pre-pandemic conditions, which means that its response to this crisis must be both strategic and creative. The enormous stress that the pandemic has put on the STEM education and research enterprise is revealing where the system is vulnerable and where it is resilient. If additional resources are available, NSF has a unique opportunity to envision a recovery that is not simply a return to normal, but instead allows the emergence of a stronger, more equitable enterprise. To support the long-term health of the research enterprise, the most important and urgent needs are to:

- continue to seek and support bold new research ideas that will advance discovery;
- maintain STEM research pathways for undergraduates, graduate students, postdoctoral associates, and early career faculty members;
- retain the participation of underrepresented researchers and under-resourced institutions that NSF has already invested significant effort in cultivating; and
- protect NSF's investment in major research facilities that support the work of many researchers.

COVID-19 Recovery Actions and Plans for the First 100 Days:

NSF has developed a menu of options, with cost estimates, should new resources become available. In the interim, NSF has focused on providing flexibilities, including extending deadlines, encouraging use of flexibilities in grant terms and conditions, as well as those provided by OMB, and encouraging use of no-cost extensions.

In some areas, support for postdoctoral fellowships has been initiated or increased, e.g., in computer and information science and engineering, biological sciences, and ocean science. Release of new opportunities for postdoctoral fellowships in engineering and polar science are anticipated in early 2021. In other areas, opportunities have been provided to extend existing fellowships. A key focus of the CISE postdoctoral fellowships has been on diversity: 52% of the 2020 fellows are women; they come from 46 unique Ph.D.-granting institutions; and they will be completing their fellowships at 43 different universities. Given COVID-19's extended impacts on faculty hiring, another CISE post-doc fellowship opportunity for ~70 postdocs is being planned.

A Dear Colleague Letter was released to signal the availability of supplements to ensure that the research activities supported by an NSF award can continue when researchers are confronted with an increase in dependent care responsibilities. Awardees can request supplements to address other COVID-19 impacts on an *ad hoc* basis. Program Directors are seeing increasing numbers of supplemental requests to help researchers support students and post-docs as well as to keep research support infrastructure operational (e.g., analytical labs, project-specific computing infrastructure, and instrumentation). Absent additional funds, program officers must balance funding supplements with ensuring support for new research projects. They have been encouraged to limit supplements to requests that are time-sensitive and well justified and to consider factors such as the preservation of opportunities for early-stage researchers, especially graduate students and post-docs, and maintaining diversity and inclusion.

NSF is promoting research that designs, tests, and validates new modalities of educational delivery at the K-12, undergraduate, and graduate levels, as seen in EAGER projects funded under the CARES Act, as well as through EHR Core Research (ECR) and ECR Building Capacity in Science Education Research (ECR: BCSER) and other programs. NSF is also supporting a study on the engineering education community's response to the pandemic. Concurrently, the agency is working to preserve, reinforce, and build new pathways to STEM and STEM education careers for the future STEM workforce—supporting innovative approaches to ensure that women and minority faculty are not disenfranchised—while focusing on critical transition points where individuals from underrepresented groups are most vulnerable. For example, NSF provided supplemental funding to multiple MSIs through HBCU-UP and TCUP to provide computers and internet access for students who otherwise could not participate in remote learning.

The National Center for Science and Engineering Statistics (NCSES) is adding questions related to COVID-19 response and recovery to surveys, specifically the Higher Education R&D Survey, the Survey of Graduate Students and Postdoctorates in Science and Engineering and the Annual Business Survey. NCSES will also provide analyses on Covid-19 response and recovery in the Science and Engineering Indicators reports. EHR is also supporting nation-wide surveys to characterize COVID's impact on STEM education.

The pandemic has highlighted the impact of gaps in equitable access to broadband internet. NSF has undertaken activities that should have a positive impact in this area:

- OVERCOME: Connectivity for Underserved Communities is an approximately $2 M project to pilot broadband deployments to enhance access to broadband by students pursuing remote learning in underserved or unserved communities, with awards to five communities expected to be announced by the end of April;
- Platforms for Advanced Wireless Research (PAWR) expects to announce by the end of April one or two rural broadband projects to enhance broadband connectivity in rural regions, with expected investments of approximately $20 M each, including $10M in funds and in-kind contributions from a consortium of wireless companies and associations.

Key Interagency, International, and Partnership Activities:

- FC-STEM, which NSF co-chairs, is coordinating the implementation of the current STEM Education Strategic Plan which has diversity, equity, and inclusion as a core value. Its Interagency Working Group on Inclusion in STEM, also co-chaired by NSF, quickly assembled an expert team in the spring to develop and share strategies for virtual, but still effective, STEM summer internships—particularly important experiences for students underrepresented in STEM. The group is also developing a compendium of best practices for successful diversity and inclusion programs and identifying opportunities to increase federal hiring flexibility.
- FC-STEM agencies have partnered with the NSF INCLUDES National Network to address persistent broadening participation challenges via collaboration and evidence-based approaches.
- NSF is partnering with the National GEM Consortium to increase participation of underrepresented groups in NSF Innovation Corps (I-Corps™) entrepreneurial training and innovation activities.
- NSF and NASA EPSCoR programs are partnering on *Fellows Advancing in Science and Technology (FAST)*, a program to support non-tenured faculty members at minority-majority institutions of higher education to extend their research capacity through collaborative visits to NASA research facilities.

- NSF co-led the formation of the COVID-19 HPC Consortium, a broad inter-agency, public-private, and international partnership. NSF is the largest provider of computing resources through the consortium.

Key Operational Policies and Activities

- Since March 2020, NSF has been holding meetings such as panel reviews, site visits, and community outreach meetings virtually. This approach has enabled the merit review process to continue at its usual cadence and has had the benefit of increasing opportunities for people to participate in the review process; for example, those normally unable to travel have been able to participate in virtual meetings.
- NSF is working closely with facility awardees to adjust construction plans and operations to accommodate local conditions. It is also tracking expected increased costs associated with interruptions to construction schedules.
- NSF has instituted a number of changes in polar operations and field research deployments to protect the safety of persons and property. Individual field researchers and large NSF-supported research field campaigns are continuing to be significantly disrupted by the lack of access to field sites nationally, internationally, and in the polar regions. In addition, quarantine costs continue to be an issue for researchers going into the field. The length of time required for quarantine has also become a morale issue. It is common for researchers and/or crew to be isolated in hotel rooms for two weeks. For projects reliant on facility support (e.g., cruises and field work), deployment delays have trickle-down costs to research projects.

Targeted Programs and Facilities:

For additional details, see the ART memo on NSF Support for Broadening Participation in STEM and Creating an Inclusive STEM Workforce.

Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program (CISE-MSI Program) is a new program focused on expanding the research capacity of MSIs and thereby broadening participation in computer science. (CISE)

Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) is committed to enhancing the quality of undergraduate STEM education and research at HBCUs to broaden participation in the nation's STEM workforce. A major component of this program is support for Broadening Participation Research Centers that serve as national hubs for the rigorous study and broad dissemination of the critical theories, structures, and pedagogies, as well as culturally sensitive interventions that contribute to the success of HBCUs in educating African American STEM undergraduates. The HBCU STEM Undergraduate Success Research Center and the Center for Advancement of STEM Leadership are noteworthy examples. (EHR, $35 M[1])

NSF Inclusion across the Nation of Communities of Learners of Underrepresented Discovers in Engineering and Science (NSF INCLUDES) is central to NSF's work to promote equity and inclusion in STEM by working to broaden participation nation-wide. (EHR, $20 M)

[1] All budget totals provided are for FY 2019, the most current year for which actual investments are publicly available.

Several additional EHR programs are targeted at promoting equity and inclusion in STEM and support the community during COVID-19 recovery, including the following:

- ADVANCE: Organizational Change for Gender Equity in STEM Academic Professions
- Improving Undergraduate STEM Education: Hispanic Serving Institutions (HSI Program)
- Tribal Colleges and Universities Program (TCUP)
- Robert Noyce Teacher Scholarship Program
- Innovative Technology Experiences for Students and Teachers (ITEST)
- Centers of Research Excellence in Science and Technology (CREST)
- Historically Black Colleges and Universities – Excellence in Research (HBCU-EiR) supports basic research by investigators from HBCUs, stimulating sustainable improvement in the research and development capacity of HBCUs and enabling investigators from HBCUs to contribute to the COVID-19 response via COVID-19 RAPIDs. (OIA, $15.2 M).

Dear Colleague Letter: Future of International Research Collaboration Post COVID-19 seeks to understand the nature and scope of COVID-19 impacts on international collaboration in research and education and to encourage creative efforts to leverage the unique moment to enable more robust, resilient, and sustainable collaborations. (OISE)

Core and other Related Programs and Facilities:

Research Experiences for Undergraduates and Research Experiences for Teachers provide meaningful, hands-on opportunities that provide insights into science and engineering concepts, innovations, and careers. (NSF-wide)

Broadening Participation in Computing Alliance Program (BPC-A) is a long-standing program to increase the number and diversity of college graduates in the computing and computationally intensive disciplines. Their 2020 activities have included efforts to mitigate the disproportionate impacts of COVID-19 and other issues on groups historically under-represented in these topic areas. (CISE)

Broadening Participation in Engineering (BPE) focuses on enhancing the diversity and inclusion of all underrepresented populations in engineering. (ENG)

The NSF-funded Innovative Postdoctoral Entrepreneurial Research Fellowship (I-PERF) recruits, trains, mentors, places, and funds underserved, early-career science and engineering doctoral degree recipients to participate in entrepreneurial activities and perform innovative research at eligible NSF-funded small businesses. (ENG-SBIR/STTR)

Partnerships for Research and Education in Materials (PREM) aims to enable, build, and grow partnerships between MSIs and centers and/or facilities supported by NSF's Division of Materials Research to increase recruitment, retention, and degree attainment by groups underrepresented in materials research, and at the same time support excellent research and education endeavors that strengthen such partnerships. (MPS)

Contributing to Build Back Better Through Support for Fundamental Research

especially for industries of the future (including AI, quantum)

Summary: NSF's investment in fundamental research—both exploratory, curiosity-driven research as well as translational, use-inspired research—has built the foundations for decades of U.S. economic growth and competitiveness. NSF-funded advances are a key component of the uniquely American research and innovation ecosystem, involving a strong partnership between academia, government, and industry, with the flow of ideas, tools, and people across these sectors. With continued NSF support, this ecosystem will be central to mobilizing American manufacturing and innovation, building a modern infrastructure, and building an equitable, clean energy future. Building Back Better will also require continued investment in both the general STEM workforce and the next generation of research scientists and engineers trained to pursue questions beyond the traditional scientific and engineering disciplines, including investments in learning science to better prepare America's students for these new disciplines.

Most of NSF's support for fundamental research is focused on identifying and funding work at the frontiers of science, engineering, and STEM education, across broad, ever-expanding horizons of inquiry. However, there are significant, targeted programs focused on critical areas of emerging technology (aka industries of the future) needed for Building Back Better, including artificial intelligence (AI), quantum information sciences (QIS), advanced manufacturing, advanced wireless technologies, biotechnology, clean energy, and civil and research infrastructure. A brief overview supported by a list of key programs and activities for each of these areas are provided below, along with a list of key cross-cutting programs supporting these areas.

Jump to:

- Artificial Intelligence
- Quantum Information Sciences
- Advanced Manufacturing
- Advanced Wireless Technologies
- Biotechnology
- Clean Energy
- Civil and Research Infrastructure
- Key Cross-Cutting Programs

Current Plans and/or Issues for First 100 Days:

- Through April 2021, additional FY 2021 solicitations will be released, and many solicitations listed here will begin the review process for FY 2021 awards, including for additional AI Institutes and Quantum Leap Challenge Institutes.
- COVID-19 has put enormous stress on the entire STEM education and research enterprise, affecting all areas of fundamental research, with a disproportionate impact on women, those under-represented in STEM, people early in their careers, and researchers at Minority Serving Institutions and lower-resourced Institutions of Higher Education. (Also see the ART memo *NSF Support for an Equitable and Inclusive COVID-19 Recovery for the Academic Research Community*.)

Key Interagency, International, and Partnership Activities:

- The NSF Director has made it a priority to develop sustainable partnerships that can amplify the translational impact of NSF's fundamental exploratory research portfolio. These partnerships are envisioned to create communities of discovery and innovation by leveraging the unique combination of government, industry, academia, and philanthropy to motivate research problems and pilot research-based solutions through principles of co-design.
- NSF participates in all the NSTC-related subcommittees and working groups related to these topics, and co-chairs the following subcommittees: Networking and IT R&D (NITRD), R&D Infrastructure, Biological Sciences, Machine Learning and AI, QIS, and Future Advanced Computing Ecosystem.
- AI: Notable partners include USDA/NIFA, DHS/S&T, DOT/FHWA; the Simons Foundation, the Partnership on AI; Accenture, Amazon, Google, Intel Corporation
- QIS: DOE; National Q-12 Education Partnership; Amazon Web Services, IBM, Microsoft Quantum.
- Advanced Manufacturing: DOD, DOE, NASA, NIOSH, NIST, USDA; Manufacturing USA Institutes
- Advanced Wireless Technologies: NIST; Intel, the Platforms for Advanced Wireless Research Industry Consortium comprising 35 private-sector companies and associations
- Biotechnology: NIH; Simons Foundation; over a dozen countries
- Clean Energy: DOD; internationally through the Belmont Forum
- Civil and Research Infrastructure: From astronomical assets, to ships at sea, to polar programs, the multi-user research facilities supported by NSF are widely involved in partnerships and collaborations, both domestic and international.

Artificial intelligence (AI)

As the largest federal funder of non-defense AI research, NSF investments in AI span fundamental research in machine learning, computer vision, and natural language processing, along with the safety, security, robustness, and explainability of AI systems; translational research at the intersection of AI and various science and engineering domains as well as economic sectors such as agriculture, manufacturing, and personalized medicine; and education and learning, including growing human capital and institutional capacity to nurture a next generation of AI researchers and practitioners. NSF investment in AI is not only critical to ensuring American scientific leadership, it is also central to long-term economic success and national security. Central components of NSF's AI portfolio are AI Institutes, the first five of which were launched in FY 2020 to serve as nodes in a broader nationwide network that will pursue transformational advances in sectors of societal impact. Additional information can be found in the AI chapter of NSF's FY 2021 Budget Request to Congress. (NSF-wide, $465 M[1])

Computer and Information Science and Engineering (CISE): Core Programs include substantial and interdisciplinary investments in foundational and translational AI research areas. (CISE)

EArly-concept Grants for Exploratory Research on Artificial Intelligence (AI) and Society - Supported Jointly with the Partnership on AI, jointly supported by NSF and the Partnership on AI, have jointly supported Early-concept Grants for Exploratory Research to understand the social challenges arising

[1] https://www.nsf.gov/about/budget/fy2021/pdf/12_fy2021.pdf. All budget totals provided are for FY 2019, the most current year for which actual investments are publicly available.

from AI technology and enable scientific contributions to overcome them, including unforeseen circumstances and social impacts, and to craft approaches to AI that consider these from the start. (CISE, SBE)

National AI Research Institutes are being established in partnership with USDA, NIFA, DHS/S&T, and DOT/FHWA. In August 2020, NSF announced the first round of NSF AI Institutes, with each of the five institutes funded at $20 M over five years. In addition to the new NSF AI Institutes, USDA NIFA announced two of its first institutes supported through this joint program. Altogether, the investment of $140 million over the next five years represents the nation's most significant single federal investment in AI research and workforce development to date. New to the program this year are contributions from partners in U.S. industry, Accenture, Amazon, Google, and Intel Corporation. (NSF-wide)

NSF Program on Fairness in Artificial Intelligence in Collaboration with Amazon (FAI), a partnership with Amazon, is jointly supporting computational research focused on fairness in AI, with the goal of contributing to trustworthy AI systems that are readily accepted and deployed to tackle grand challenges facing society. (CISE, SBE)

NSF-Simons Research Collaborations on the Mathematical and Scientific Foundations of Deep Learning (MoDL) is a partnership between NSF and the Simons Foundation supporting interdisciplinary projects to understand and develop the theoretical foundations for deep learning networks and train students in these foundations. Complementing NSF's National Artificial Intelligence Research Institutes, this program supports collaborations between mathematicians, statisticians, electrical engineers, and theoretical computer scientists. (CISE, ENG, MPS)

Quantum Information Sciences (QIS)

NSF has a long history of investment in quantum research, with NSF-funded researchers paving the way for the current international focus on QIS. NSF investments in QIS harness uniquely quantum phenomena to advance information processing, transmission, and measurement in ways that classical approaches can only do much less efficiently, or not at all. NSF's QIS priorities are to advance the frontiers of knowledge in the quantum arena, accelerate progress in all areas of quantum applications through multidisciplinary collaboration, and train the workforce that is essential to progress and commercialization in this rapidly expanding field. Notable, large-scale projects include EPiQC: Enabling Practical-Scale Quantum Computation and Software-Tailored Architecture for Quantum co-design (STAQ). NSF has spearheaded the formation of the National Q-12 Education Partnership with industry and academia to provide training and tools to students ready to become the future quantum workforce, beginning with quantum education in middle and high schools nationwide. NSF is also working with leading industry partners to ensure that diversity, equity, and inclusion are central to the quantum work it supports. Additional information can be found in the QIS chapter of NSF's FY 2021 Budget Request to Congress. (NSF-wide, $106 M)

Connections in Quantum Information Science (CQIS) examines concepts and paradigms harnessing fundamental quantum properties for exploration of new scientific frontiers and development of new technologies that lie at the interface of traditional scientific disciplines. Research is currently supported through core programs across six participating Divisions. (CISE, ENG, MPS)

Dear Colleague Letter: Enabling Quantum Computing Platform Access for National Science Foundation Researchers with Amazon Web Services, IBM, and Microsoft Quantum is making available cloud-based quantum-computing platforms to advance research and build capacity in the academic setting through

partnerships with Amazon Web Services, IBM, and Microsoft Quantum. NSF's supplemental funding for active awards will support graduate-student time to work on these platforms. (CISE, MPS)

Dear Colleague Letter: International Collaboration Supplements in Quantum Information Science and Engineering Research provides supplemental funding to existing QIS and engineering research awards to add a new or strengthen an existing international dimension to their award. (NSF-wide)

Dear Colleague Letter: Quantum Algorithm Challenge invites proposals for research ideas seeking to develop innovative quantum algorithms for many-body systems, develop novel algorithms that expand the applications of quantum computation, or propose new quantum-computing paradigms. (CISE, MPS)

NSF Quantum Computing & Information Science Faculty Fellows (QCIS-FF) aims to grow academic research capacity in the computing and information science fields to support advances in quantum computing and/or communication over the long term. QCIS-FF funds departments and schools in hiring tenure-track and tenured faculty in quantum computing and/or communication. (CISE)

Quantum Leap (QL), one of NSF's Big Ideas, is building upon and extending the existing knowledge of the quantum world to observe, manipulate, and control, from first principles, the behavior of particles at atomic and subatomic scales. It is enabling discoveries in both naturally occurring and engineered quantum systems and developing next-generation quantum technologies and devices for sensing, information processing, communications, and computing. (NSF-wide, $58 M)

Quantum Leap Challenge Institutes (QLCI) are large-scale, interdisciplinary research projects to advance the frontiers of QIS and engineering. Institutes are exploring quantum computation, quantum communication, quantum simulation and/or quantum sensing and fostering multidisciplinary approaches to specific scientific, technological, and educational workforce development goals. Three institutes were announced in 2020. (NSF-wide)

Advanced Manufacturing

NSF investments in advanced manufacturing support the fundamental research needed to revitalize American manufacturing and reshape our strategic industries. NSF research accelerates advances in manufacturing technologies with emphasis on multidisciplinary research that fundamentally alters and transforms manufacturing capabilities, methods, and practices. Investments in advanced manufacturing include research on highly connected cyber-physical systems in smart processing and cybermanufacturing systems, and activities that develop new methods, processes, analyses, tools, or equipment for new and existing manufacturing products, supply chain components, and materials. NSF's investments will enable new functionalities that will increase the efficiency and sustainability of the production of the next generation of products and services. These developments will yield advantages such as reduced time to market, new performance attributes, improved small-batch production, cost savings, energy savings, and reduced environmental impact from the manufacturing of products. (Investments in Future of Work at the Human-Technology Frontier, Harnessing the Data Revolution, and Understanding the Rules of Life also contribute to advanced manufacturing.) Additional information can be found in the Advanced Manufacturing chapter of NSF's FY 2021 Budget Request to Congress. (BIO, CISE, EHR, ENG, MPS, OISE, $298 M)

Advanced Manufacturing (AM) is accelerating advances in manufacturing technologies with emphasis on multidisciplinary research that fundamentally alters and transforms manufacturing capabilities, methods, and practices. (CISE, ENG, MPS, OISE, SBE)

Emerging Frontiers in Research and Innovation (EFRI): Distributed Chemical Manufacturing (DCheM) and Engineering the Elimination of End-of-Life Plastics (E3P) (EFRI-2021) will support interdisciplinary teams of researchers to embark on rapidly advancing frontiers of fundamental engineering research. For this FY 2020 solicitation, NSF will consider proposals that aim to investigate emerging frontiers in Distributed Chemical Manufacturing (DCheM) and Engineering the Elimination of End-of-Life Plastics (E3P). E3P will be supported in partnership with DOE and NIST. (BIO, ENG, MPS, SBE)

Future Manufacturing will support fundamental research and education of a future workforce to enable manufacturing that either does not exist today or exists only at such small scales that it is not viable. Future Manufacturing will require the design and deployment of diverse new technologies for synthesis and sensing, and new algorithms for manufacturing new materials, chemicals, devices, components, and systems This new initiative begins with a focus on the emerging areas of cybermanufacturing, eco-manufacturing, and biomanufacturing research. (NSF-wide)

National Robotics Initiative 2.0: Ubiquitous Collaborative Robots (NRI-2.0) builds upon the original NRI program to support fundamental research in the United States that will accelerate the development and use of collaborative robots (co-robots), including in manufacturing environments. The NRI-2.0 program is supported by multiple other agencies including USDA, NASA, and NIOSH. (CISE, ENG, EHR, SBE)

Advanced Wireless Technologies

NSF investments in advanced wireless technologies, including the Spectrum Innovation Initiative, are advancing knowledge gaps and innovation in areas critical to future generations of wireless technologies and networks, including wireless devices, circuits, protocols, and systems; mobile edge computing; distributed machine learning and inference on mobile devices; human-machine-network interactions; and dynamic spectrum allocation and sharing. This research will offer new insights capable of making wireless communication faster, smarter, more responsive, and more robust, and more secure—with profound implications for science and society. Research in advanced wireless includes support for passive uses of the spectrum, including advanced receiver design and interference mitigation techniques for radio astronomy and atmospheric science. NSF's leadership in wireless research has three intertwined components: supporting fundamental research enabling advanced wireless technologies; establishing advanced wireless research testing platforms, in collaboration with industry and other government agencies, to experiment on new approaches at scale; and catalyzing academic, industry, national scientific facility, and community leaders to work together to prototype innovative wireless approaches to address societal challenges.

Dear Colleague Letter: NSF's Spectrum Innovation Initiative and associated Supplemental Funding Opportunities NSF 20-081 is an opportunity for supplemental support to existing NSF-owned and operated facilities, NSF platforms, NSF-supported projects, and NSF educational programs directly related to spectrum innovation as well as support for conferences and workshops. (BIO, CISE, EHR, ENG, GEO, MPS, SBE)

Dear Colleague Letter: Supplemental Funding Opportunity to explore feasibility of National Radio Dynamic Zones (NRDZ) NSF 20-079 is an opportunity to supplement existing NSF awards to explore the feasibility of establishing National Radio Dynamic Zones and to identify the underlying research and deployment challenges. (BIO, CISE, ENG, GEO, MPS)

National Center for Wireless Spectrum Research (SII-Center): NSF intends to catalyze the development and establishment of a successful national center called the Spectrum Innovation Initiative National Center for Wireless Research (SII-Center) to conduct foundational spectrum research. The spectrum research SII-Center will serve as a focal point for sustained research and development in the most challenging areas that are expected to create advanced wireless technologies and systems that benefit society, of which 5G cellular networks are an example. The SII-Center is also expected to educate and develop an agile workforce needed to support industries of the future which will rely heavily on wireless technologies and will require new advanced and automated spectrum management techniques. NSF awarded multiple Planning Grants in FY 2020. (BIO, CISE, GEO, EHR, ENG, MPS, SBE)

NSF/Intel Partnership on Machine Learning for Wireless Networking Systems (MLWiNS) is accelerating fundamental, broad-based research on wireless-specific machine learning (ML) techniques, towards a new wireless system and architecture design, which can dynamically access shared spectrum, efficiently operate with limited radio and network resources, and scale to address the diverse and stringent quality-of-service requirements of future wireless applications. In parallel, this program is also supporting research on reliable distributed ML by addressing the challenge of computation over wireless edge networks to enable ML for wireless and future applications. (CISE, ENG)

Platforms for Advanced Wireless Research (PAWR) is supporting advanced wireless research platforms conceived by the U.S. academic and industrial wireless research community. PAWR is enabling experimental exploration of robust new wireless devices, communication techniques, networks, systems, and services that will revolutionize the nation's wireless ecosystem, thereby enhancing broadband connectivity, leveraging the emerging Internet of Things (IoT), and sustaining US leadership and economic competitiveness for decades to come. The PAWR Project Office is managing this $100 million public-private partnership between NSF and a wireless industry consortium of 35 companies and associations to deploy and manage about four city-scale research testbeds. (CISE)

Spectrum and Wireless Innovation Enabled by Future Technologies (SWIFT) is focused on effective spectrum utilization and/or coexistence techniques, especially with passive uses, which have received less attention from researchers. Breakthrough innovations are sought on both the wireless communication hardware and the algorithmic/protocol fronts through synergistic teamwork. The goal of these research projects may be the creation of new technology or significant enhancements to existing wireless infrastructure, with an aim to benefit society by improving spectrum utilization, beyond mere spectrum efficiency. The SWIFT program seeks to fund collaborative team research that transcends the traditional boundaries of individual disciplines. (CISE, ENG, GEO, MPS)

Spectrum Innovation Initiative, a new NSF initiative in advanced wireless technologies, represents a suite of opportunities to address the pressing challenges arising from the growing demand for usage of the electromagnetic spectrum, including passive and active applications. The goal of this Initiative is to promote dynamic and agile spectrum utilization, while ensuring innovation and security for all users. Reaching this goal will require basic research, infrastructure development, new collaborations, public outreach, education, and workforce development. Enhancing efficient spectrum utilization and access is vital to the national interest, including the scientific enterprise and the other industries of the future. (BIO, CISE, EHR, ENG, GEO, MPS, SBE)

Biotechnology

NSF investments in biotechnology are supporting the data, research infrastructure, and innovation that enable an understanding of living organisms and their biologically related processes at the level of the genetic code. Advanced biotechnology, including advanced sequencing, metabolic engineering, epigenetic modulation of gene expression, and gene editing, serve to both accelerate scientific discovery in biology and to enable the harnessing of biological systems for economic and societal benefit. Biotechnology is considered one of the key drivers of growth in the bioeconomy. NSF invests in biotechnology and related drivers of the U.S. bioeconomy through a multitude of programs in research, infrastructure, and education, including genomics, synthetic biology, bioinformatics, computational biology, engineering biology, tissue engineering, and the development of new types of biomaterials, bio-based microelectronics, and biomanufacturing. NSF's educational investments in these areas are essential to support the biotechnology workforce needed to grow the U.S. bioeconomy. NSF investments in research on ethical, legal, and environmental consequences of synthetic biology and other biotechnologies also support the bioeconomy through understanding of product adoption and socially responsible use. (NSF-wide)

Understanding the Rules of Life (URoL), one of NSF's Big Ideas, is creating a new paradigm at the convergence of science, engineering, and technology that will elucidate theoretical frameworks, or rules, to enable prediction of the diversity of solutions that biological systems use to support life processes. Advances in understanding life at the fundamental level of the genome will enable re-engineering of cells, organisms, and ecosystems, and innovative biochemicals and biomaterials that sustain a vibrant bioeconomy and strengthen society. URoL is also training the next generation of researchers capable of using those rules and theories not only to predict the behavior of living systems, but to design them to benefit humankind. (BIO, CISE, ENG, GEO, MPS, SBE, $108 M).

Enabling Discovery through Genomic Tools (EDGE) supports the development of innovative biotechnologies, resources, and infrastructure that advances understanding of the causal mechanisms connecting genes and phenotypes and enables new capability for genomic manipulation of complex traits in diverse organisms. (BIO)

Systems and Synthetic Biology provides the core funding to advance new capabilities and biotechnology in synthetic biology and metabolic engineering and to apply the tools of systems and synthetic biology to understand complex interactions within biological systems across different scales. (BIO)

Reproducible Cells and Organoids via Directed-Differentiation Encoding (RECODE) supports research to elucidate mechanisms of, and develop strategies to, direct the differentiation of undifferentiated cells into mature, functional cells or organoids. The control of cell differentiation will enable advanced biomanufacturing, leading to novel products, biomaterials, and significant improvements in individualized medicine, environmental control and monitoring, adaptive sensing, as well as the scalable and reproducible application of 3D organoids in drug testing. (BIO, ENG)

Dear Colleague Letter: Plant Synthetic Biology focuses support for proposals that advance the growing field of plant synthetic biology, including basic research, tool development, and applications that emphasize potential outcomes with benefits to society. (BIO, ENG)

Designing Synthetic Cells Beyond the Bounds of Evolution (Designer Cells) leverages technological advances in synthetic biology and bioengineering to tailor cells and cell-like systems for a variety of basic and applied research purposes with goals to develop cell-like systems to identify the minimal

requirements for the processes of life; design synthetically-modified cells to address fundamental questions in the evolution of life or to explore biological diversity beyond that which currently exists in nature; and build novel synthetic cell-like systems and cells for innovative applications. (BIO, ENG, SBE)

Molecular Foundations of Biotechnology (MFB) supports new approaches in chemistry to drive innovations in biotechnology. This multiyear campaign will focus this year on synthetic, physical organic and molecular recognition chemistry to drive new developments in small molecule-protein interactions with applications for biotechnology. (MPS)

Infrastructure Innovation for Biological Research (Innovation) focuses on research infrastructure that is broadly applicable to researchers in bioinformatics, instrumentation, and research methods, where the infrastructure is advancing biological understanding by improving scientists' abilities to manipulate, control, analyze, or measure critical aspects of biological systems. (BIO)

Semiconductor Synthetic Biology for Information Storage and Retrieval (SemiSynBio-II) seeks high-risk/high-return interdisciplinary research on novel concepts and enabling technologies that will address the fundamental scientific issues and technological challenges associated with the underpinnings of synthetic biology integrated with semiconductor technology for future ultra-low energy storage-based computing systems built on principles derived from organic systems. This program will foster collaborations involving biology, physics, chemistry, materials science, computer science and engineering to enable heretofore unanticipated breakthroughs. (BIO, CISE, ENG, MPS)

NSF-Simons Research Centers for Mathematics of Complex Biological Systems (MathBioSys), in partnership with the Simons Foundation, is supporting collaborative research at the intersection of mathematics and molecular, cellular, and organismal biology, to establish new connections between these two disciplines, and to promote interdisciplinary education and workforce training. (BIO, MPS)

Future Manufacturing, as discussed above, will support fundamental research and education of a future workforce to enable manufacturing that either does not exist today or exists only at such small scales that it is not viable. One of the three focus areas is Future Biomanufacturing Research. (NSF-wide)

Clean Energy

NSF's investments in research support nearly every aspect of America's clean energy future—from fundamental physics, chemistry, and materials science, to large-scale systems engineering and cyber-infrastructure. Both core and targeted programs are supporting relevant projects NSF-wide. NSF's clean energy investments support innovative interdisciplinary research related to sustainability science and engineering, such as the conversion, storage, and distribution of diverse power and fuel sources (including smart grids); the science and engineering of energy materials, energy use, and energy efficiency; and the ways that people think about and use energy. Clean energy investments also create vital research and education partnerships in science**.**

Energy, Power, Control, and Networks (EPCN) supports research in modeling, optimization, learning, adaptation, and control of networked multi-agent systems; higher-level decision making; and dynamic resource allocation; as well as risk management in the presence of uncertainty; sub-system failures; and stochastic disturbances. EPCN also supports research related to electric power systems, including generation, transmission, storage, and integration of renewable energy sources into the grid; power electronics and drives; battery management systems; hybrid and electric vehicles; and understanding of

the interplay of power systems with associated regulatory and economic structures and consumer behavior. (ENG)

Critical Aspects of Sustainability (CAS) supports fundamental research aimed at improving the sustainability of resources through the design, manufacture, and use of efficient, effective, safe, and more environmentally benign products and processes. It also supports research to better understand how communication between the environment and living systems can confer resilience and/or could foster adaptability of living systems subject to changing environments. (ENG, GEO, MPS)

Designing Materials to Revolutionize and Engineer our Future (DMREF), the primary program by which NSF participates in the Materials Genome Initiative (MGI), supports activities that significantly accelerate materials discovery and development by building the fundamental knowledge base needed to advance the design and development of materials with desirable properties or functionality. This goal is being accomplished through interdisciplinary teams of researchers working synergistically in a "closed loop" fashion, building a vibrant research community, leveraging data science, providing ready access to materials data, and educating the future MGI workforce. NSF is currently partnering with AFOSR to coordinate and potentially co-fund synergistic research. (CISE, ENG, MPS)

Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET) supports the creation of effective solutions to our most pressing environmental and sustainability challenges requires imaginative thinking - the kind that evolves when researchers from disparate fields, expertise, or perspectives fully immerse themselves in work toward a common goal. support fundamental research activities that confront vexing environmental engineering and sustainability problems by developing foundational knowledge underlying processes and mechanisms such that the design of innovative new materials, processes, and systems is possible.

The NSF-funded National High Magnetic Field Laboratory (National MagLab) is a global destination for groundbreaking research across scientific disciplines, leveraging the power of high magnetic fields to overcome energy challenges, among other focus areas. Researchers are using MagLab's Ion Cyclotron Resonance to better understand existing energy sources and to explore new ones. By examining crude oil samples, scientists are learning how to improve petroleum refining, minimize the impact of oil spills and convert abundant, lower-quality crude oil into usable fuel. Data collected in high-field magnets on natural products is providing important information on how to diversify our energy sources. (MPS)

Chemical Catalysis (CAT) supports experimental and computational research directed towards the fundamental understanding of the chemistry of catalytic processes, including processes fundamental to understanding clean energy, carbon cycling, approaches for carbon sequestration, and for harnessing visible light and electricity to drive chemistry. (MPS)

Civil and Research Infrastructure

NSF's support for developing a modern infrastructure for the Nation includes both research for civil infrastructure and robust support for the modern and effective research infrastructure needed for maintaining U.S. international leadership in science and engineering. NSF's portfolio of civil infrastructure programs support the integration of research and education across potentially transformative research to enable advances in manufacturing and building technologies across size scales from nanometers to kilometers, with emphases on efficiency, economy, and minimal environmental footprint; efficient, economical and sustainable transformation and use of engineering

materials; resilient and sustainable civil infrastructure and distributed infrastructure networks; advances in the creation of models, analyses, and algorithms that link data with decisions related to manufacturing and service enterprises; and design, control, and optimization methods applied at levels ranging from component to enterprise systems. **For further information about research infrastructure, see the ART memo on *NSF Research Infrastructure to Build Back Better***. (NSF-wide)

Campus Cyberinfrastructure (CC*) invests in coordinated campus-level networking and cyber–infrastructure improvements, innovation, integration, and engineering for science applications and distributed research projects. Learning and workforce development in cyberinfrastructure is also explicitly addressed in the program. (CISE)

Civil Infrastructure Systems (CIS) supports fundamental and innovative research in the design, operation and management of civil infrastructure that contributes to creating smart, sustainable and resilient communities at local, national, and international scales. (ENG)

Computational and Data-Enabled Science and Engineering (CDS&E) supports research that enables major scientific and engineering breakthroughs through new computational and data analysis approaches. The key feature of the program is that the outcome relies on the development, adaptation, and utilization of one or more of the capabilities offered by advancement of both research and infrastructure in computation and data, either through cross-cutting or disciplinary programs. (CISE, ENG, MPS)

Cyberinfrastructure for Sustained Scientific Innovation (CSSI) seeks to enable funding opportunities that are flexible and responsive to the evolving and emerging needs in cyberinfrastructure (CI). The program is currently emphasizing integrated CI services, quantitative metrics with targets for delivery and usage of these services, and community creation. (CISE)

Engineering Design and System Engineering (EDSE) supports fundamental research into the basic processes and phenomena of engineering design and systems engineering. (ENG)

Humans, Disasters, and the Built Environment (HDBE) supports fundamental, multidisciplinary research on the interactions between humans and the built environment within and among communities exposed to natural, technological, and other types of hazards and disasters. The program's context is provided by ongoing and emerging changes in three interwoven elements of a community: its population, its built environment (critical infrastructures, physical and virtual spaces, and buildings and related structures), and the hazards and disasters to which it is exposed. (ENG)

Natural Hazards Engineering Research Infrastructure (NHERI) supports a network of university-based, experimental facilities that provide researchers with state-of-the-art tools to investigate earthquake, wind and water hazards, and test ground-breaking concepts to protect individuals, communities, and infrastructure. (ENG)

NSF Smart and Connected Communities (S&CC) supports the creation of the scientific and engineering foundations that will enable smart and connected communities to bring about new levels of economic opportunity and growth, safety and security, and health and wellness. The program is currently soliciting proposals for the Civic Innovation Challenge (CIVIC), a competition that flips the community-university dynamic, asking *communities* to identify civic priorities ripe for innovation and then to partner with researchers to address those priorities. (CISE, EHR, ENG, SBE)

Operations Engineering (OE) supports fundamental research on advanced analytical methods for improving operations in complex decision-driven environments. Analytical methods include, but are not limited to, deterministic and stochastic modeling, optimization, decision and risk analysis, data science, and simulation. (ENG)

Strengthening American Infrastructure (SAI) is a new, multidisciplinary initiative to help America build and maintain smarter, more effective infrastructure at lower costs (BIO, CISE, ENG, EHR, MPS, OIA, SBE)

Sustainable Regional Systems Research Networks (SRS RNs) will develop and support interdisciplinary, multi-organizational teams of investigators and stakeholders working collaboratively to produce cutting-edge convergent research, education, and outreach that addresses grand challenges in sustainable regional systems. Sustainable regional systems are connected urban and rural systems that are transforming their structures and processes collaboratively with the goal of measurably and equitably advancing the well-being of people and the planet. (NSF-wide)

Key Cross-Cutting Programs

Advanced Technological Education (ATE), with an emphasis on two-year Institutions of Higher Education (IHEs), focuses on the education of technicians for the high-technology fields that drive our nation's economy. The program involves partnerships between academic institutions (grades 7-12, IHEs) and industry to promote improvement in the education of science and engineering technicians at the undergraduate and secondary institution school levels. It explicitly encourages partnerships with other entities that may impact technician education, including Manufacturing USA Institutes (supported through an NSF-wide Dear Colleague Letter) and NSF Industry University Cooperative Research Centers. The ATE program encourages proposals from Minority Serving Institutions and other institutions that support the recruitment, retention, and completion of students underrepresented in STEM in technician education programs that award associate degrees. (EHR, $67 M)

Centers for Chemical Innovation (CCI) supports research centers focused on major, long-term fundamental chemical research challenges. The current program is specifically encouraging centers related to advanced manufacturing AI, biotechnology, and QIS. (MPS, $24M)

Convergence Accelerator (C-Accel) Phase I and II seeks to transform how NSF supports the most innovative science, while also encouraging rapid advances through partnerships between academic and non-academic stakeholders. C-Accel focuses on use-inspired, convergence research, with directed deliverables and using an approach that rewards innovation, risk-taking, and transition to practice. The first (2019) cohort includes teams focused on AI and Future Jobs; the 2021 cohort is focusing on delivering societal impact through quantum and AI-driven data and model sharing research. (OIA, $41 M)

Dear Colleague Letter: Advancing Educational Innovations that Motivate and Prepare PreK-12 Learners for Computationally-Intensive Industries of the Future will support the development of educational approaches or pathways to support preK-12 learners' computational skills and interest in artificial intelligence and quantum information systems. (CISE, EHR)

Engineering Research Centers (ERC) support convergent research, education, and technology translation at U.S. universities that will lead to strong societal impacts. Each ERC has interacting foundational components that go beyond the research project, including engineering workforce development at all participant stages, a culture of diversity and inclusion where all participants gain mutual benefit, and value creation within an innovation ecosystem that will outlast the lifetime of the ERC. As of August

2020, NSF supports 18 ERCs in advanced manufacturing, energy and environment, health, and infrastructure. (ENG, $59 M)

Established Program to Stimulate Competitive Research (EPSCoR) at NSF promotes collaborations among researchers in EPSCoR jurisdictions and emphasizes recruitment/development of diverse early career faculty and STEM education and workforce development. The FY 2021 EPSCoR competition is specifically focused on advancing research towards industries of the future to ensure economic growth for EPSCoR jurisdictions. (OIA, $176 M)

Exploring the NSF 2026 Idea Machine is supporting exploratory research and conferences to refine research approaches in, among others, the fate of plastics in the environment, a world without waste, carbon sequestration with the aid of microbes, net negative emissions energy systems, nitrogen upcycling, and the intersection of equity and energy system transitions. (OIA)

Future of Work at the Human-Technology Frontier (FW-HTF), one of NSF's Big Ideas, is supporting research at the intersection of technology, workers, and work with a focus on the impact and implications of advances in computer and engineering technologies such as artificial intelligence, robotics, and augmented reality; deeper understanding of economic and societal consequences; advances in the learning sciences; pervasive, intelligent, and autonomous systems; and new conceptions of lifelong learning for work. (NSF-wide, $173 M)

Harnessing the Data Revolution (HDR), one of NSF's Big Ideas, is a national-scale activity to enable new modes of data-driven discovery that allow new fundamental questions to be asked and answered at the frontiers of science and engineering. To help close the loop from data generation to analysis and simulation, and on to discovery, HDR is supporting fundamental research in data science and engineering; the development of a cohesive, federated approach to the research data infrastructure needed to power this revolution; and development of a 21st-century data-capable workforce. (NSF-wide, $196 M)

Innovation Corps (I-Corps™) has been using experiential education since 2011 to help researchers gain valuable insight into entrepreneurship, starting a business, and industry requirements and challenges. Current investments focus on establishing Hubs to implement the I-Corps™ program in the research community nation-wide through a network of universities (and with a stronger requirement to support a diverse and inclusive community of innovators). (BIO, CISE, ENG, GEO, MPS, SBE, $33 M)

National Center for Science and Engineering Statistics (NCSES), the nation's leading provider of statistical data on the U.S. science and engineering enterprise, provides unique data and analysis on R&D, infrastructure, and the STEM workforce in the Science and Engineering Indicators reports. A variety of other products directly address specific topics of interest, including the following:

- Survey of Science and Engineering Research Facilities and associated NCSES InfoBriefs on research infrastructure;
- Annual Business Survey;
- Business Enterprise R&D Survey; and
- National Patterns of R&D Resources.

NCSES also contributed to the 2019 GAO report WORKFORCE AUTOMATION: Better Data Needed to Assess and Plan for Effects of Advanced Technologies on Jobs. (SBE)

SBIR/STTR, "America's Seed Fund" powered by NSF, helps startups and small businesses transform their ideas into marketable products and services, with a focus on high-risk, high-impact technologies. each year, we award $200 million in funding to entrepreneurs across the country. Our goals are to foster innovation and help create businesses and jobs in the United States, and companies seed funded by our program have since gone on to tremendous success. The portfolio is dominated by companies working in the sectors of these industries of the future. (NSF-wide, $212 M)

Science and Technology Centers (STCs): Integrative Partnerships supports innovative, potentially transformative, complex research and education projects that require large-scale, long-term awards. STCs conduct world-class research through partnerships among academic institutions, national laboratories, industrial organizations, and/or other public/private entities, and via international collaborations, as appropriate. Current Centers include some specifically relevant to these emerging technology areas. (NSF-wide)

Semiconductor and Microelectronics Research Investments at NSF support basic research and research infrastructure to advance the "full stack" associated with semiconductor materials and devices and their integration into systems: materials; devices and interconnects; computing architectures; fabrication/manufacturing; software, modeling, and simulation; and applications. NSF concomitantly invests in the future workforce for this industry, from the skilled technical workforce, to those with advanced degrees needed to maintain U.S. leadership in this sector. These investments are a foundation for future advances upon which virtually every emerging technology area depends. NSF also has a long tradition of partnering with mission agencies and industry to ensure NSF research quickly translates into new technologies. NSF coordinates its work internally through a cross-NSF working group and with other agencies through the NSTC Semiconductor Leadership R&D Working Group. (NSF-wide)

NSF Support for Broadening Participation in STEM and Creating an Inclusive STEM Workforce

NSF Tools for Improving Diversity, Equity, and Inclusion in the US STEM Workforce

NSF Support for and Relationships with HBCUs and other MSI

How NSF STEM Education Programs Can Provide STEM Opportunities for Everyone

Summary: NSF is strongly committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans, including within NSF's own workforce. NSF is working to identify priorities and scale evidence-based solutions to achieving equity in training and higher education opportunities connected to the work of the future. Within the academic research enterprise, NSF has secured a leadership role in addressing sexual harassment, sexual assault, and other forms of harassment. It has issued a formal NSF award "term and condition" that requires reporting about offenders for whom action has been taken; requires organizers of workshops supported by the Foundation to have a published Code of Conduct and avenues for reporting incidents during the workshop by any participant; is emphasizing to the grantee community that policies on harassment include all forms of harassment and is not limited to gender harassment; and has made it explicit in policy that the responsible and ethical conduct of research includes treating all students and colleagues fairly and respectfully.

NSF works closely with the Committee on Equal Opportunities in Science and Engineering (CEOSE), a congressionally mandated committee that advises NSF on policies and programs that encourage full participation of women, underrepresented racial and ethnic groups, and persons with disabilities in the scientific enterprise. Recommendations from CEOSE play a key role in informing NSF activities in this area, which currently include 28 coordinated programs from across the Foundation aimed at broadening participation in STEM fields, including programs specifically addressing STEM education at our nation's Minority Serving Institutions (MSIs). A cornerstone among these programs is NSF INCLUDES, a comprehensive national initiative designed to enhance U.S. leadership in discoveries and innovations by focusing on diversity, inclusion, and broadening participation in STEM at scale by building a robust, collaborative infrastructure. NSF INCLUDES now encompasses a nation-wide network supported by a set of large-scale Alliances and has expanded to include participation by other Federal agencies and industry partners. Finally, demonstrating his commitment to this issue, the NSF Director recently established a Racial Equity Task Force to identify barriers to equity within NSF and identify employment practices and program delivery methods with the potential to remove barriers based on race.

Current Plans and/or Issues for First 100 Days:

- Through April 2021, additional diversity and inclusion-related FY 2021 solicitations will be released and many solicitations already accepting proposals will begin the review process.
    - OVERCOME: Connectivity for Underserved Communities is an approximately $2 M project to pilot broadband deployments to enhance access to broadband by students pursuing remote learning in underserved or unserved communities, with awards to five communities expected to be announced by the end of April.
- As a follow up to extensive engagement between CISE and the MSI community, CISE has launched a new MSI Research Expansion Program and will convene a number of "MiniLabs" to foster capacity-building and the formation of collaboration networks in the community and help them better respond to the solicitation's April deadline.

Key Interagency, International, and Partnership Activities:

- NSF has broad leadership roles in NSTC STEM education-related groups, including the Committee on STEM Education (CoSTEM, co-chair); its subcommittee, Federal Coordination in STEM Education (FC-STEM, co-chair); and its interagency working groups: Inclusion in STEM (co-chair), Veterans in STEM, Computational Literacy, Convergence, Strategic Partnerships, and Transparency & Accountability (co-chair). NSF also provides leadership supporting STEM education and workforce development within other topical groups, including the STEM Education Working Group (co-chair) within the Interagency Arctic Research Policy Committee (IARPC, chair); the Workforce Development Working Group within the Biological Sciences Subcommittee (co-chair); the Machine Learning and AI Subcommittee (co-chair); the Future Advanced Computing Ecosystem Subcommittee (FACE) (co-chair), which recently published a strategic plan identifying workforce development as one of four major priority areas; and has spearheaded collaboration between FC-STEM and the NITRD Subcommittee.
- NSF co-chairs the Safe and Inclusive Research Environments (SIRE) Subcommittee within the NSTC Joint Committee on Research Environment (JCORE). Collaboration with OSTP and science-funding agencies strengthens NSF's efforts to create a research environment that is safe and inclusive and encourages all participants to contribute their maximum potential to the research enterprise.
- NSF, along with NOAA, NASA, and the Department of Education, manage the STEM Education Advisory Panel, a Congressionally-mandated FACA committee that provides advice and recommendations to CoSTEM; assesses CoSTEM's progress in carrying out its responsibilities as required by the America COMPETES Reauthorization Act; and helps identify opportunities for revision to the Federal STEM education strategic plan.
- Since 2018, eight Federal agencies have become partners in NSF INCLUDES and it's national network (DOD, DOE, NASA, NIH, NIST, NOAA, USGS, and USPTO), committing to seek ways to advance diversity and inclusion within and across agencies; helping develop common metrics to define success; and leveraging public-private partnerships to prepare the next generation of the STEM workforce. An example outcome of this partnership is a new NASA program, the Minority University Research and Education Project, to support collaborations between MSIs and other organizations within the NSF INCLUDES community to broaden participation in the engineering workforce.
- NSF-EPSCoR is partnering with NASA-EPSCoR to provide opportunities for non-tenured Principal Investigators (PIs) to further develop their individual research potential through extended collaborative visits to NASA research facilities through EPSCoR Research Infrastructure Improvement Track 4: EPSCoR Research Fellows (RII Track-4).
- NSF has partnered with NIH to co-fund a new NASEM consensus study to look at ways of Addressing Diversity, Equity, Inclusion, and Anti-Racism in 21st Century STEM Organizations. The Statement of Work is currently being negotiated.

Key Personnel and Operational Policies and Activities

As an employer, NSF is committed to a supportive, encouraging, inclusive, and nurturing work environment—a zero tolerance for harassment and discrimination is imperative to changing the persistent cultural drivers behind harassment and discrimination. Below are key policies and activities within NSF that support this commitment.

The Office of Diversity & Inclusion (ODI) works across the Foundation and with the NSF awardee community to promote diversity and inclusion; and provide equal opportunity and access and eliminate unlawful discrimination, harassment, and retaliation in employment at NSF and in participation with NSF-funded or conducted programs. Organizations receiving funding awards from NSF are prohibited from discriminating against individuals who participate in any of their programs, services, and activities under the follow civil rights laws: Title VI of the Civil Rights Act of 1964, (prohibits discrimination on the basis of race, color, or national origin); Section 504 of the Rehabilitation Act of 1973 (prohibits discrimination on the basis of disability); Title IX of the Educational Amendments of 1972 (prohibits discrimination on the basis of sex in Federally assisted education programs or activities); and the Age Discrimination Act of 1975 (prohibits discrimination on the basis of age). To that end, ODI investigates complaints of unlawful discrimination, harassment and retaliation in NSF-funded programs services and activities. ODI also conducts civil rights compliance reviews of NSF awardee organizations and their NSF-funded programs and activities.

NSF's Term and Condition requires awardee organizations to notify NSF of any findings/determinations of sexual harassment, other forms of harassment (including racial harassment), or sexual assault regarding an NSF funded Principal Investigator (PI) or co-PI, or of the placement of the PI or co-PI on administrative leave, or the imposition of any administrative action relating to harassment or sexual assault finding or investigation. ODI receives the harassment notifications from NSF awardee organization Authorized Organization Representatives (AORs) and coordinates review of these forms with NSF's Office of General Counsel, the Policy Office and program staff who manage the affected NSF funding awards.

Conference grant requirements aimed at reducing harassment were included in the most recent version of the NSF Proposal and Award Policies and Procedures Guide (PAPPG) to make clear that it is NSF policy to foster harassment-free environments wherever science is conducted, including at NSF-sponsored conferences, and to require all NSF-supported conferences to have a policy or code-of-conduct that addresses sexual harassment, other forms of harassment, and sexual assault.

NSF has established a staff-led Racial Equity Task Force to examine the potential for racial barriers and make recommendations regarding how NSF can be a leader in meaningfully addressing them with the goal of extinguishing them. Other groups within NSF are monitoring and evaluating agency-wide efforts to grow and diversify the STEM workforce, including the impact of the new term and condition and conference policies and the effectiveness of the Research Experiences for Undergraduates (REU) and International Research Experiences for Students (IRES) programs.

Targeted Programs and Facilities:

ADVANCE: Organizational Change for Gender Equity in STEM Academic Professions provides grants to enhance the systemic factors that support equity and inclusion and to mitigate the systemic factors that create inequities in the academic profession and workplaces. ADVANCE is working to broaden the implementation of evidence-based systemic change strategies that promote equity for STEM faculty in academic workplaces and the academic profession through intersectional approaches in the design of systemic change strategies in recognition that gender, race, and ethnicity do not exist in isolation from each other and from other categories of social identity. (NSF-Wide, $18 M[1])

Alliances for Graduate Education and the Professoriate (AGEP) seeks to advance knowledge about models to improve pathways to the professoriate and success for historically underrepresented minority doctoral students, postdoctoral fellows and faculty—particularly African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders—in specific STEM disciplines and/or STEM education research fields. Strategic collaborations are encouraged with multiple academic partners, the private sector, NGOs, professional organizations, government agencies, national laboratories, field stations, teaching and learning centers, informal science centers, and other relevant STEM and/or STEM education research organizations. (EHR, $8 M)

Broadening Participation in Computing (BPC) is a three-year pilot to enhance the engagement of the *full* CISE research community in Broadening Participation in Computing (BPC) activities. This pilot encourages university departments to write and submit BPC plans with proposals submitted to a subset of CISE's research programs and requires them at time of award. (CISE)

Broadening Participation in Computing Alliance Program (BPC-A) supports large-scale alliances between academic institutions, educators, professional societies, community organizations, and industrial partners working to create best practices, educational resources, advocacy networks, and forums needed to transform computing education. The BPC Alliances are focused on addressing the long-standing underrepresentation of many groups within the computing community by increasing awareness, access, engagement, and inclusion for all students. (CISE)

Broadening Participation in Engineering (BPE) focuses on enhancing the diversity and inclusion of all underrepresented populations in engineering, including gender identity and expression, race, and ethnicity (African Americans/Blacks, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders), disability, LGBTQ+, first generation college, and socio-economic status. (ENG)

Centers of Research Excellence in Science and Technology (CREST) and HBCU Research Infrastructure for Science and Engineering (RISE) is enhancing the research capabilities of MSIs through the establishment of centers that effectively integrate education and research. CREST promotes the development of new knowledge, enhancements of the research productivity of individual faculty, and an expanded presence of students historically underrepresented in STEM disciplines. CREST Postdoctoral Research Fellowship awards provide research experience and training for early career scientists at active CREST Centers. HBCU-RISE awards specifically target HBCUs to support the expansion of institutional research capacity as well as the production of doctoral students, especially those from groups underrepresented in STEM,

[1] All budget totals provided are for FY 2019, the most current year for which actual investments are publicly available; see https://www.nsf.gov/about/budget/fy2021/pdf/12_fy2021.pdf.

at those institutions. Diversity Collaboration Supplements provide an opportunity for existing SBIR/STTR Phase II projects to initiate collaborations with minority-serving institutions that have active CREST Center or HBCU-RISE awards. (EHR, ENG, $24 M)

Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program (CISE-MSI Program) is a new program focused on expanding the research capacity of MSIs and thereby broadening participation in computer science. (CISE)

Computing Innovation Fellows (CIFellows), managed by the Computing Community Consortium with NSF support, was created by NSF to mitigate faculty hiring disruptions caused by COVID-19 and includes strong diversity, equity, and inclusion elements in its selection process. Through its first round of selections, 59 fellows received two-year emergency postdoctoral fellowships, drawing from over 50 institutions, and with strong demographic balance including a nearly 50-50 gender balance. (CISE)

Dear Colleague Letter: Broadening Participation in STEM Entrepreneurship and Innovation (BPINNOVATE) supports research on broadening participation in STEM-related entrepreneurship and innovation through the Science of Science program. (SBE)

Dear Colleague Letter: Build and Broaden: Enabling New Social, Behavioral and Economic Science Collaborations with Minority-Serving Institutions encourages submission of proposals from MSIs, and partnerships with and among MSIs, to create opportunity and broaden access to large populations of historically underserved populations. (SBE)

Dear Colleague Letter: Career-Life Balance (CLB) Supplemental Funding Requests announced (in November 2020) NSF's continued interest in CLB supplemental funding requests, including support for those currently confronted with a short-term increase in dependent care responsibilities. This update to this ongoing initiative includes two key changes: an increase in the amount and duration of salary support that may be requested; and an extension of the opportunity to Principal Investigators (PIs) and co-PIs of all active NSF grant or cooperative agreements. (OIA)

Dear Colleague Letter: Geoscience Opportunities for Leadership in Diversity - Expanding the Network (GOLD-EN) aims to expand the reach of the ongoing Geoscience Opportunities for Leadership in Diversity (GOLD) program, which since 2016 has been working to improve diversity in the geosciences community. GOLD-EN will bring to scale related diversity activities in the geosciences or develop unique approaches for greater inclusion in the geoscience education and research community through supplemental funding for a variety of activities, including conference, early-concept grants, and research coordination networks. (EHR, GEO)

Dear Colleague Letter: MPS AGEP-GRS is a mechanism by which a current MPS research awardee can support an additional Ph.D. student in an ongoing MPS-funded research project if their institution is a current or past participant in the AGEP program. The goal is to create an opportunity to engage additional students in research, to develop a positive learning environment for students, and to improve diversity and retention at the doctoral level within all fields of MPS research, with an emphasis placed on increasing the involvement in these fields by members of underrepresented groups. (MPS, $2 M)

Dear Colleague Letter: MPS Graduate Research Supplement for Veterans (MPS-GRSV) recognizes that veterans represent a potential underutilized workforce for America's research and industrial communities and provides supplemental funding to support one (additional) Ph.D. student per award, as long as the student is a veteran. (MPS)

EPSCoR at NSF invested $176 M of FY 2019 funds across 28 eligible jurisdictions to increase the research competitiveness of those jurisdictions and build a STEM-capable workforce. One of EPSCoR's main goals is to broaden direct participation of diverse individuals, institutions, and organizations in the project's science and engineering research and education initiatives. As such, each of EPSCoR's investment opportunities emphasizes this aspect within the solicitations and during the merit review process. EPSCoR also tracks project participant and outcome data to ensure that this goal is being met. (OIA)

EPSCoR Research Infrastructure Improvement Track 4: EPSCoR Research Fellows (RII Track-4) invests in project that build research capacity in institutions and transforms the career trajectories of non-tenured investigators by developing their potential through extended collaborative visits to the nation's premier private, governmental, or academic research centers. The experiences gained through the fellowships are intended to have lasting impacts on Fellows' research trajectories and, in turn, improve the research capacity of their institutions and jurisdictions more broadly. (OIA)

Historically Black Colleges and Universities – Excellence in Research (HBCY-EiR) supports basic research by investigators from HBCUs, stimulating sustainable improvement in the R&D capacity of HBCUs (in FY 2020, 41 awards were made to 20 HBCUs). (NSF-Wide, $15 M)

Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) is committed to enhancing the quality of undergraduate STEM education and research at HBCUs to broaden participation in the nation's STEM workforce. HBCU-UP works towards this goal by providing awards to develop, implement, and study innovative approaches for making effective improvements in the preparation and success of HBCU undergraduate students so that they may participate successfully in graduate programs and/or careers in STEM disciplines. (EHR, $35 M)

Improving Undergraduate STEM Education: Hispanic-Serving Institutions (HSI Program) is enhancing the quality of undergraduate STEM education and working to increase the recruitment, retention, and graduation rates of students pursuing associate's or baccalaureate degrees in STEM at HSIs. It supports strategies to build capacity at HSIs through innovative approaches to incentivize institutional and community transformation and promote fundamental research on engaged student learning, what it takes to diversify and increase participation in STEM effectively, and the understanding of how to build institutional capacity at HSIs. (EHR, $40 M)

Improving Undergraduate STEM Education: Pathways into the Earth, Ocean, Polar and Atmospheric & Geospace Sciences (IUSE:GEOPAths) is part of a Foundation-wide effort to accelerate improvements in the quality and effectiveness of undergraduate education in all STEM fields including the learning, social, behavioral, and economic sciences—investments enabling NSF to lead national progress toward a diverse and innovative workforce and a STEM-literate public. IUSE:GEOPAths addresses the current needs and opportunities related to education within the geosciences community through the formation of STEM Learning Ecosystems that engage students in the study of the Earth, its oceans, polar regions and atmosphere, with a goal to increase the number of students pursuing undergraduate and/or postgraduate degrees in geoscience. Engaging students from historically excluded groups or from non-geoscience degree programs is a priority. (EHR, GEO)

Inclusion Across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) is a comprehensive national initiative to broaden participation in STEM *at scale* by catalyzing the STEM enterprise to collaboratively work for inclusive changes needed to make the national STEM workforce more representative of the population. It is the first NSF broadening

participation program to engage all Directorates and Offices in an NSF-wide initiative to support the scaling of proven strategies. A hallmark of NSF INCLUDES is the focus on the five design elements of collaborative infrastructure to achieve systemic change—the process by which partnering organizations come together to map out mutually reinforcing activities through shared vision; partnerships; goals and metrics; leadership and communication; and expansion, sustainability, and scale. Through these five design elements of collaborative infrastructure, the successful implementation of NSF INCLUDES will result in substantial advances toward a diverse, innovative, and well-prepared STEM workforce to support our Nation's economy and continued U.S. leadership in the global STEM enterprise. The program has established large scale alliances and a Coordination Hub to extend the scale and impact of a growing nation-wide network that includes Federal and industry partners. (NSF-Wide, $20 M)

Louis Stokes Alliances for Minority Participation (LSAMP) is an alliance-based program helping universities and colleges to diversify the nation's STEM workforce by increasing the number of STEM baccalaureate and graduate degrees awarded to populations historically underrepresented in these disciplines. LSAMP takes a comprehensive approach to student development and retention, with particular emphasis on transforming undergraduate STEM education through innovative, evidence-based recruitment and retention strategies, and relevant educational experiences in support of racial and ethnic groups historically underrepresented in STEM disciplines. (EHR, $46 M)

Mid-Career Advancement (MCA) supports scientists and engineers at the Associate Professor rank to enhance and advance their research program through synergistic and mutually beneficial partnerships. MCA seeks to grow a more diverse scientific workforce (women, persons with disabilities, and underrepresented minorities) at high academic ranks, who remain active in cutting-edge research (BIO, EHR, ENG, GEO, SBE)

National Center for Science and Engineering Statistics (NCSES), the nation's leading provider of statistical data on the U.S. science and engineering enterprise, provides unique data and analysis on R&D, infrastructure, and the STEM workforce in the Science and Engineering Indicators reports. It will provide analyses on COVID-19 impacts on the academic research community in the next updates of Women, Minorities, and Persons with Disabilities in Science and Engineering and the Indicators reports. NCSES also is adding or has already added questions related to COVID-19 impacts on the academic research community to its other surveys related to the STEM workforce. (SBE)

NSF Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM) provides awards to Institutions of Higher Education to fund scholarships for low-income, academically talented students with unmet financial need—recognizing that financial aid alone cannot increase retention and graduation in STEM The program also advances the adaptation, implementation, and study of effective evidence-based curricular and co-curricular activities that support recruitment, retention, transfer (if appropriate), student success, academic/career pathways, and graduation in STEM. (EHR, $115 M)

Partnerships in Astronomy & Astrophysics Research and Education (PAARE) is enhancing diversity in astronomy and astrophysics research and education by stimulating the development of formal, long-term, collaborative research and education partnerships among MSIs and partners at research institutions, including academic institutions, private observatories, and NSF Division of Astronomical Sciences (AST)-supported facilities. (MPS)

Partnerships in Research and Education in Materials (PREM) aims to enable, build, and grow partnerships between MSIs and DMR-supported centers and /or facilities to increase recruitment, retention and degree attainment by members of those groups most underrepresented in materials research, and at the same time support excellent research and education endeavors that strengthen such partnerships. (MPS)

Postdoctoral Research Fellowships in Biology (PRFB), includes a Broadening Participation track focused on increasing the diversity of scientists at the postdoctoral level in biology. (BIO)

Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM) recognize those who have made significant contributions to mentoring and thereby support the future productivity of the U.S. STEM workforce, including by enhancing participation of individuals (including persons with disabilities) who might not otherwise have considered or had access to opportunities in STEM disciplines and professions. Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) recognizes teachers who have both deep content knowledge of the subjects they teach and the ability to motivate and enable students to be successful in those areas. (EHR, $6 M)

Re-entry to Active Research (RARE) supports efforts to reengage, retrain, and broaden participation within the academic workforce. It catalyzes the advancement along the academic tenure-track of highly meritorious individuals who are returning from a hiatus from active research. By providing re-entry points to active academic research, the program reinvests in the nation's most highly trained scientists and engineers, while broadening participation and increasing diversity of experience. (ENG, MPS)

SBE Science of Broadening Participation (SBE SBP) supports social, behavioral, economic, and learning science research to better understand the factors that enhance as well as the barriers that hinder our ability to expand participation in education, the workforce, and major social institutions in society, including STEM and other sectors. This program advances scientific theory or knowledge in innovative ways so that educators, employers, and policy makers can make informed decisions, design effective interventions, and create programs that successfully engage diverse groups. (SBE, $1.4 M)

Tribal Colleges and Universities Program (TCUP) invests in Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions to promote high quality science (including sociology, psychology, anthropology, economics, statistics, and other social and behavioral sciences as well as natural sciences), STEM education, research, and outreach. Support is available to TCUP-eligible institutions for transformative capacity-building projects, centers, and partnerships to increase Native individuals' participation in STEM careers and improve the quality of STEM programs at TCUP-eligible institutions (EHR, GEO, SBE, $15 M)

Core and other Related Programs and Facilities:

Advanced Technological Education (ATE) supports efforts of community colleges and their business/industry partners to provide STEM education in the technological fields that power the nation's economy. (EHR, $67 M)

Advancing Informal STEM Learning (AISL) seeks to advance new approaches to and evidence-based understanding of the design and development of STEM learning opportunities for the public in informal environments; provide multiple pathways for broadening access to and engagement in STEM learning experiences; advance innovative research on and assessment of STEM learning in informal environments; and engage the public of all ages in learning STEM in informal environments. (EHR, $62 M)

CISE Education and Workforce Cluster supports the development of a diverse workforce well prepared for careers in computing-related and computationally intensive fields, including through

- CSForAll, which supports new evidence-based instructional materials and teacher professional development to expand K-12 computing education ($10 M each from CISE and EHR); and
- Improving Undergraduate STEM Education: Computing in Undergraduate Education (IUSE: CUE), a component of EHR's IUSE investment, which broadens accessibility of computing education at the undergraduate level ($3 M).

Discovery Research PreK-12 (DRK-12) seeks to significantly enhance the learning and teaching of STEM by PreK-12 students and teachers through research and development of STEM education innovations and approaches. Driven by the pressing needs to improve PreK-12 STEM teaching and learning for all U.S. students, the program is particularly interested in projects that focus on populations that are underperforming or underserved by current practice. (EHR, $88 M)

EHR Core Research (ECR) invests in fundamental research (basic research or use-inspired basic research) that advances knowledge in one or more of the three Research Tracks: Research on STEM Learning and Learning Environments, Research on Broadening Participation in STEM fields, and Research on STEM Workforce Development. The ECR program places emphasis on the rigorous development of theory and accumulation of knowledge to inform efforts to address challenges in STEM interest, learning, and participation, for all groups and all ages in formal and informal settings. (EHR)

EHR Core Research (ECR): Building Capacity in STEM Education Research (ECR: BCSER) supports projects that build individuals' capacity to carry out high quality STEM education research that will enhance the nation's STEM education enterprise and broaden the pool of researchers that can conduct fundamental research in STEM learning and learning environments. The program broadens participation through both awards for individual investigator development and support for professional development institutes. Proposals must include plans to involve faculty and postdoctoral researchers from underrepresented groups and minority serving institutions. (EHR)

Graduate Research Fellowship Program (GFRP) selects, recognizes, and financially supports individuals who have demonstrated the potential to be high achieving scientists and engineers, early in their careers. NSF is working to broaden participation of underrepresented groups, including women, minorities, persons with disabilities, and veterans in GFRP through solicitation-specific review criteria. (NSF-Wide, $285 M)

Improving Undergraduate STEM Education: Education and Human Resources (IUSE: EHR) is a core NSF STEM education program that seeks to promote novel, creative, and transformative approaches to generating and using new knowledge about STEM teaching and learning to improve STEM education and increase the success of all undergraduate learners. (BIO, CISE, EHR, ENG, GEO, $102 M)

Innovations in Graduate Education (IGE) Program funds projects that will design, pilot, and test new, innovative, and transformative approaches for inclusive STEM graduate education. IGE specifically addresses both workforce development—emphasizing broad participation—and institutional capacity building needs in graduate education. (NSF-Wide)

Innovative Technology Experiences for Students and Teacher (ITEST) is an applied R&D program providing direct student learning opportunities for PreK-12 based on innovative use of technology to strengthen knowledge and interest in STEM and information and communication technology (ICT) careers. ITEST projects broaden participation of all students, particularly those in underrepresented and underserved groups in STEM fields and related education and workforce domains. (EHR, $34 M)

Major Research Instrumentation Program (MRI) devotes a significant fraction of its investment to primarily undergraduate institutions and minority serving institutions, providing cutting-edge laboratory instrumentation to support contemporary science and engineering training for students as well as advanced research. (NSF-Wide)

National Science Foundation Research Traineeship (NRT) Program supports projects that explore ways for graduate students in research-based master's and doctoral degree programs to develop the skills, knowledge, and competencies needed to pursue a range of STEM careers. The program includes specific review criteria such that to be competitive, a proposal must include a high-quality plan to recruit and retain the participation of underrepresented groups in the project. (EHR, $33 M)

Robert Noyce Teacher Scholarship Program provides direct scholarships to preservice and in-service STEM teachers to prepare them to teach effectively in high need schools, thus expanding the pipeline into STEM higher education. (EHR, $75 M)

SBE Core Research is expanding the understanding of bias and how to counter its negative effects. Across multiple programs and research divisions, SBE has for decades supported research that uncovers causes and consequences of racial bias, including fundamental work on topics like implicit bias. Mixing complex empirics and multi-layered theories, SBE research continues to build the tactical and strategic foundation for efforts to expand access, reduce violence, and create opportunity. (SBE)

Training-based Workforce Development for Advanced Cyberinfrastructure (CyberTraining), within the Office of Advanced Cyberinfrastructure, seeks to prepare, nurture, and grow the national scientific research workforce for creating, utilizing, and supporting advanced cyberinfrastructure (CI). It is specifically focused on broadening CI access and adoption by institutions with lower levels of CI adoption and harnessing the capabilities of larger segments of diverse underrepresented groups. (CISE)

Interagency Work in Which NSF Participates

Summary: NSF staff members, from the Director on down, participate in a wide range of Executive Branch interagency S&T and Federal management groups. Because many NSF staff are well-known leaders in their fields, many chair or co-chair one or more groups. (Note that NSF staff members also participate occasionally in NSC Policy Coordination Councils not listed below.)

Federal Management Councils:

- Budget Officers' Advisory Council
- Chief Acquisition Officers Council
- Chief Data Officers Council
  - Chief Data Officers Council Operations Working Group
- Chief Financial Officers Council
  - Financial Assistance Committee for E-Government
- Chief Human Capital Officers Council
- Chief Information Officers Council
  - Chief Information Officers Council Executive Committee
  - Chief Information Security Officers Council
  - Innovation Committee
  - Services, Strategies, and Infrastructure Committee
  - Workforce Committee (Co-Chair)
- Chief Learning Officers Council
- Federal Interagency Council on Statistical Policy
- Federal Real Property Council
- Grants Quality Services Managing Organization (QSMO), Executive Steering Committee
- Interagency Council of Statistical Policy
- Performance Improvement Council
- President's Management Agenda, Cross Agency Priority Goal Committees
  - NSF participates in all but one of the CAP Goal committees (the one focused on infrastructure permitting), and leads the Executive Steering Committees *Leverage Data as a Strategic Asset* and *Results-Oriented Accountability for Grants*.
- President's Management Council
- Senior Agency Official for Privacy Council
- Senior Travel Officers Council
- Small Agency Council
- Unified Shared Services Management

Other Federal Groups:

- EPSCoR Interagency Coordinating Committee (Chair)
- National Council of the American Worker

- National Earthquake Hazards Reduction Program Interagency Coordinating Committee
- National Windstorm Impact Reduction Program Interagency Coordinating Committee
- Technology Modernization Fund Board

National Science and Technology Council:

- Committee on Environment
  - Global Change Research Subcommittee
  - Interagency Arctic Research Policy Committee
  - Ocean Science Subcommittee (Co-chair)
    - Harmful Algal Blooms & Hypoxia Interagency Working Group
    - Ocean Acidification Interagency Working Group
    - Ocean and Coastal Mapping Interagency Working Group
    - Ocean Observations Interagency Working Group
  - U.S. Group on Earth Observations Subcommittee
- Committee on Homeland and National Security
  - Biodefense R&D Subcommittee
  - Critical Minerals Subcommittee
  - Economic Security Implications on Quantum Subcommittee
  - Resilience S&T Subcommittee
  - Space Weather, Security, and Hazards Subcommittee (Co-chair)
    - Space Weather Interagency Working Group
- Committee on S&T Enterprise
  - International S&T Subcommittee (Co-chair)
  - Lab to Market Subcommittee
  - Networking and Information Technology R&D (NITRD) Subcommittee (Co-chair)
    - Artificial Intelligence R&D Interagency Working Group (Co-chair)
    - Big Data Interagency Working Group (Co-chair)
    - Computing-Enabled Networked Physical Systems Interagency Working Group (Co-chair)
    - Cyber Security and Information Assurance Interagency Working Group (Co-chair)
    - Health Information Technology Research and Development Interagency Working Group (Co-chair)
    - High End Computing Interagency Working Group (Co-chair)
    - Intelligent Robotics and Autonomous Systems Interagency Working Group (Co-chair)
    - Large Scale Networking Interagency Working Group (Co-chair)
    - Privacy Research & Development Interagency Working Group
    - Software Productivity, Sustainability, and Quality Interagency Working Group (Co-chair)
    - Wireless Spectrum Research and Development Interagency Working Group (Co-chair)

        - Fast Track Action Committee to Develop a Secure 5G and Beyond Implementation Plan (Co-chair)
    - R&D Infrastructure Subcommittee (Co-chair)
        - Scientific Collections Interagency Working Group
- Committee on Science (Co-chair)
    - Biological Sciences Subcommittee (Co-chair)
        - Synthetic Biology Working Group (Co-chair)
        - Biological Data Working Group
        - Workforce Development Working Group (Co-chair)
        - Fast-Track Action Committee on a National Strategy for Microgravity Research
    - Open Science Subcommittee (Co-Chair)
    - Physical Sciences Subcommittee (Co-Chair)
    - Quantum Information Science Subcommittee (Co-Chair)
- Committee on STEM Education (Co-chair)
    - Federal Coordination in STEM Education Subcommittee (Co-chair)
        - Computational Literacy Interagency Working Group
        - Convergence Interagency Working Group
        - Inclusion in STEM Interagency Working Group (Co-chair)
        - Strategic Partnerships Interagency Working Group
        - Transparency & Accountability Interagency Working Group (Co-chair)
- Committee on Technology
    - Advanced Manufacturing Subcommittee
    - Machine Learning and AI Subcommittee (Co-chair)
    - Materials Genome Initiative Subcommittee (Co-chair)
    - Nanoscale Science, Engineering, and Technology Subcommittee
        - Nanotechnology Environmental and Health Implications (NEHI) Working Group
        - Semiconductor Leadership R&D Working Group
    - Future Advanced Computing Ecosystem Subcommittee (Co-chair)
- Joint Committee on Research Environment (Co-chair)
    - Coordinating Administrative Requirements for Research Subcommittee (Co-chair)
    - Research Security Subcommittee (Co-chair)
    - Rigor and Integrity in Research Subcommittee (Co-chair)
    - Safe and Inclusive Research Environments Subcommittee (Co-chair)
- Select Committee on Artificial Intelligence (Co-chair)

NSF's Role in Promoting and Facilitating International Scientific Cooperation

Summary: NSF promotes international scientific collaboration through programmatic and diplomatic activities. Utilizing a variety of mechanisms that include investments at all scales—from research infrastructure to principal investigator-led projects—the Foundation's portfolio includes cooperation with almost every nation. Diplomatically, the Foundation participates in numerous multilateral bodies to include the Group of Seven, the Global Research Council, the Arctic Science Ministerial, and the Organisation for Economic Cooperation and Development (OECD). The Foundation coordinates its international engagements with other Departments and Agencies through National Security Council and National Science and Technology Council bodies.

Current Plans and/or Issues for First 100 Days:

- On February 8, 2021, Kendra Sharp will begin as the new head of NSF's Office of International Science and Engineering.
- The Republic of Ireland, the United Kingdom of Great Britain and Northern Ireland, and the U.S. agreed to coordinate research between Science Foundation Ireland, UK Research and Innovation, and NSF to enhance capabilities needed to transform infectious disease outbreak prediction and prevention. NSF is planning workshops this winter to identify research priorities needed for an integrated system of rapid detection, analysis, modeling, and countermeasures.
- The NSF will initiate dialogs with Australia, Canada, India, Japan, and the United Kingdom to explore cooperation on artificial intelligence, quantum information science, and smart-and-connected-communities in the first quarter of 2021.
- NSF and the German Research Foundation will pilot a cooperative activity on electrochemical synthesis and manufacturing in 2021.
- NSF will host a virtual MULTIPLIER (vide infra) with Australia in the first quarter of 2021 to discuss cooperation on plastics research.

Key Interagency, International, and Partnership Activities:

- Global Research Council: Established by the NSF in 2012, the GRC is a virtual organization comprised of the heads of science and engineering funding agencies from around the world that shares data and best practices.
- OECD: NSF provides the U.S. National Delegates to the Global Science Forum (GSF) and the National Experts on Science & Technology Indicators (NESTI) Working Parties. The GSF fosters improved science policy through sharing of best practices while NESTI supports efforts to develop an internationally consistent methodology for collecting and using R&D statistics. NCSES reports on this topic in the Science and Engineering Indicators , and provides data on international mobility of students in the Survey of Doctorate Recipients. NSF also contributed to the drafting of the OECD Principles on Artificial Intelligence.
- Antarctic Treaty: The NSF represents the United States on the Council of Managers of National Antarctic Programs to facilitate working level decision making and information exchange on Antarctic activities.
- NSTC International S&T Coordination (ISTC) Subcommittee: The NSF co-chairs this congressionally mandated subcommittee to the Committee on S&T Enterprise. The ISTC focuses on interagency coordination of current and future international science cooperation.

Targeted Programs and Facilities:

Accelerating Research through International Network-to-Network Collaborations supports strategic linkages between U.S. research networks and complementary networks to tackle research challenges that require significant coordinated international effort. (NSF-wide)

Belmont Forum, established in 2009 and composed of 29 members, focuses on international trans-disciplinary research to understand, mitigate, and adapt to global environmental change. (NSF-wide)

Collaborative Research in Computational Neuroscience, in partnership with Germany, France, Israel, Japan, Spain, the Department of Energy, and NIH, brings together theory, modeling, and experiment to understand neurobiological systems from genes to cell process to the interaction of neurons and circuits. (BIO, CISE, ENG, MPS, OISE, SBE)

Dimensions of Biodiversity, a partnership with Brazil, China, and South Africa, promotes novel integrative approaches to understand the intersection of genetic, phylogenetic, and functional dimensions of biodiversity. (BIO)

Evolution and Ecology of Infectious Disease supports research on the ecological, evolutionary, and social drivers that influence the transmission of infectious diseases in partnership with the United Kingdom, China, Israel, the USDA and the NIH. (BIO, GEO, SBE)

Human Frontier Science Program, a partnership among fifteen countries and the National Institutes of Health (NIH), promotes collaboration on the basic research to elucidate complex mechanisms of living organizations. (BIO, OISE)

International Research Experiences for Students supports international research and research-related activities for U.S. science and engineering students to promote workforce development. (OISE)

Molecular and Cellular Biosciences Interface, in partnership with France, funds multidisciplinary approaches that emphasize quantitative, predictive, and theory driven science aimed at understanding essential life processes at the molecular, subcellular, and cellular scales. (BIO, MPS)

Multiplying Impact Leveraging International Expertise in Research Missions (MULTIPLIER) deploys interdisciplinary teams of NSF subject matter experts on short term missions to assess, and seize upon, opportunities with foreign counterparts on priority topics. (NSF-wide)

NSF – Israel Binational Science Foundation (BSF): Under the auspices of a 2012 agreement, BSF funds the Israeli portion of NSF awarded (and reviewed) joint projects from eighteen divisions across six directorates. (NSF-wide)

Opportunities in Biological Informatics, Microbes and the Host Immune System, Quantum Biology and Synthetic Cell, in partnership with the United Kingdom, funds research to address the development of novel informatics approaches and cyberinfrastructure resources to enable novel use of data in biological research. (BIO)

Research opportunities in Europe, under the auspice of a 2019 agreement, provides supplement funding for current NSF grantees to visit counterparts in Europe who are funded by the European Research Council. (NSF-wide)

Core and other Related Programs and Facilities:

Dear Colleague Letter: Special Guidelines for Submitting Collaborative Proposals under U.S. National Science Foundation (NSF) and French Agence Nationale de la Recherche (ANR) Collaborative Research Opportunities facilitates collaboration between U.S. and French researchers on projects that develop new knowledge in all aspects of computing, communications, and information science and engineering, as well as advanced cyberinfrastructure. (CISE)

Dear Colleague Letter: ANR - NSF/Physics/MCB Lead Agency Opportunity at the Physics - Molecular and Cellular Biosciences Interface facilitates collaboration between U.S. and French researchers on projects that use multidisciplinary approaches emphasizing quantitative, predictive, and theory driven science aimed at understanding mechanisms underlying essential life processes at the molecular, subcellular, and cellular scales. (BIO, MPS)

International Research and Education Network Connections (IRNC) supports high-performance network connectivity required by international science and engineering research and education collaborations involving the NSF research community. (CISE)

NSF-DFG Lead Agency Activity in Electrosynthesis and Electrocatalysis (NSF-DFG EChem) supports collaborative work between U.S. researchers and their German counterparts in novel and fundamental electrochemical studies addressing transformations in organic and polymer synthesis, water splitting, and nitrogen reduction. (MPS, ENG)

Physics of Living Systems (PoLS) supports the international Physics of Living Systems (iPoLS) Student Research Network, a resource for graduate students and educators engaged in research that connects physics with biology to network across 10 US colleges and universities and institutions in seven other countries around the world. (MPS)

NSF's Role in Promoting Open Science, Open Data, and Scientific Integrity

Summary: It is important that research funded by NSF be findable, usable, presented in forms that produce increasingly accurate understandings of essential scientific concepts, and be trusted and valued by both the research community and the public. For NSF, the Responsible and Ethical Conduct of Research involves not only a responsibility to generate and disseminate knowledge with rigor and integrity, but also a responsibility to conduct peer review with the highest ethical standards; diligently protect proprietary information and intellectual property from inappropriate disclosure; and treat students and colleagues fairly and respectfully. NSF policies and programs address not only research and publication practices but also the environment in which those practices are carried out.

- NSF requires funded researchers to provide other researchers and the public with comprehensive access to publications and the underlying data.
- NSF encourages researchers to describe materials and methods with enough clarity and detail to allow readers to interpret published research claims accurately and to facilitate replication. It also offers training and support that helps researchers properly use statistical methods and inferences in drawing conclusions.
- NSF encourages, and supports training for researchers to consider the ethical, legal, and social implications of their work.
- NSF works to keep research and the dissemination of scientific results free from political interference.
- NSF works to broaden participation in the S&T workforce through training opportunities and other activities in ways that align the workforce with national priorities and advances in science.
- NSF works to prevent, identify, and respond to research misconduct, defined by 45 CFR 689 as fabrication, falsification, or plagiarism in proposing or performing research funded by NSF, reviewing research proposals submitted to NSF, or in reporting research results funded by NSF.
- NSF works to prevent, identify, and respond to detrimental research practices, generally defined as questionable research practices along with damaging behaviors by research institutions, sponsors, or journals (per Fostering Integrity in Research, NASEM 2017).
- NSF identifies and mitigates conflicts of interest related to funding and peer review.

NSF works to promote open science, open data, and scientific integrity by *characterizing the issues and identifying priorities* through stakeholder engagement complemented by data collection and analysis; *funding basic research* into the underlying issues, including the effectiveness of different approaches to improve the research enterprise; and *implementing change through policy and public engagement*, as described in the sections below.

Current Plans and/or Issues for First 100 Days:

- Through April 2021, additional FY 2021 solicitations will be released and solicitations already accepting proposals will begin the review process for FY 2021 awards.

Key Interagency, International, and Partnership Activities:

- NSF co-chairs the NSTC subcommittees on Open Science and on Rigor and Integrity in Research.
- NSF leadership regularly engages with other funders (domestic and international) and publishers (including professional societies) to discuss and share best practices in open science and open data.

Characterizing the Issues and Identifying Priorities (since 2017):

Fostering Integrity in Research (2017), a NASEM study funded by NSF's OIG and a multitude of other agencies, philanthropies, and professional societies, concluded that the research enterprise is not broken but faces serious challenges in creating the appropriate conditions to foster and sustain the highest standards of integrity. To meet these challenges, the report recommends deliberate steps to strengthen the self-correcting mechanisms that are an implicit part of research.

NSF Workshop on Developing Collection Management Tools to Create More Robust and Reliable Linguistic Data (2017) outlines the desirable attributes for a collection management tool for Linguistics and suggests ways in which such a tool could be built upon existing foundations.

NSF Workshop on Reproducibility Taxonomies for Computing and Computational Science (2017) brought together a small representative group to discuss competing reproducibility taxonomies associated with computing and computational science, and to accurately characterize them by illustrating their use with a set of concrete scenarios, resulting in a report that proposes a set of steps to achieve compatible, if not common, taxonomies in computational sciences and computing science.

NSF Workshop on Systematic Approach to Robustness, Reliability, and Reproducibility in Scientific Research (2017) describes opportunities to improve robustness, reliability, and reproducibility in scientific research, including more transparency for data and analysis methods, better training, and stakeholder outreach.

Companion Guidelines on Replication & Reproducibility in Education Research (2018), produced jointly by NSF and the Institute of Education Sciences at ED, addresses the challenges and implications of planning and conducting reproducibility and replication studies within education.

NSF Workshop on Statistics at a crossroads: Challenges and Opportunities in the Data Science Era (2018) brought together leading researchers and educators to develop a vision for the field of statistics, taking advantage of the unprecedented opportunities and challenges in the era of data science. Recommendations include emphasis on impact and real-world data problem solving, stability/ robustness, reproducibility, fairness, privacy, and development of a diverse workforce including ethics training.

Reproducibility and Replicability in Science (2019), a NASEM report supported by NSF and the Alfred P. Sloan Foundation (directed by Congress), offers definitions of reproducibility and replicability, examines the factors that may lead to non-reproducibility and non-replicability in research, and provides recommendations to researchers, academic institutions, journals, and funders on steps they can take to improve reproducibility and replicability in science.

Responsible Computing Research: Ethics and Governance of Computing Research and its Applications, a recently-launched NASEM study supported by NSF, will identify ethical principles and practices that research funders, research-performing institutions, and individual researchers can use to formulate, conduct, and evaluate research and associated activities responsibly.

Societal Experts Action Network (SEAN), a new NASEM group supported by NSF in response to the COVID-19 outbreak, is providing decision-makers with actionable responses to urgent policy questions based on evidence from the social, behavioral, and economic sciences. SEAN consists of experts available to develop evidence-based recommendations to support local, state, and national responses and policies.

Funding Basic Research (Key Programs):

CISE core programs support research and education projects that develop new knowledge in all aspects of computing, communications, and information science and engineering, as well as advanced cyberinfrastructure. All proposals are required to must describe, as part of their Data Management Plans, how they will provide access to well-documented datasets, modeling and/or simulation tools, and codebases to support reproducibility/replicability of their methods and results for a reasonable time beyond the end of the project lifecycle consistent with the 2017 Dear Colleague Letter: Encouraging Reproducibility in Computing and Communications Research. (CISE)

Dear Colleague Letter: Fairness, Ethics, Accountability, and Transparency: Enabling Breakthrough Research to Expand Inclusivity in Computer and Information Science and Engineering Research is a central element to NSF's commitment to maximizing the positive consequences of the research that it funds through inclusive research approaches and a key component of CISE's mission is to contribute to universal, transparent, and affordable participation in an information-based society. This DCL, now part of the CISE core programs, invites proposals to those programs that specifically contribute to discovery in research and practice related to fairness, ethics, accountability, and transparency in computer and information science and engineering. (CISE)

Dear Colleague Letter: Fundamental Research on Equity, Inclusion, and Ethics in Postsecondary Academic Workplaces and the Academic Profession within the EHR Core Research Program supports fundamental research on equity, inclusion, and/or ethics for STEM faculty in postsecondary STEM academic workplaces and academic professions. (EHR)

Ethical and Responsible Research (ER2) funds research projects that identify factors that are effective in the formation of ethical STEM researchers and approaches to developing those factors in all STEM fields that NSF supports. ER2 research projects will use basic research to produce knowledge about what constitutes or promotes responsible or irresponsible conduct of research, and how to best instill this knowledge into researchers and educators at all career stages. In some cases, projects will include the development of interventions to ensure ethical and responsible research conduct. (BIO, CISE, EHR, ENG, GEO, MPS, OISE, SBE)

Improving Undergraduate STEM Education: Computing in Undergraduate Education (IUSE: CUE) supports teams of Institutions of Higher Education (IHEs) in re-envisioning the role of computing in interdisciplinary collaboration within their institutions. In addition, NSF encourages partnering IHEs to use this opportunity to integrate the study of ethics into their curricula, both within core CS courses and across the relevant interdisciplinary application areas. (CISE, EHR)

Innovations in Graduate Education (IGE). This NSF-wide program is designed to encourage the development and implementation of bold, new, and potentially transformative approaches to STEM graduate education training. The program seeks proposals that explore ways for graduate students in research-based master's and doctoral degree programs to develop the skills, knowledge, and competencies needed to pursue a range of STEM careers, including the importance of conducting research responsibly and ethically. (EHR)

Methodology, Measurement, and Statistics (MMS) supports the development of innovative analytical and statistical methods and models for those sciences. As part of its larger portfolio, the MMS Program partners with a consortium of Federal statistical agencies to support research proposals that further the production and use of official statistics. (SBE)

NSF Program on Fairness in Artificial Intelligence in Collaboration with Amazon (FAI), a partnership with Amazon, is jointly supporting computational research focused on fairness in AI, with the goal of contributing to trustworthy AI systems that are readily accepted and deployed to tackle grand challenges facing society. (CISE, SBE)

Online Ethics Center for Engineering and Science is an important resource supported by NSF (maintained by the U. of Virginia) to provide engineers, scientists, faculty, and students with resources for understanding and addressing ethically significant issues that arise in scientific and engineering practice and from the developments of science and engineering; and serve those who promote learning and advance understanding of responsible research and practice in engineering, science, and social sciences. (SBE)

Professional Formation of Engineers: Research Initiation in Engineering Formation (PFE: RIEF) is part of a multi-year initiative (PFE) to create and support an innovative and inclusive engineering profession for the 21st Century—who recognize that the profession must be responsive to national priorities, grand challenges, and dynamic workforce needs and must be equally open and accessible to all. (ENG)

Science and Technology Studies (STS) supports research that uses historical, philosophical, and social scientific methods to investigate the intellectual, material, and social facets of the scientific, technological, engineering, and mathematical (STEM) disciplines. It encompasses a broad spectrum of topics including interdisciplinary studies of ethics, equity, governance, and policy issues that are closely related to STEM disciplines. (SBE)

Science of Science: Discovery, Communication, and Impact (SoS:DCI) is designed to increase the public value of scientific activity through research in three fundamental areas: how to increase the rate of socially beneficial discovery; how to improve science communication outcomes; and how to expand the societal benefits of scientific activity. (SBE)

Statistics supports basic research in statistical theory and methods. including causal inference, robust statistical methods, reliability and interpretability for machine learning algorithms, uncertainty quantification, replicability, and privacy-preserving methods. (MPS)

Implementing Change Through Policy and Public Engagement for Open Science, Open Data, and Scientific Integrity

Public Access to Results of NSF-Funded Research is consistent with the objectives set forth in the Office of Science and Technology Policy's Feb. 22, 2013, memorandum, "Increasing Access to the Results of Federally Funded Research," and with long-standing policies encouraging data sharing and communication of research results. NSF requires that either the version of record or the final accepted manuscript in peer-reviewed scholarly journals and papers in juried conference proceedings or transactions must be deposited in the NSF Public Access Repository (NSF-PAR); be available for download, reading and analysis free of charge no later than 12 months after initial publication; possess a minimum set of machine-readable metadata elements in a metadata record to be made available free of charge upon initial publication; be managed to ensure long-term preservation; and be reported in annual and final reports during the period of the award with a persistent identifier that provides links to the full text of the publication as well as other metadata elements. In addition, NSF has also used DCLs and other approaches to encourage the community to develop effective practices for providing broader access to research data.

Dissemination and Sharing of Research Results - NSF Data Management Plan Requirements make clear that all NSF investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections, and other supporting materials created or gathered during work under NSF grants. Awardees are expected to encourage and facilitate such sharing. Moreover, each proposal must include a supplementary Data Management Plan that describes how the proposal will conform to NSF policy on the dissemination and sharing of research results. To accommodate the diversity of data types among the many disciplines supported by NSF, individual program solicitations may provide specific guidance on preparation data management plans. In the absence of such guidance, each Directorate provides guidance on preparation of data management plans applicable to their core programs.

Limiting Proposal Requirements for Qualifications of Senior Project Personnel, to emphasize quality rather than quantity of prior work in proposal review. NSF limits the items provided to up to five products most closely related to the proposed project; and up to five other significant products, whether or not related to the proposed project.

Awardee Conflict of Interest Policies are required for each grantee organization employing more than fifty persons. NSF encourages the increased involvement of academic researchers and educators with industry and private entrepreneurial ventures but recognizes that such interactions carry with them an increased risk of conflicts of interest. NSF requires such organizations (and funded subrecipients or collaborators) to maintain an appropriate written and enforced policy on conflict of interest (COI) and that all conflicts of interest for each award be managed, reduced, or eliminated prior to the expenditure of the award funds.

Conflict-of-Interests and Confidentiality Statement for NSF Panelists are required for all proposal review panel member, site visitor, or committee of visitors member. Panelists are required to be aware of and avoid potential conflict situations that may arise. Moreover, panelists must not copy, quote, or otherwise use or disclose to anyone, including their graduate students or post-doctoral or research associates, any material from any proposal they are asked to review. A panelist must certify under

penalty of law that they have no conflicts of interest and will not divulge or use such confidential information.

Senior Personnel Must Disclose all Appointments on their grant applications, including any titled academic, professional, or institutional position whether or not remuneration is received, and whether full-time, part-time, or voluntary (including adjunct, visiting, or honorary). Senior personnel include the individual(s) designated by the proposer, and approved by NSF, who will be responsible for the scientific or technical direction of the project (Principal Investigator/Project Director) and any other individuals considered by the performing institution to be a member of its faculty or who holds an appointment as a faculty member at another institution (Faculty Associate), and who will participate in the project being supported.

Senior Personnel Must Disclose all Collaborators and Other Affiliations on their grant applications to that NSF can manage reviewer selection and ensure proposals can be reviewed objectively, without personal or institutional conflicts of interest. In addition, names and affiliations are required for individuals whose relationship would preclude their service as a reviewer, including those with personal, family, or business relationships, Ph.D. advisors, and recent co-authors, co-editors, and collaborators.

Senior Personnel Must Disclose All Current and Pending Support on their grant applications so that NSF can effectively assess the capacity of the individual to carry out the research as proposed as well as to help assess any potential overlap/duplication with the project being proposed.

NSF's Research Misconduct regulation is specified as 45 CFR 689. Research misconduct means fabrication, falsification, or plagiarism in proposing or performing research funded by NSF, reviewing research proposals submitted to NSF, or in reporting research results funded by NSF. Note that the definition is consistent with OSTP's government-wide guidance issued in 2000 and is not intended to elevate ordinary errors in research to the level of research misconduct. Nor does it contemplate that NSF OIG will act as an arbitrator of personal disagreements or technical and philosophical disputes between researchers. Neither will we investigate matters that do not involve NSF. Complainants should report allegations to the OIG or to the appropriate institutional official. Institutions aware of substantive allegations of NSF-related misconduct are required to notify OIG.

NSF's Ongoing and Potential Support for Build Back Better Priorities

Overview: In the more than 70 years since its founding, NSF has advanced foundational, exploratory research, like the detection of gravitational waves, as well as use-inspired, translational research, like the page-rank algorithm that became the basis for Google. The translational impacts of NSF-supported exploratory research can occur at varying time scales, from a few months—as demonstrated by the rapid-response projects responding to COVID-19—to years or decades, like development of the Internet.

NSF's task of identifying and funding work at the frontiers of science and engineering is not a "top-down" process; it is a process involving deep, collaborative interactions with its broad community of stakeholders, centered on the U.S. academic research and education community. As the funding source for approximately 25 percent of all federally supported basic research conducted by America's colleges and universities—and the major source of Federal funding in many fields—NSF's funding opportunities represent a balance between broad, core research areas underpinning long-term innovation and more targeted, use-inspired programs based on emerging priorities. Ultimately, the projects that NSF supports are those selected through its gold-standard merit review process by demonstrating superior intellectual merit and broader impacts. As a result of this process, for many S&T topics there are multiple core and targeted investment areas across many NSF Directorates through which relevant projects are funded. This situation is especially true for topics widely appreciated to be of broad impact, such as the R&D topics which support the four Build Back Better Priorities.

NSF Director Sethuraman Panchanathan has identified three pillars for his vision for NSF: advancing research into the future, ensuring inclusivity, and continuing global leadership in science and engineering—pillars well positioned to support the Build Back Better Priorities. He has also made clear through outreach to leaders across government, industry, academia, and philanthropy, that all sectors much collaborate and coordinate to meet today's societal challenges. Accordingly, he is prioritizing the development of sustainable partnerships that create communities of discovery and innovation to improve the critical services that local communities deliver to their residents, transform higher education to meet the needs of tomorrow's workforce, and advance public policies.

Brief overviews of how NSF priorities and programs can support the four Build Back Better Priorities are provided below. This overview is intended as a supplement to NSF's responses to the more specific S&T questions from the Agency Review Team (ART).

COVID-19: NSF's support for responding to, overcoming, and recovering from COVID-19 involves three components initiated in March 2020: keeping the NSF staff safe and productive; supporting fundamental research; and helping the academic research community manage the consequences of the pandemic. (See *NSF Coronavirus Information*.)

NSF took prompt steps to ensure all employees had access to virtual collaboration tools such as Zoom and Microsoft Teams, enabling NSF to continue to work and collaborate and for all merit review panels to be held virtually. NSF reacted quickly to ensure the building was safe for occupancy by adding building signage, closing common areas, installing plexiglass barriers, and using physical distancing protocols. (NSF remains in Phase Two, where employees may voluntarily work inside the building while maintaining mask-wearing and physical distancing protocols but telework is encouraged.) NSF has provided all staff with maximum telework flexibilities, expanding core work hours and weather and safety leave flexibilities to help balance dependent care with telework.

NSF released a Dear Colleague Letter calling for proposals focused on the COVID-19 pandemic. Using both CARES Act funds ($75M) and regular appropriations, NSF has since made over 1,000 COVID-19-related research awards from across the Foundation, primarily through our Rapid Response Research (RAPID), aimed at understanding the virus, detecting it, predicting, and mitigating spread, as well as understanding how behavior impacts transmission, and how the pandemic is impacting and will impact society. (This rapid surge of support was possible because of the broad, core programs already in place in relevant research areas.) NSF is supporting the new *Societal Experts Action Network* at NASEM to provide decision-makers with actionable responses to urgent policy questions based on evidence from the social, behavioral, and economic sciences. NSF is planning a series of interdisciplinary workshops this spring to enable a shift from being primarily reactive to being proactive in addressing future potential pandemics (For additional details, see the ART memo on *NSF Science for COVID-19 Response and Recovery.*)

NSF made the health and safety of the research community a priority, understanding the effects the pandemic is having (and will have) on NSF-funded research and facilities, and is committed to providing the greatest flexibilities to support the community consistent with OMB guidance. NSF has also implemented or expanded support aimed at mitigating the effects of COVID-19 on individual researchers—recognizing the disproportionate impact on women, those underrepresented in STEM, people early in their careers—through new fellowships, supplements to help with career-life balance, and opportunities to reorganize and replan disrupted field work.

Economic Recovery: NSF's current research and workforce development investments are supporting and are well positioned to further support the Biden-Harris plan for economic recovery through manufacturing and innovation, infrastructure and a clean energy future, workforce development, and racial equity (discussed below). NSF invests more than $300 M per year in advanced manufacturing, from improving existing processes to be more productive to training the future workforce. NSF also partners with all the Manufacturing USA Institutes, with NSF program directors sitting on multiple advisory boards. NSF supports a nation-wide array of approximately 70 centers that help support their State and local economies, including new National AI Research Institutes and Quantum Leap Challenge Institutes specifically targeted to partner with industry to accelerate economic activity in these areas. (For additional details, see the ART memo on *Contributing to Build Back Better Through Support for Fundamental Research*.)

Over the past decade, NSF has developed new or expanded approaches for supporting "high-risk, high pay-off" ideas, novel collaborations, entrepreneurship, and partnerships well-poised to address emerging areas of S&T. Programs such as the NSF Innovation Corps™ (I-Corps™), Industry-University Cooperative Research Centers, and the NSF Convergence Accelerator have extended NSF's reach beyond traditional academic research to catalyze more rapid innovation and technology translation, and to support a diverse and inclusive community of innovators.

NSF invests in the nation's infrastructure and clean energy future through research and related activities and support for major research equipment and facilities. NSF's investments in research support nearly every aspect of America's infrastructure and clean energy future—from fundamental physics, chemistry, and materials science, to large-scale systems engineering and cyberinfrastructure. NSF's investments in modern and effective research infrastructure are critical to maintaining U.S. international leadership in science and engineering, with the future success of entire fields of research depending upon access to new generations of powerful research tools.

A critical component of NSF's mission is to advance excellence in U.S. STEM education at all levels and in all settings (investing $934 M in EHR alone in FY 2019). NSF's STEM education portfolio is essential to the

development of a diverse and well-prepared U.S. workforce of scientists, technicians, engineers, mathematicians and educators and a well-informed citizenry that have access to the ideas and tools of science and engineering. Through support from all of its research directorates and offices, NSF is a leader in Federal efforts to prepare the STEM workforce for the future; remove barriers to participation in STEM careers; increase diversity, equity, and inclusion in STEM; and promote excellence in STEM education for all learners across the life-course. NSF also is a major supporter of the development of the Nation's human capital in STEM through traineeships, fellowships, research experiences, reskilling and upskilling professional development, and a wide range of institutional capacity building. In response to the COVID-19 pandemic, NSF has also increased investments for students at all stages. (For additional details, see the ART memos on *Contributing to Build Back Better Through Support for Fundamental Research* and *NSF Support for Broadening Participation in STEM and Creating an Inclusive STEM Workforce*.)

Racial Equity: NSF is strongly committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans, including within NSF's own workforce. NSF is working to identify priorities and scale evidence-based solutions to achieving equity in management, training, and higher education opportunities connected to the jobs of the future. Within the academic research enterprise, NSF has secured a leadership role in addressing sexual harassment, sexual assault, and other forms of harassment by making reporting in this area a term and condition for receiving NSF support, and is working to emphasize to the grantee community that policies on harassment include harassment beyond gender (including race). NSF has also made it explicit in policy that the responsible and ethical conduct of research includes treating all students and colleagues fairly and respectfully. NSF also supports the Committee on Equal Opportunities in Science and Engineering (CEOSE), a congressionally mandated group that advises NSF on policies and programs that encourage full participation of women, underrepresented racial and ethnic groups, and persons with disabilities in the scientific enterprise. Recommendations from CEOSE play a key role in informing NSF activities in this area—NSF currently has 28 programs spanning the entire Foundation for which Broadening Participation is a focus or an emphasis, including programs specifically addressing STEM education at our nation's Minority Serving Institutions and NSF INCLUDES—an innovative program aimed at scaling successful approaches to broadening participation through collective impact, networked communities, and/or strategic partnerships ($20 M in FY 2019). Within NSF (as an employer), the Director recently established a Racial Equity Task Force to examine employment practices and program delivery methods for potential racial barriers and make recommendations regarding how NSF can be a leader in meaningfully addressing them with the goal of extinguishing them. (For additional details, see the ART memo on *NSF Support for Broadening Participation in STEM and Creating an Inclusive STEM Workforce*.)

Climate Change: NSF is broadly investing in research related to climate change across the entire Foundation ($241 M in FY 2019), advancing the frontiers of knowledge on how and why the climate system is changing, what the impacts of climate change are and will be on ecosystems and society, developing the knowledge needed to increase the Nation's resilience to climate change, and identifying strategies to slow or halt additional warming of the planet. Key elements of these investments include support for developing and sustaining major facilities needed by the climate science community, educational resources needed for an informed citizenry, and fellowship programs to cultivate a diverse, highly trained workforce. NSF leadership in polar research programs is essential to international efforts to understand and protect the critical parts of the planet. Similarly, NSF leadership in multiple national and international coordinating bodies, including USCRCP and the Belmont Forum, is key to ensuring collaborative approaches to the global challenge of climate change. (For additional details, see the ART memo on *NSF Contributions to Climate Research.*)

NSF Research Infrastructure to Build Back Better

including Mid-Scale investments and capacity-building investments through EPSCoR, Office of Advanced Cyberinfrastructure

Summary: Modern and effective research infrastructure is critical to maintaining U.S. international leadership in science and engineering, with the future success of entire fields of research dependent upon access to new generations of powerful research tools developed, constructed, and maintained through NSF support. NSF supports more than 20 major research facilities that are operating or under development or construction—all world-leading and many unique. These major facilities include radio and optical telescopes, gravitational-wave detectors, ocean-going research vessels, networks of ocean, geological, and biological sensors, high-magnetic-field science research facilities, particle accelerators, atmospheric research facilities, and the physical infrastructure needed to maintain U.S. presence and scientific research in Arctic and Antarctic regions. NSF's major facilities attract the best scientists in the world to use those facilities and to work at U.S.-based institutions.

NSF also funds a suite of mid-scale academic research infrastructure that is a critical component of hands-on instrumentation development and training for the next generation of scientists and engineers. A new NSF-wide program was begun in 2019, in response to both Congressional language and a comprehensive report by the National Science Board on the need to fund research infrastructure in the mid-scale range. Under this new program, Mid-scale RI-1 (R&RA) supports "implementation" proposals for projects from $6 M to $20 M that are ready to launch and "design" proposals to bring potential projects to a state of readiness for future consideration. Mid-scale RI-2 (MREFC) supports implementation projects from $20 M to $100 M. Established mid-scale research infrastructure includes a set of long-term ecological research centers, the network of telescopes that recently acquired the first image of a massive black hole, the Alvin deep-ocean submersible vehicle, associated computing and data infrastructure , a national-scale network infrastructure for experimenting on new ideas for the next-generation Internet, and a set of experiments probing the cosmic microwave background. The Chief Officer for Research Facilities in the Office of the Director serves as the senior agency official whose responsibility is oversight of the development, construction, and operations of major facilities across NSF.

Established Program to Stimulate Competitive Research (EPSCoR) at NSF is investing to strengthen research capacity and competitiveness in 28 eligible jurisdictions, including through research infrastructure improvement awards that support physical, human, and cyberinfrastructure development. One current focus of NSF's EPSCoR program is the approximately 150 Minority-Serving Institutions located within these jurisdictions.

The NSF Office of Advanced Cyberinfrastructure (OAC) invests in the development, acquisition, provisioning and coordination of state-of-the-art cyberinfrastructure resources, tools, systems and services, and expertise essential to the advancement and transformation of academic science and engineering research and education nation-wide. These investments in a national network of advanced computing resources include advanced computing systems and services; community-scale data and software systems; high-speed domestic and international networking systems; cybersecurity; and related human capacity building through programs for training and workforce development.

Current Plans and/or Issues for First 100 Days:

COVID-19 has impacted almost all the major facilities in operation and under construction. Most facilities had to curtail operations to some extent due to closure of local field sites, travel restrictions, or social distancing requirements. Extensive changes and accommodations have been required for operations and research in Antarctic logistics to ensure the safety of all personnel. COVID-19 related restrictions have similarly impacted facilities under construction. Many facilities have multi-stage plans for returns to operations that are in various stages of execution. These typically involve transitions from fully remote work to having some high-priority activities conducted on-site and are subject to changing pandemic conditions. Costs and delays for construction project completion will depend on the lengths of project suspensions or slowdowns and can be estimated when the additional costs and time required to restart construction are better known.

Finally, inspired by the success of the COVID-19 High Performance Computing Consortium, a Request for Information on a potential National Strategic Computing Reserve will be issued this month with responses requested next month. Planning will continue after feedback is received from the community.

Key Interagency, International, and Partnership Activities:

- NSF co-chairs the NSTC subcommittees on R&D Infrastructure, Networking and Information Technology R&D, and the Future Advanced Computing Ecosystem.
- NSF chairs the EPSCoR Interagency Coordinating Committee.
- From astronomical assets, to ships at sea, to polar programs, the multi-user research facilities supported by NSF are widely involved in partnerships and collaborations, both domestic and international.

Major Facilities Under Construction including Mid-Scale Research Infrastructure (Mid-scale RI):

In FY 2019, NSF invested $285 M in construction of major research facilities. The five currently active major facility construction projects are listed below. *The costs shown are the planned total project costs prior to the impacts of COVID-19*; costs are generally expected to increase by amounts not yet known.

Antarctic Infrastructure Modernization for Science (AIMS) will replace several major structures at McMurdo Station, Antarctica, one of three permanent stations that comprise the U.S. presence in Antarctica, to meet anticipated science support requirements for the next 35 to 50 years while reducing operations costs. The project will help ensure enduring U.S. leadership and influence in this strategic region. It will also support critical scientific research and capabilities such as nuclear test detection, earthquake monitoring, and real-time weather data collection for global forecasting. (MREFC, $410 M[1])

Daniel K. Inouye Solar Telescope (DKIST) will be the world's most powerful solar observatory, poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities and helping to answer questions about solar activity that can affect civil life on Earth (through phenomena generally described as space weather) and may affect the Earth's climate. (MREFC, $344 M)

[1] https://www.nsf.gov/about/budget/fy2021/pdf/12_fy2021.pdf. Estimated total project costs are provided from the FY 2021 budget request, the most current year for which facilities actual investments are publicly available.

High Luminosity-Large Hadron Collider Upgrade (HL-LHC) will upgrade two major detectors (ATLAS and CMS) essential for high-energy physics research at the LHC, the world's largest and highest-energy particle accelerator, operated by the CERN near Geneva, Switzerland. The detector upgrades will help physicists learn about the elementary particles and fundamental forces that shape the universe. (MREFC, $153 M)

Regional Class Research Vessels (RCRV) will be three cutting-edge additions to the U.S. Academic Research Fleet—ship-based laboratories that enable scientists and educators to study U.S. coastal waters. (MREFC, $354 M)

Vera C. Rubin Observatory, previously known as the Large Synoptic Survey Telescope, will be comprised of an 8.4-meter wide-field optical telescope in Chile with a 3.2 giga-pixel camera and an advanced data management system, which together are designed to carry out a deep survey of nearly half of the sky approximately twice a week. This unique capability has the potential to advance every field of astronomical study, from the inner Solar System to the large-scale structure of the Universe. (MREFC, $473 M)

The following three projects are the first awards made from the new Mid-scale RI-2 program.

Global Ocean Biogeochemistry Array will release a network of 500 robotic floats into the ocean to collect chemistry and biology data from the surface down to a depth of more than 1 mile. Five research institutions, led by the Monterey Bay Aquarium Research Institute, will work with industry partners to construct the floats. This array will improve and expand monitoring of the ocean's health, including the health of ocean life and fisheries, by measuring temperature, depth, salinity, oxygen concentration, acidity, nitrate concentration, sunlight, chlorophyll, and particles in the water. (Mid-scale RI-2, $53 M)

Grid-Connected Testing Infrastructure for Networked Control of Distributed Energy Resources will provide unique, open-access assets with the potential to advance the integration of renewables and distributed energy resources into the power grids of the future. Based at U. of California, San Diego, this testbed will incorporate real-time data analytics, machine learning and distributed control algorithms. The facility, which researchers around the country will be able to access remotely, will provide outreach to students and teachers at local K-12 schools and community colleges as well as offer training to Native American tribes who rely on microgrids for electricity. (Mid-scale RI-2, $39 M)

High Magnetic Field Beamline at the Cornell High Energy Synchrotron Source will equip one of the world's most powerful X-ray light sources with unprecedented capabilities to learn about the quantum properties of materials. The new beamline will feature the highest direct current magnetic fields available at any synchrotron facility in the world. (Mid-scale RI-2, $33 M)

Facilities Under Development or in Planning Phase

Advanced LIGO Plus will upgrade the Laser Interferometer Gravitational-wave Observatory (LIGO) with a third generation of detectors, increasing the volume of deep space the observatory can survey by as much as seven times to further increase our understanding of the events that shape the universe. (MPS)

Antarctic Research Vessel is a concept for the next generation of research vessel to support ocean-going research projects in the Antarctic region. This vessel would replace the *Nathaniel B. Palmer* and the *Laurence M. Gould* and would have capabilities to perform marine science research over significantly larger oceanic regions off the Antarctic continent. (GEO)

Cosmic Microwave Background-Stage 4, with development funded through Mid-scale RI-1, is planning a next-generation ground-based cosmic microwave background experiment consisting of dedicated telescopes equipped with highly sensitive superconducting cameras operating at the South Pole, the high Chilean Atacama plateau, and possibly northern hemisphere sites. This facility would provide a dramatic leap forward in the understanding of the fundamental nature of space and time and the evolution of the Universe. (MPS and GEO)

Extremely Large Telescopes (ELTs), include two candidates in the design and planning phases, the Thirty Meter Telescope (TMT) and the Giant Magellan Telescope (GMT) to provide optical and infrared observations from the ground. These two projects would constitute a two-hemisphere system of complementary ELT-class telescopes that would provide the US science community with access to 100% of the night sky to make the next generation of discoveries about our Universe. Chile is the proposed site for the GMT in the south, and for the north, Maunakea, Hawai'i, USA is the proposed primary site for the TMT (with La Palma, Canary Islands, Spain as the back-up site). (MPS)

IceCube Gen2 is a concept under development for a next-generation observatory at IceCube, the South Pole neutrino observatory with a cubic-kilometer particle detector made of Antarctic ice and located near the Amundsen-Scott South Pole Station. The next generation would increase the (ice) detector volume by more than a factor of two, providing a unique opportunity to measure the properties of neutrinos, the least understood of the fundamental particles discovered to date. (GEO and MPS)

Leadership-Class Computing Facility (LCCF), is expected to support a computing system providing ten-fold or more time-to-solution performance improvement over Frontera, the current NSF leadership system. This project was recently admitted to the preliminary design phase, the second of three phases in NSF's formal design stages leading to possible construction. (CISE)

Next-generation Very Large Array (ngVLA) is exploring the science opportunities, design concepts, and technologies needed to construct a new class of radio telescope—an array, consisting of 263 antennas, to be concentrated across the desert southwest of the United States and with outlying antennas at distances as large as the U.S.—to address some of the biggest science questions that radio astronomy can help answer. (MPS)

Superconducting-Resistive Hybrid Magnets are under development at National High Magnetic Field Laboratory (NHMFL). NSF has funded the R&D for a 40-Tesla all-superconducting DC magnet as a steppingstone for a possible future MREFC project to design and build a 60-Tesla magnet. Such magnets provide increased time at field and/or decreased noise levels to reveal new physics associated with a range of materials. (MPS)

Major Multi-User Research Facilities and FFRDCs in Operation:

In FY 2019, NSF invested $1.0 B operating and maintaining major facilities and Federally-Funded Research and Development Centers (FFRDCs). These major multi-user research facilities provide large, state-of-the-art tools for research and education. These major facilities include radio and optical telescopes, gravitational-wave detectors, ocean-going research vessels, networks of ocean, geological, and biological sensors, high-magnetic-field science research facilities, particle accelerators, atmospheric research facilities, and the physical infrastructure needed to maintain U.S. presence and scientific research in Arctic and Antarctic regions. In addition, scientific utilization of cyber-enabled and geographically distributed facilities continues to increase because of rapid advances in computer,

information, and communication technologies. NSF's investments are coordinated with those of other organizations, federal agencies, and international partners to ensure they are complementary and well-integrated. Planning, operations, and maintenance of major facilities are funded through the R&RA account. (Most construction is funded through the MREFC account.) For details, see the Major Facilities List (current as of 11/04/2020) and the NSF FY 2021 Budget Request to Congress. (NSF-wide)

Capacity-building Investments Through EPSCoR:

NSF EPSCoR currently covers 28 eligible jurisdictions where investments are made to increase the research competitiveness of those jurisdictions and build a STEM-capable workforce. One current focus is the approximately 150 Minority-Serving Institutions located within these jurisdictions, where NSF investments are being made to enhance their ability to engage in data-intensive discovery, develop their STEM workforce, and support their early career faculty members.

EPSCoR utilizes three investment strategies in pursuit of its goal to strengthen research capacity and competitiveness in eligible jurisdictions: Research Infrastructure Improvement (RII) awards that support physical, human, and cyberinfrastructure development; co-funding in partnership with NSF directorates and offices that support individual investigators and groups within EPSCoR jurisdictions; and outreach activities and workshops that bring EPSCoR jurisdiction investigators together with program staff from across the Foundation to explore opportunities in emerging areas of science and engineering aligned with NSF strategic priorities and with jurisdictional science and technology goals.

In FY 2019, NSF EPSCoR invested a total of $176 M in program support, with $145 M (82.5%) directed to RII (including mid-scale awards to U. of Delaware and U. of Wyoming); $31 M (17.%) to co-funding; and $120,000 (0.1%) to outreach activities and workshops. Including commitments made in prior years, NSF invested $916 M in EPSCoR jurisdictions in FY 2019.

Capacity-building Investments Through the Office of Advanced Cyberinfrastructure:

NSF Office of Advanced Cyberinfrastructure (OAC) supports the conceptualization, design, and implementation of the advanced research cyberinfrastructure (CI) ecosystem that is critical to advances in all areas of science and engineering research and education in the 21st century. OAC's investments enable advances in the industries of the future, such as AI, QIS, and advanced wireless technologies, and those envisioned by the recent interagency strategic plan for the future advanced computing ecosystem and its predecessor, the National Strategic Computing Initiative.

OAC works in partnership with all NSF directorates and offices as well as all the CISE divisions to provide support to academic institutions and encourages a rich and vibrant ecosystem that blends translational computer and computational research and research-specific CI with innovations from the private sector. Specifically, OAC investments include acquisition, integration, coordination, and operations associated with shared data, secure networking, advanced computation, scientific software and data systems and services, and the design and development of computational and data-enabled science and engineering tools. OAC also nurtures the computational and data skills and expertise needed for next-generation science and engineering research. About 34 percent of the OAC portfolio is available to support new awards, with the remaining 66 percent supporting awards made in prior years.

OAC investments directly drive capacity-building in three ways. First, investments are made holistically at the institutional, regional, and national scales, resulting in an expanding ecosystem of advanced CI resources widely accessible to U.S. researchers. Second, through dedicated funding programs in

Learning and Workforce Development (for instance, CAREER, CyberTraining), OAC supports skill development for CI, targeting researchers (including students and faculty), CI developers, and CI professionals. Third, OAC invests in a diverse range of community-building activities— from support for community-engaging organizations, to support for projects and workshops that bring together the CI and disciplinary research communities in new ways. An increasing area of emphasis between OAC and the disciplinary research communities is in the area of NSF's large facilities, notably ensuring OAC community expertise in the design and implementation of the underlying cyberinfrastructure (e.g., NSF Workshops on Cyberinfrastructure for Large Facilities, Cyberinfrastructure Center for Excellence (CI CoE) in collaboration with the National Ecological Observatory Network). Collectively, OAC enables thousands of faculty and researchers to address complex and multidisciplinary discovery, prediction, and innovation challenges using NSF-supported cyberinfrastructure. (CISE, $222 M in FY 2019)

How NSF Can Collaborate to Promote Research Security and Research Openness

working together with the White House, science agencies, and others

Summary: NSF continues a 70-year legacy of supporting fundamental research at U.S. academic institutions—a legacy rooted in the values of open science, where non-classified research that is collaborative and openly shared with others, regardless of nationality, results in the maximal benefit for *all* parties involved. The recent challenge of competing countries using questionable mechanisms to recruit U.S.-based talent to expand their intellectual and human capital has led NSF to contribute to several interagency efforts to better coordinate policies needed for the United States to safely maintain an open research enterprise. NSF is committed to balancing the value of openness with legitimate concerns about inappropriate dissemination of information and unreported conflicts of interest and commitment when researchers have multiple affiliations and sources of support. The urgency and impact of international collaborations and sharing of knowledge during the COVID-19 pandemic has dramatically reinforced how vital such open collaboration is to scientific progress.

NSF's task of identifying and funding work at the frontiers of science and engineering relies on deep, collaborative interactions with its broad community of stakeholders, centered on the U.S. academic research community. Therefore, it is important that **NSF program staff not have or appear to have the role of a watchdog over the community; rather, NSF has chosen to strengthen its policies to ensure that researchers adhere to a rigorous standard of research integrity**. These policies include strengthening requirements for reporting of all professional appointments and sources of research funding to be able to assess conflicts of interest and commitment; maintaining the integrity of the merit review process and minimizing the risk of improper foreign influence; and ensuring the security of pre-publication data. NSF further supports these efforts through continuous engagement with the research community and other Federal agencies. These activities are led by the Chief of Research Security Strategy and Policy (CRSSP), a new position created in March 2020 to handle the increasing attention research security requires. NSF will continue its efforts in cross-agency coordination, balancing between protecting the nation's investment in fundamental research and safely enabling the research community to continue its role as an international leader of collaborative, open science.

Current Plans and/or Issues for First 100 Days:

- NSF continues to regularly engage with stakeholders from the Federal. Congressional, academic, and industrial communities on issues related to research security and disclosure.

Key Interagency, International, and Partnership Activities:

- NSF actively participates in the NSTC subcommittee on Research Security (co-chair); Economic Security Implications on Quantum; International S&T Coordination (co-chair); R&D Infrastructure (co-chair); and Rigor and Integrity in Research (co-chair).
- NSF is an *ex-officio* member of the NASEM Roundtable on Research Security, which is convening members of the national intelligence, business, law enforcement, and research communities to explore critical issues related to science security. The first meeting was held in November 2020.

Key Activities to Characterize the Issues and Identify Priorities for Research Security and Openness

- In 2019, NSF tasked the JASON advisory group to examine threats to basic research posed by foreign governments and investigate whether current open science policies compromise national security. (The JASON is a long-standing, independent group of scientists with security clearances

often tasked by the military to investigate S&T concerns relevant to national security.) A key recommendation of the resulting report, Fundamental Research Security, was that the Federal government should continue the policy spelled out in NSDD-189—*that, to the maximum extent possible, the products of fundamental research remain unrestricted*.

- Enhancing the Security and Integrity of America's Research Enterprise (2020), prepared by the NSTC-JCORE subcommittee on research security (co-chaired by NSF), outlines OSTP's top concerns and priorities for research security.
- NSF employs a full-time data scientist dedicated to developing new analytics capacities for the CRSSP and assisting the agency in understanding security concerns within its funding portfolio.

Agency Activities and Policies to Balance Research Security and Openness:

NSF is continuously developing its policies to ensure the entire enterprise supporting NSF's mission—including everyone involved in NSF-funded research—performs with the utmost rigor and integrity. In addition, NSF collaborates closely with its independent Office of Inspector General (OIG) to respond to newly reported incidents of conflict of interest and commitment. Cases considered to exhibit waste, fraud, or abuse of NSF grants are referred to OIG for further investigation, which then recommends whether administrative actions such as suspension or debarment are warranted by the agency.

As NSF's understanding of the research security landscape has improved, new policies have been implemented over the past two years focused on strengthening the transparency of reporting and increasing the awareness of the research community to existing NSF requirements related to reporting and ethical conduct. NSF activities during this time include the following:

- Improving NSF reporting requirements for current and pending support (grants supporting the applicant's work) in the proposal submission process. Updates include a clarified revised definition and FAQ of what support needs to be disclosed and the implementation of a web-based form to submit Biosketch and current and pending support information (a form that NIH and Department of Energy have publicly stated they will adopt).
- Prohibiting NSF employees and IPAs detailed to NSF from participating in foreign government talent recruitment programs to avoid potential conflicts of interest.
- Launching mandatory research security training for all NSF employees and developing specific training for NSF program officers (to be launched in February 2021) focused on NSF's integrity practices (defined by our Responsible and Ethical Conduct of Research guidelines) and issues and concerns associated with multiple professional affiliations and commitments.
- Implementing new guidelines for post-award disclosures of affiliations and commitments that were not but should have been included when the proposal was submitted. Required disclosures of concern include unreported funding and in-kind contributions per the NSF's terms and conditions for grant management (Article 38).
- Establishing a leadership-level research security strategy and policy group to provide guidance and oversight during the development of policies and activities supporting research security.
- Implementing a new term and condition for international collaboration at large facilities. NSF has also established an agency review team for International Collaboration in Large Facilities to assess proposals for international collaboration and provide guidance to the awardee.

These efforts build upon a strong foundation of research integrity-related policies, highlighted as follows:

Also see the ART memo on NSF's Role in Promoting Open Science, Open Data, and Scientific Integrity.

Conflict-of-Interests and Confidentiality Statement for NSF Panelists are required for all proposal review panel members, site visitors, or Committee of Visitors members. Panelists are required to be aware of and avoid potential conflict situations that may arise. Moreover, panelists must not copy, quote, or otherwise use or disclose to anyone, including their graduate students or post-doctoral or research associates, any material from any proposal they are asked to review. A panelist must certify under penalty of law that they have no conflicts of interest and will not divulge or use such confidential information.

Awardee Conflict of Interest Policies are required for each grantee organization employing more than fifty persons. NSF encourages the increased involvement of academic researchers and educators with industry and private entrepreneurial ventures but recognizes that such interactions carry with them an increased risk of conflicts of interest. NSF requires such organizations (and funded subrecipients or collaborators) to maintain an appropriate written and enforced policy on conflict of interest (COI) and that all conflicts of interest for each award be managed, reduced or eliminated prior to the expenditure of the award funds.

Senior Personnel Must Disclose all Appointments on their grant applications, including any titled academic, professional, or institutional position whether or not remuneration is received, and whether full-time, part-time, or voluntary (including adjunct, visiting, or honorary). Senior personnel include the individual(s) designated by the proposer, and approved by NSF, who will be responsible for the scientific or technical direction of the project (Principal Investigator/Project Director) and any other individuals considered by the performing institution to be a member of its faculty or who holds an appointment as a faculty member at another institution (Faculty Associate), and who will participate in the project being supported.

Senior Personnel Must Disclose All Current and Pending Support on their grant applications so that NSF can effectively assess the capacity of the individual to carry out the research as proposed as well as to help assess any potential overlap/duplication with the project being proposed.

Senior Personnel Must Disclose all Collaborators and Other Affiliations on their grant applications so that NSF can manage reviewer selection and ensure proposals can be reviewed objectively, without personal or institutional conflicts of interest. In addition, names and affiliations are required for individuals whose relationship would preclude their service as a reviewer, including those with personal, family, or business relationships, Ph.D. advisors, and recent co-authors, co-editors, and collaborators.

NSF Science for COVID-19 Response and Recovery

Summary: NSF has long supported research across a broad spectrum of areas relevant to understanding the emergence, evolution, and transmission of viruses, the biology and ecology of how they function, and effective approaches to detect and mitigate their impact on living systems, social organizations, and the economy. These areas are supported on an on-going basis through core programs, focused standing programs and special initiatives, and large facilities and state-of-the-art infrastructure. As the COVID-19 pandemic emerged in early 2020, NSF quickly mounted an agency-wide response, using both supplemental funding supplied through the CARES Act ($76 M) as well as regular FY 2020 appropriations ($121.5M)[1] to support research to understand the biology of SARS-CoV-2, the spread and social context of the COVID-19 disease, the ability to track and mitigate viral spread, and the behavioral and societal impacts of the pandemic

NSF employed several funding mechanisms, most notably the Rapid Response Research (RAPID) mechanism, to fund 1,172 awards for COVID-19 research, supporting nearly 2,250 principal investigators in 48 states and the District of Columbia. These awards enabled research in all fields of science and engineering and STEM education, facilitated access to data and advanced computational infrastructure, and enabled translation to innovative products through our small business programs. Together, these provided the critical knowledge to understand the virus, model its spread, and mitigate the impacts. In addition to COVID science, NSF has supported STEM education projects to provide science-based educational resources about COVID-19 and develop way to address misconceptions about the pandemic.

NSF, in partnership with OSTP, DOE, and IBM, had a key role in establishing the COVID-19 High Performance Computing (HPC) Consortium. NSF-supported computing systems are an essential component of the HPC Consortium, which gives researchers access to HPC resources for research on simulating viral structures for vaccine and therapeutics development and modeling disease transmission to identify mitigation strategies.

Becoming more effective at predicting future outbreaks of disease would enable interventions, in real time, to contain those outbreaks and prevent large numbers of deaths and economic hardships. To achieve that predictive capability, there is a critical need to understand the molecular, organismal, ecological, and evolutionary origins of emerging infectious diseases; to develop general computational approaches to model physical and social drivers of their transmission including mechanisms of cellular and host resistance; to enhance predictive models of human behavior and decision-making; and to create agile processes and devices for detection to acquire, share, and integrate the data necessary to inform response in the event of an outbreak.

Current Plans and/or Issues for First 100 Days:

- Additional infectious disease science-related FY 2021 solicitations will be released and many solicitations already accepting proposals will begin the review process for FY 2021 awards.
- As part of NSF's collaboration with Ireland and the UK to develop capabilities for predictive intelligence of future disease outbreaks, NSF is planning workshops this winter to identify research priorities needed for an integrated system of rapid detection, analysis, modeling, and countermeasures.

[1] FY 2020 Agency Financial Report

- Inspired by the success of the COVID-19 High Performance Computing Consortium, a Request for Information on a potential National Strategic Computing Reserve will be issued in December, 2020 with responses requested in January, 2021. Planning will continue after feedback is received from the community.
- The CIVIC Innovation Challenge (CIVIC) is a competition that flips the community-university dynamic, asking *communities* to identify civic priorities ripe for innovation and then to partner with researchers to address those priorities. CIVIC expects to make stage 1 awards in early 2021 to bring together community stakeholders and researchers to solve issues associated with COVID-19.
- *Operations at most of the NSF-supported large facilities have been disrupted by the pandemic to some degree*, ranging from minor disruptions due to full telework status, all the way to closure/limited operations at some facilities. Biological and geoscience research at field sites nationally, internationally, and at polar regions has been severely limited due to lack of access. International research partnerships, as well as NSF's International Research Experiences for Undergraduates, have been disrupted due to lack of access and travel restrictions.

Key Interagency, International, and Partnership Activities:

- NSF co-chairs the NSTC Biological Science Subcommittee and a working group effort to develop a pandemic playbook identifying cutting-edge biotechnologies that will better prepare the Nation for future emerging infectious diseases. NSF also participates in the working group on Emerging Infectious Diseases under the Subcommittee on Health Security Threats and co-chairs the Machine Learning and AI subcommittee and the Future Advanced Computing Ecosystem Subcommittee.
- NSF, CDC, IARPA, and OSTP recently held a National Summit on the Science and Technology of Epidemiological Modeling and Prediction, which convened top researchers and end-users from across all sectors of the S&T ecosystem to improve America's capacity to respond to infectious disease outbreaks.
- NSF co-led the formation of the COVID-19 HPC Consortium, a broad inter-agency, public-private, and international partnership, and is its largest provider of computing resources.
- OSTP has designated NSF as the lead to organize and lead monthly meetings with Chief Science Advisors and Funding Agency Heads from 15 countries to discuss and coordinate on COVID-19 research efforts. NIH, State, and OSTP have also participated in these meetings.
- The Republic of Ireland, the United Kingdom of Great Britain and Northern Ireland, and the U.S. agreed to coordinate research between Science Foundation Ireland, UK Research and Innovation, and NSF to enhance capabilities needed to transform infectious disease outbreak prediction and prevention. (See plans above.)
- NSF engages in significant international collaborations to support COVID-19 and other infectious diseases projects through programs listed below, notably including the international and interagency program on Ecology and Evolution of Infectious Disease.
- NSF supports and participates in the Human Science Frontiers Program (HFSP), which promotes international collaboration in basic biological research. Through HSFP, NSF also helped to launch the Global Biodata Coalition that aims to identify and support a set of Global Core Data Resources that are crucial for ensuring international coordination of biodata, including infectious diseases.

Targeted Programs and Facilities:

Ecology and Evolution of Infectious Diseases (EEID), a partnership with NIH, USDA, China, United Kingdom, and Israel, supports research on the ecological, evolutionary, and social drivers that determine the transmission dynamics of infectious diseases through quantitative, mathematical, or computational models that elucidate infectious disease systems. (BIO, GEO, SBE)

Dear Colleague Letter; Sentinel Cells for Surveillance and Response to Emergent Infectious Diseases (Sentinels) will support research combing synthetic biology, cellular engineering, biosensing, and immune-engineering, and other approaches at the intersection of biology and engineering to address the threat of emerging infectious diseases through novel approaches to sense and respond to new infectious agents via their destruction and/or protection of the host. (BIO, ENG)

NSF is providing ongoing support for an Expeditions in Computing project on Computational Epidemiology and the PREPARE Project to facilitate communication and collaboration among CISE researchers currently involved in pandemic research. (CISE)

Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science (SCH), a partnership with NIH, supports transformative high-risk, high-reward advances in computer and information science, engineering, mathematics, statistics, behavioral and/or cognitive research to address pressing questions in the biomedical and public health communities. (CISE, ENG, MPS, SBE)

Dear Colleague Letter: Future of International Research Collaboration Post COVID-19 seeks to understand the nature and scope of COVID-19 impacts on international collaboration in research and education and to encourage creative efforts to leverage the unique moment to enable more robust, resilient, and sustainable collaborations. (OISE)

Dynamics in Socio-Environmental Systems (DISES) supports understanding of integrated socio-environmental systems and the complex interactions among the environmental and human components of such a system, including infectious diseases. (BIO, GEO, SBE)

Core and other Related Programs and Facilities:

Core programs in the Division of Environmental Biology, including Population and Community Ecology, and Evolutionary Processes, support basic research on ecological interactions and the evolution of zoonotic infectious diseases, and the systematics and biodiversity of parasites, microbes, and viruses. (BIO)

Symbiosis, Infection and Immunity and related programs in the Division of Integrative Organismal Systems support research on mechanisms of interactions among viruses, prokaryotes, and animals, advancing the basic understanding of immunity including viral-host interactions. (BIO)

Core programs in the Division of Molecular and Cellular Science, including Cellular Dynamics and Function, Genetic Mechanisms, Systems and Synthetic Biology, and Molecular Biophysics support basic research in genomics and structural biology of virus function and viral-host cell interactions. (BIO)

Core programs in the Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET), especially the Engineering Biology and Health Cluster, support engineering research to promote novel systems for detection, screening, and modeling in cells and tissues; stimulating advancements in synthetic biology and biomanufacturing; and improving quality of life through technologies and devices. (ENG)

NSF's SBIR program focuses on transforming scientific discovery into products and services with commercial potential and/or societal benefit, including research and development of devices for detection and contract tracing of infectious disease. (ENG)

Mathematical Biology supports research in areas of applied and computational mathematics with relevance to the biological sciences, including modeling of infectious disease transmission. (MPS)

Joint DMS/NIGMS Initiative to Support Research at the Interface of the Biological and Mathematical Sciences (DMS/NIGMS), a partnership with NIH, supports projects that promote basic research at the interface between mathematical and life sciences. (MPS)

Division of Chemistry programs broadly support chemical discovery and innovation, including foundational research important to biotechnology, drug discovery, and life process. For example, Chemistry of Life Processes is advancing the fundamental understanding of the molecular underpinnings of biological processes (such as the SARS-CoV-2 virus) and new chemical approaches to monitor and mitigate the effects of COVID-19. (MPS)

The Molecular Software Institute (MolSSI), an NSF-funded nexus for science, education, and cooperation serving the worldwide community of computational molecular scientists, quickly set-up and is hosting the COVID-19 Molecular Structure and Therapeutics Hub. The hub serves as a community-driven data repository and curation service for molecular structures, models, therapeutics, and simulations related to computational research related to therapeutic opportunities for COVID-19. (CISE, MPS)

Division of Materials Research (DMR) programs broadly advance the building blocks of technology and innovation, including advances in biotechnology needed to combat COVID-19 and future pandemics. For example, Biomaterials (BMAT) supports fundamental materials research related to biological materials, biomimetic, bioinspired and bioenabled materials, synthetic materials intended for applications in contact with biological systems, and processes through which nature produces biological materials. (MPS)

NSF-supported Multi-user Facilities, including the National High Magnetic Field Laboratory (MagLab) and Center for High-Energy X-ray Science (CHEXS), have made available state-of-the-art instrumentation and prioritized time for research to understand and mitigate the SARS-CoV-2 virus. (MPS)

Biological Anthropology supports basic research in areas related to human evolution and contemporary human variation, including genetic variation and adaptability to infectious disease. (SBE)

Decision, Risk and Management Sciences (DRMS) supports research to increase the effectiveness of decision making by individuals, organizations, and society including risk analysis, perception, and communication concerning public health and diseases. (SBE)