NSF FY 2024 Budget Request to Congress

The National Science Foundation Act of 1950 (Public Law 81-507) sets forth our mission: ***"To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..."***

The National Science Foundation's FY 2024 Budget Request of $11.314 billion will fund research and education across all fields of science, technology, engineering, and mathematics (STEM), supporting the economic and national security interests of the Nation and its workforce. Simply put, NSF investments are critical for modernizing the existing research and development infrastructure, expanding the STEM workforce, and promoting equitable access to scientific learning and resources to unleash the full potential of the Nation's R&D enterprise.

Over the past seven decades, NSF has funded research and researchers, innovations and innovators, and infrastructure, resulting in transformational technologies and incredible benefits to the Nation. Many of the technologies and industries that are at the root of US economic competitiveness and sustainability — advanced manufacturing, advanced wireless, artificial intelligence, biotechnology, microelectronics and semiconductors, quantum information science and engineering — are grounded in sustained NSF support. The Internet, Qualcomm, 3D printing, economic theory underpinning spectrum auctioning and kidney exchanges, and even the polymerase chain reaction (PCR) testing technique that was critical in the fight against COVID-19 were all supported by early NSF investments.

In FY 2024, the Foundation will continue to move the needle forward on scientific priorities articulated in the CHIPS and Science Act. The agency will strengthen at speed and scale its capacity to produce breakthroughs, to innovate and identify new industries, to accelerate the translation of research results to practice and commercialization, and to cultivate the diverse workforce needed to power our country forward. NSF has the know-how and energy to help create this brighter future.

The NSF Director's vision for this future is expressed in **three pillars** that point to opportunities to continue building on recent investments, particularly those enabled by the CHIPS and Science Act and by the FY 2023 Omnibus and the Disaster Relief Supplemental appropriations. These are:

1. **Strengthening Established NSF**
   For more than 70 years, NSF has been making investments that expand the frontiers of knowledge and technology. This will continue to be our central focus: to accelerate discovery and enhance state-of-the-art research capabilities.

2. **Inspiring Missing Millions**
   The National Science Board (NSB) in its *Vision 2030*[1] report states, "Faster progress in increasing diversity is needed to reduce a significant talent gap" and they name that talent gap the "Missing Millions." NSB estimates that, for the S&E workforce to be representative of the U.S. population in FY 2030, the number of women in STEM must nearly double from the number in the 2020 U.S. S&E workforce, the number of Black or African Americans must more than double, and the number of Hispanic or Latinos must triple. These estimates are based on projections from the U.S. Census and Bureau of Labor Statistics, together with data from the National Center for Science and Engineering Statistics (NCSES), which is housed at NSF.

   Every demographic and socioeconomic group in every geographic region of the country has talented people who can participate in STEM and contribute to the innovation enterprise. In our effort to bring the "Missing Millions" into the STEM workforce, we will continue scaling up existing pathways into STEM fields and creating new tracks. NSF's commitment to finding talent provides opportunities that lead to a well-paid workforce and a vibrant U.S. economy.

3. **Accelerating Technology and Innovation**
   Global competition for leadership and talent in science, engineering and technology is at an all-time high, inspiring and motivating us to accelerate our progress. For the U.S. to remain in the vanguard of competitiveness for decades to come, we must continue to invest in advancing breakthrough technologies, translating research results to the market and society, and nurturing diverse talent by creating opportunities for everyone everywhere. To enable these investments, NSF will accelerate partnerships with other agencies, private industry, philanthropy, and like-minded countries to foster environments that leverage resources and deliver results.
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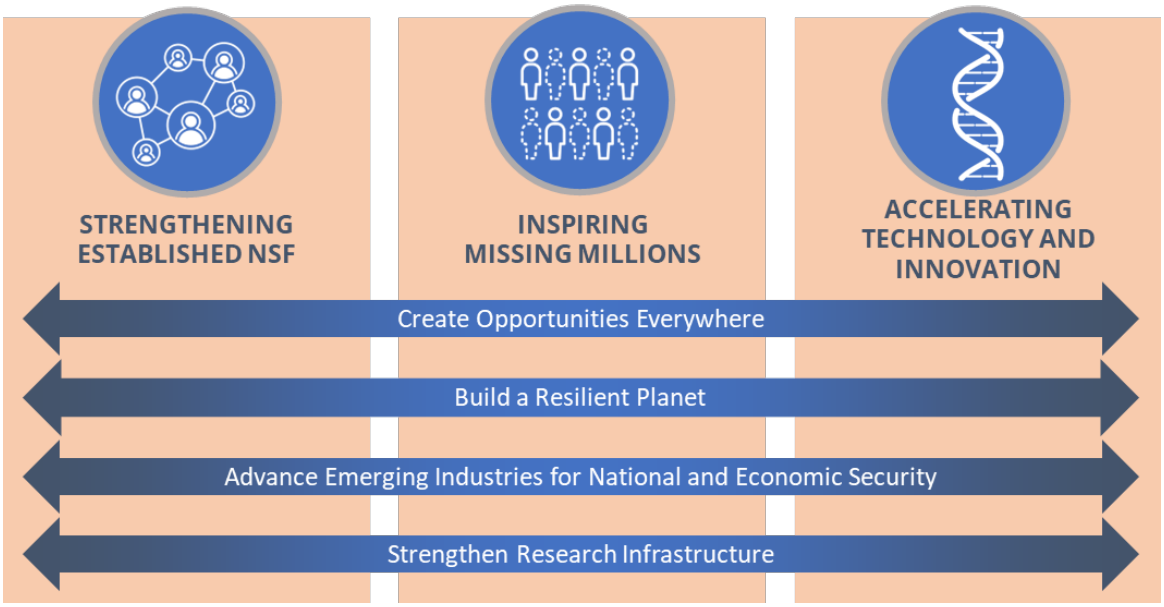
In NSF's FY 2024 Budget Request, these three pillars infuse four major themes— **Create Opportunities Everywhere, Build a Resilient Planet, Advance Emerging Industries for National and Economic Security, Strengthen Research Infrastructure**. These themes align with the Administration's priorities of expanding basic research to tackle hard topics and empower new approaches to applied research that spur technology transfer. The themes, expanded upon below, appear repeatedly in the broad portfolio of fundamental research that is the heart of NSF's mission. They bring to life new efforts and connect existing efforts throughout the research portfolio. They also point to opportunities envisioned in the CHIPS and Science Act.

[1] www.nsf.gov/nsb/publications/2020/nsb202015.pdf



NSF's four themes that shape our FY 2024 Request are:

Create Opportunities Everywhere (COE) Theme

NSF is strongly committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans, wherever they are found. Create Opportunities Everywhere is a comprehensive approach for attracting, supporting, and advancing groups underrepresented in STEM. This whole-of-NSF strategy incorporates all directorates and offices and surpasses prior efforts by striving to ensure equity in program delivery, while building on the concept of the "Missing Millions." It focuses on expanding access and inclusion in STEM along individual, institutional, and geographic lines.

In FY 2024, NSF intends to apply four guiding principles to create and implement opportunities everywhere: (1) address research equity, (2) build capacity, (3) foster collaborations and partnerships, and (4) support the next generation of researchers. For individuals, NSF will focus on groups that are underserved and underrepresented in STEM, and continue efforts to support individuals who are extremely underrepresented in STEM (those with low presence and/or low visibility in NSF programs) including those at the intersections of various dimensions of identity. For institutions, NSF will be more intentional in engaging Minority Serving Institutions (MSIs) and Emerging Research Institutions (ERIs) in our programming, focusing on the importance of bridge programs (funding open to all institutions that encourage participation by MSIs and ERIs). For jurisdictions, U.S. states and territories, NSF will expand support for individuals and institutions in EPSCoR jurisdictions to ensure geographic diversity.

The CHIPS and Science Act provides authorization for NSF support for diversity at the individual, institutional, and jurisdictional levels. At the individual level, CHIPS and Science authorizes programs that empower individuals through scholarships, fellows, traineeships, and project activities that enrich STEM education at all levels. At the institutional level, awards to minority serving colleges and universities, including community colleges, will lead to greater opportunities for all students and faculty. Finally, at the jurisdictional level, NSF is working toward more geographical diversity across the portfolio, especially to rural and urban institutions that serve diverse students.

NSF's commitment to finding talent provides opportunities that build strong STEM pathways that lead to a well-paid workforce and support the U.S. economy. To that end, the following programs are increased in the FY 2024 Budget Request over the FY 2023 Estimate Base.

- **Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED)** ($50.0 million) will improve the Nation's research support and service capacity at emerging and underserved research institutions. GRANTED will use a variety of mechanisms and programs to further NSF's reach in advancing the geography of innovation and engaging the Missing Millions. GRANTED activities will support the enhancement of research administration and post-award management as well as the sharing and implementation of effective practices that lead to competitive proposal development for external funding in STEM research and training. GRANTED funding in FY 2024 will aim to mitigate the barriers to competitiveness at underserved institutions, including minority-serving institutions and emerging research institutions within the Nation's research enterprise.

- **Alliances for Graduate Education and the Professoriate (AGEP)** ($15.50 million) program aims to increase the number of African American, Hispanic American, Native American Indian, Alaska Native, Native Hawaiian and Native Pacific Islander (or AGEP population) faculty in STEM at all types of institutions of higher education. The program funds projects that increase the understanding of institutional policies and practices to help doctoral candidates, postdoctoral scholars, and faculty improve their academic pathways to tenure and promotion in the STEM professoriate.

- **Centers of Research Excellence in Science and Technology (CREST)** ($41.0 million) enhance the research capabilities of minority-serving institutions (MSI) 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.

- **Eddie Bernice Johnson INCLUDES Initiative (NSF INCLUDES)** ($50.50 million) is a comprehensive national initiative to enhance U.S. leadership in STEM discoveries and innovations focused on NSF's commitment to diversity, inclusion, and broadening participation in these fields. The vision of this program is to catalyze the STEM enterprise to work collaboratively for inclusive change, resulting in a STEM workforce that reflects the population of the Nation.

- The **Hispanic-Serving Institutions Program (HSI)** ($60.50 million) seeks to enhance the quality of undergraduate STEM education at HSIs and to increase retention and graduation rates of undergraduate students pursuing degrees in STEM fields at HSIs. The HSI program seeks to build capacity at HSIs that typically do not receive high levels of NSF grant funding.

- **Historically Black Colleges and Universities Excellence in Research (HBCU-EiR)** ($37.93 million) program supports projects that enable STEM and STEM education faculty to further develop research capacity at HBCUs and to conduct research.

- **Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)** ($48.50 million) 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 provides awards to develop, implement, and study evidence-based innovative models and approaches for improving the success of HBCU undergraduates so that they may pursue STEM graduate programs and/or careers.

- The **Louis Stokes Alliances for Minority Participation (LSAMP)** ($70.50 million) is an alliance-based program that works to increase the number of STEM baccalaureate and graduate degrees awarded to populations historically underrepresented in STEM disciplines.

- The **Tribal Colleges and Universities Program (TCUP)** ($23.0 million) provides awards to Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions to promote high quality STEM education, research, and outreach.

- **Established Program to Stimulate Competitive Research (EPSCoR) Office** ($280.68 million) provides strategic programs and opportunities that stimulate sustainable improvements to EPSCoR jurisdictions' R&D capacity and capability. EPSCoR aims to stimulate research that enhances jurisdictional competitiveness in NSF disciplinary and multidisciplinary research programs, especially those that drive economic growth and geographic diversity. Also, pursuant to the CHIPS and Science Act, all NSF research divisions will commit additional support for meritorious proposals from EPSCoR jurisdictions.

- **Analytics for Equity Initiative** ($4.04 million) builds on the Evidence-Based Policymaking Act.[2] Led by NSF with four interagency partners, this program will fund researchers to produce rigorous empirical research and actionable recommendations in equity-related topics aligned to agency Learning Agendas[3]. Federal agencies and other organizations can use the resulting recommendations to increase the impact of equity-focused evidence-based strategies.

- **Graduate Research Fellowship Program** ($380.32 million) will support no less than 2,500 new fellows in FY 2024.

Build a Resilient Planet Theme

Resilience is the watchword as the U.S. and the world begin to feel the impacts of a changing climate and the growing need for clean, reliable, sustainable energy. Without resilience we are at the mercy of heat waves, droughts, floods, wildfires, rising oceans, and other extreme events, as well as power disruptions, economic instability, food insecurity, and deleterious effects on human health. NSF's Build a Resilient Planet initiative takes on these multifaceted challenges. The magnitude of these challenges demands an accelerated and integrated NSF-wide approach to engage scientists and engineers across disciplines through convergent research that addresses societal needs and integrates research and education.

NSF will take action to advance knowledge, empower communities, and generate innovative technological solutions. FY 2024 NSF investments will advance the priorities of the CHIPS and Science Act. Funding will focus on action to meet the urgent demands of the climate crisis on people, places, and economies. Investments will include:

[2] www.congress.gov/115/plaws/publ435/PLAW-115publ435.pdf

[3] www.evaluation.gov/evidence-plans/learning-agenda/

- **Clean Energy Technology (CET)** ($550.51 million) and NSF's clean-energy investments in high-risk, high-reward ideas from researchers across the science and engineering spectrum create broad new understanding and innovations that may increase energy efficiency, enhance sustainability, mitigate climate change, or lead to other societal benefits. NSF's investments in integrated clean energy research and education span longstanding programs as well as focused new solicitations and will continue to advance the fundamental science and engineering underlying clean energy technologies and infrastructure to continue to decrease energy prices and build our domestic supply chain. NSF also will support multidisciplinary research in areas such as affordable green housing and sustainable systems for clean water, clean transit, and other infrastructure.

- **U.S. Global Change Research Program (USGCRP)** ($1,047.06 million) supports research that contributes to the USGCRP goals to (1) advance scientific knowledge of the integrated natural and human components of the Earth system and (2) inform decisions by providing the scientific basis to inform and enable timely decisions on adaptation and mitigation. In FY 2024, NSF will continue to engage with other USGCRP agencies on priorities from intra-seasonal to centennial predictability, predictions, and projections; water cycle research; impacts of climate change on the nation's critical ecosystems, including coastal, freshwater, agricultural and forests systems; understanding the impacts of global change on the Arctic region and effects on global climate; and fundamental research on actionable science. In addition, NSF will seek greater integration of social-science research, methodologies, and insights into understanding and supporting responses to global change, improving computing capacity, and maintaining needed observational capabilities over time.

- **Climate Equity Fellowships** ($15.0 million) will allow students and researchers to develop a deeper understanding of the disparate impacts of climate change on disadvantaged or underserved communities and equip them to work to mitigate those impacts. The program will train students in climate science, disparities in climate impacts on different communities, engagement with such communities, and climate-related policies, to enable them to lead and advance climate equity.

NSF will continue to enhance its investment in **greenhouse gas (GHG) research**, where NSF-funded projects will develop measuring and monitoring strategies as well as reporting and verification systems with an emphasis on methane.

Programmatic examples supported in FY 2024 include further development of the **National Discovery Cloud (NDC) for Climate** ($30.0 million), a resource that will federate advanced compute, data, software and networking resources, democratizing access to a cyberinfrastructure ecosystem that is increasingly necessary to further climate-related S&E as well as investment in the **OISE Global Centers (GC)** program ($25.0 million), an international larger-scale collaborative activity to enable interdisciplinary and international teams to address grand societal challenges through use-inspired research with topics related to climate change and clean energy.

Advance Emerging Industries for National and Economic Security

As the U.S. faces intensifying global competition for science and technology leadership, NSF will strengthen and scale investments in breakthrough technologies, innovation, and translation by

expanding support for basic research, nurturing technology transfer, and empowering new approaches to potential application of research breakthroughs. NSF's investment in Emerging Industries for National and Economic Security will also focus on nurturing diverse talent. Building on NSF's deep relationships with over 2,000 of America's leading research institutions, we plan to harness the innovative spirit that exists in all corners of the country.

The FY 2024 Request advances research by creating conditions to expand research from the lab to the market and society and by targeting investments in new industries and people. For example:

- **The Directorate for Technology, Innovation, and Partnerships (TIP)** ($1,185.63 million), in close collaboration with all of NSF's directorates and offices, advances key technology focus areas to address societal and economic challenges and opportunities; accelerates the translation of research results from the lab to the market and society; and cultivates new education pathways leading to a diverse and skilled future technical workforce comprising researchers, practitioners, technicians, entrepreneurs, and educators. Building on NSF's longstanding leadership in science and engineering research and education, TIP serves as a crosscutting platform that leverages, energizes, and rapidly advances use-inspired research and innovation. Further, TIP opens new possibilities for research, innovation, and education by catalyzing strategic partnerships linking academia; industry, including startups and small businesses; federal, state, local, and tribal governments; nonprofits and philanthropic organizations; civil society; and communities of practice to cultivate 21st-century innovation ecosystems that give rise to future, high-wage, good-quality jobs and enhance the Nation's long-term competitiveness.

  Specific programs include:

  - **NSF Regional Innovation Engines (NSF Engines)** ($300.0 million), authorized in the CHIPS and Science Act, will catalyze new business and economic growth in those regions of America that have not fully participated in the technology boom of the past several decades. They will advance equitable and inclusive use-inspired research, entrepreneurship, and workforce development to nurture and accelerate regional industries. Collectively, they will contribute to long-term U.S. competitiveness.

  - **Experiential Learning in Emerging Industries (ExLENT)** ($50.0 million) will support inclusive experiential learning opportunities designed to provide cohorts of diverse learners with the crucial skills needed to succeed in the key technology focus areas and prepare them to enter the workforce ready to solve the Nation's most pressing societal, economic, national, and geostrategic challenges. Of note, ExLENT will enable those active in the workforce today to pivot into key technology focus areas to pursue high-wage, good-quality jobs.

  - **NSF Entrepreneurial Fellows** ($10.0 million), authorized in the CHIPS and Science Act, will provide a diverse cohort of Ph.D.-trained scientists and engineers with resources, including lab space, to mature promising ideas and technologies from the lab to the market and society. These fellows will forge connections between academic research and government, industry, and finance, becoming leaders in technology translation.

  - **Accelerating Research Translation (ART)** ($45.0 million), in alignment with CHIPS and

Science Act authorization, will support institutions of higher education that wish to build the necessary infrastructure to boost their overall institutional capacity to accelerate the pace and scale of translational research. Importantly, ART will result in a network of ambassadors who will champion translational research throughout the Nation.

- **NSF Convergence Accelerator** ($100.0 million) will regionalize its approach to accelerate the translation of use-inspired research by investing in regional cohorts of transdisciplinary, multi-sector teams pursuing technology solutions to location-specific challenges in food and agriculture, disaster response and mitigation, and transportation, to name a few.

FY 2024 funding will also catalyze research and innovation in these key areas to drive investments in Emerging Industries that address the following:

- **Advanced Manufacturing** ($453.86 million) investments will accelerate breakthroughs in manufacturing materials, technologies, and systems through fundamental, multidisciplinary research that transforms manufacturing capabilities, methods, and practices. NSF investments will further advanced manufacturing through advanced energy and industrial efficiency technologies, resilient manufacturing strategies, novel methods in engineering biology, next-generation materials, sustainable processes to support a circular economy, and the power of data science, automation, robotics and machine learning to intelligently design and develop future approaches that are secure, sustainable, and resilient to natural and anthropogenic disasters.

- **Advanced Wireless** ($179.17 million) investments will advance knowledge gaps and innovations in areas critical to future generations of communications technologies and networks, such as 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, while ensuring innovation and security for all users. For example, this investment will serve to advance both new active spectrum applications and spectrum used for non-commercial purposes, such as advanced receiver design and interference mitigation techniques for radio astronomy and atmospheric science. NSF investments will provide the backbone that connects users, devices, applications, and services that will continue to enrich America's national and economic security.

- **Artificial Intelligence** ($796.48 million) (including machine learning, autonomy, and related advances) investments will bring together numerous fields of scientific inquiry—including computer and information science; cognitive science and psychology; economics and game theory; education research; engineering and control theory; ethics; linguistics; mathematics; and philosophy—to advance the frontiers of trustworthy AI, including advancing perception, learning, reasoning, recommendation, and action in the context of specific fields and economic sectors. NSF investments will support the development of new foundational AI theory and implementation techniques, as well as novel AI methods that are inspired by use cases in specific application domains and contexts.

- **Biotechnology** ($470.05 million) investments will support fundamental research, infrastructure, and education to understand and harness biological processes for societal benefit. It will propel advances in genomics, bioinformatics and data analytics, structural and computational biology, biophysics, synthetic and engineering biology, tissue and metabolic engineering, medical

technology, development of new types of biomaterials, bio-inspired data storage and microelectronics, and biomanufacturing, as well as accelerate the ability to harness biological systems to create goods and services that contribute to agriculture, health, security, manufacturing, and resilience to climate change, including natural and anthropogenic disaster prevention and mitigation. As part of the National Engineering Biology Research and Development Initiative codified in the CHIPS and Science Act, NSF will make investments that advance areas of research at the intersection of engineering and the biological, physical, chemical, data, computational and information sciences and engineering, and social, behavioral and economic sciences to accelerate scientific understanding and technological innovation in engineering biology as well as assure public acceptance of the products of engineering biology.

- **Microelectronics and Semiconductors** ($209.68 million) investments will address the microelectronics and semiconductor challenges facing our Nation due to technological and global trends, such as the end of Moore's Law and offshoring of semiconductor fabrication and manufacturing, by supporting work in semiconductor discovery, development, and fabrication, leading to future domestic and related electronics foundries, as well as the design ecosystem of secure, sustainable microelectronic systems and devices based on them. This investment will enable future advanced computing systems, including quantum computing and networking technologies. Investments will also advance next-generation materials and highly parallel chip designs that will improve the performance of AI algorithms as well as integrate advanced energy efficiencies for low-power and high-performance devices that will drive a mobile and wireless future, and smart sensors that will interface between biosystems and electronics. Additionally, the CHIPS and Science Act provides NSF with $200 million in appropriated funding over five years for microelectronics workforce development activities.

- **Quantum Information Science (QIS)** ($332.67 million) investments will pioneer development of quantum computing, communication, sensing, and networking to advance information processing, transmission, and measurement in ways that classical approaches can only do much less efficiently, or not at all. This investment will develop proof-of-concept devices, tools, systems, and applications with a demonstrable quantum advantage over their classical counterparts. For example, quantum sensors will enhance resolution and detection capabilities.

Research Infrastructure Theme

Research infrastructure (RI), from individual instruments to major research facilities, is foundational to the scientific endeavor. Definitions of RI have evolved significantly over the years, particularly as remote access and cyberinfrastructure have become essential components of almost every tool in use by the research community. The COVID-19 pandemic further emphasized the critical nature of these components and illustrated how they can enable ongoing efforts to expand access to RI to historically underserved groups and communities. Additionally, NSF investments in science and engineering have stimulated discovery and innovation in the design and development of novel infrastructure, giving rise to new and different forms of RI.

RI is a fundamental enabler of science and engineering advancement, of both ideas and people. Needed for all forms of fundamental research – from exploratory to solutions-oriented – RI investments enable advances in areas as varied as measurement of the evolution of carbon in the atmosphere, assessment of the rate at which glaciers are losing ice, analysis of the changes in biomass in forests, studies of the rate at which underrepresented groups are engaged in science and

engineering disciplines, modeling of the epidemiology of infectious diseases, investigation of the fundamental structure of particles that make up everything in the universe, studies of biological, chemical, and physical processes at various timescales, and characterization of the contents of our solar system (including potentially hazardous asteroids). Catalyzed by the CHIPS and Science Act and by FY 2023 appropriations, investments in FY 2024 will support modernization of existing research infrastructure and the development of new infrastructure.

Support for **Major Facilities operations and maintenance (O&M**) ($1,069.80 million) continues to reflect a balance among multiple priorities. NSF divisions carefully allocate resources between research grants and O&M costs for research infrastructure. In addition to regular O&M needs to keep a facility functional, support for upgrades, significant periodic maintenance, and infrastructure renewal must also be addressed within Facilities O&M, which accounts for almost 10 percent of NSF's total request in FY 2024. NSF continues to explore ways to invest in research infrastructure, at all scales, to keep pace with changing technologies, increased demand by users, and expanding research opportunities.

The **Major Research Instrumentation (MRI)** ($92.75 million) program is responsible for catalyzing new knowledge and discoveries by helping STEM professionals acquire or develop the instrumentation needed for innovative science and engineering research. MRI grants support instrumentation in all NSF-supported research disciplines. In FY 2024, NSF will continue the implementation of CHIPS and Science Act provisions that began in FY 2023. These include waiving cost-sharing for new MRI projects and supporting projects for equipment and instrumentation to conserve or reduce the consumption of helium.

The **Mid-scale Research Infrastructure (Mid-scale RI)** ($155.06 million) program supports research infrastructure with a total project cost above the upper limit for the MRI program ($4.0 million) and below the Major Research Equipment and Facilities Construction (MREFC) threshold ($100.0 million). This dedicated funding line implements a high-priority, agency-wide mechanism that includes upgrades to major facilities as well as stand-alone projects.

The goals of the Mid-Scale RI program are to:

- Provide access to cutting-edge mid-scale research infrastructure, including instrumentation.
- Enable agile development and implementation of frontier scientific and engineering research infrastructure with a high potential to significantly advance the Nation's research capabilities.
- Train early-career scientists and engineers in the development and use of advanced research infrastructure.

In FY 2024, NSF investments will support Mid-scale RI Track-1 ($4.0 million to $20.0 million awards), funded through the Research & Related Activities account, and Track-2 ($20.0 million to $100.0 million awards), funded through the MREFC account. Both use an approximately biennial funding opportunity; the third solicitation for Mid-scale RI-1 (NSF 22-637[4]) was issued in FY 2022 and the second for Mid-scale RI-2 (NSF-21-537) in FY 2021, with awards in both planned for FY 2023. Subject to availability of funding in FY 2024, Mid-scale RI-1 will support projects from the FY 2022 competition and Mid-scale RI-2 will continue to support projects awarded from the first two competitions.

[4] www.nsf.gov/pubs/2022/nsf22637/nsf22637.htm

Major Research Equipment and Facilities Construction. Construction projects that require an investment of more than $100 million are generally supported in NSF's MREFC account. The FY 2024 Request includes funding for three ongoing projects -- the Antarctic Infrastructure Recapitalization program (an enduring program that replaces the Antarctic Infrastructure Modernization for Science or AIMS project), the two detector upgrades to operate at the High Luminosity-Large Hadron Collider (HL-LHC), and the Vera C. Rubin Observatory -- and the start of one new project -- the Leadership-Class Computing Facility (LCCF). The MREFC account also supports the Mid-scale RI Track 2 program, covering projects in the $20 million to $100 million range.

MREFC Account Funding, by Project

(Dollars in Millions)

	FY 2023 Estimate	FY 2024 Request
Antarctic Infrastructure Recapitalization (AIR)	$60.00	$60.00
HL-Large Hadron Collider Upgrade (HL-LHC)	33.00	38.00
Leadership-Class Computing Facility (LCCF)	-	93.00
Mid-scale Research Infrastructure, Track 2	76.25	105.06
Regional Class Research Vessel (RCRV)	1.98	-
Vera C. Rubin Observatory (Rubin)	15.00	7.61
Dedicated Construction Oversight	1.00	1.00
Total	**$187.23**	**$304.67**

NSF manages all U.S. Antarctic activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and other U.S. agencies. Impacts of the COVID-19 pandemic on U.S. Antarctic Program (USAP) operations required construction activities at McMurdo Station to be suspended and caused a significant delay to completion of AIMS. In the meantime, other investments in facilities and infrastructure on the continent have emerged as priorities that cannot be deferred until after completion of AIMS. As a result, the **Antarctic Infrastructure Recapitalization** (AIR) ($60.0 million) program was conceived as a portfolio of investments in infrastructure across the USAP stations that will replace AIMS. On-ice AIMS construction will continue in FY 2023 with a focus on meeting near-term needs, and unfunded parts of AIMS will be considered for incorporation into the longer-term AIR program. Some FY 2023 funding ($60.0 million) will be used to fund adjusted AIMS scope, if necessary, following a FY 2022 re-baseline of the project and the remainder will transition to a broader recapitalization of NSF's Antarctic infrastructure.

The Large Hadron Collider is the world's largest and highest energy particle accelerator. Located near Geneva, Switzerland and operated by the European Organization for Nuclear Research (CERN), LHC can accelerate and collide counter-propagating bunches of protons at a total energy of 14 tera-electron volts. A Toroidal LHC ApparatuS (ATLAS) and Compact Muon Solenoid (CMS) are two general purpose detectors used by researchers to observe these collisions and analyze their characteristics. In FY 2024, funding for **HL-LHC Upgrade** ($38.0 million) will support year four of the five-year project that began in FY 2020, prior to the onset of the COVID-19 pandemic. This investment will upgrade components of the ATLAS and CMS detectors, enabling them to function at much higher collision rates following an upgrade to the LHC to increase its luminosity. A re-baseline of the ATLAS and CMS upgrades will be conducted in FY 2023 to evaluate the impacts of the COVID-19 pandemic on the cost and schedule of the projects.

The **Regional Class Research Vessels** ($0.0), part of the U.S. Academic Research Fleet, are designed to meet the needs of researchers for work in coastal zones in support of biological, chemical, physical, and geological oceanography. The vessels will enable virtual participation of shore-based scientists using telepresence/data presence technology, greatly expanding the potential user base. The first of three vessels under construction is planned for delivery in 2023, with subsequent vessels being delivered six and twelve months thereafter. No additional funding is requested in FY 2024.

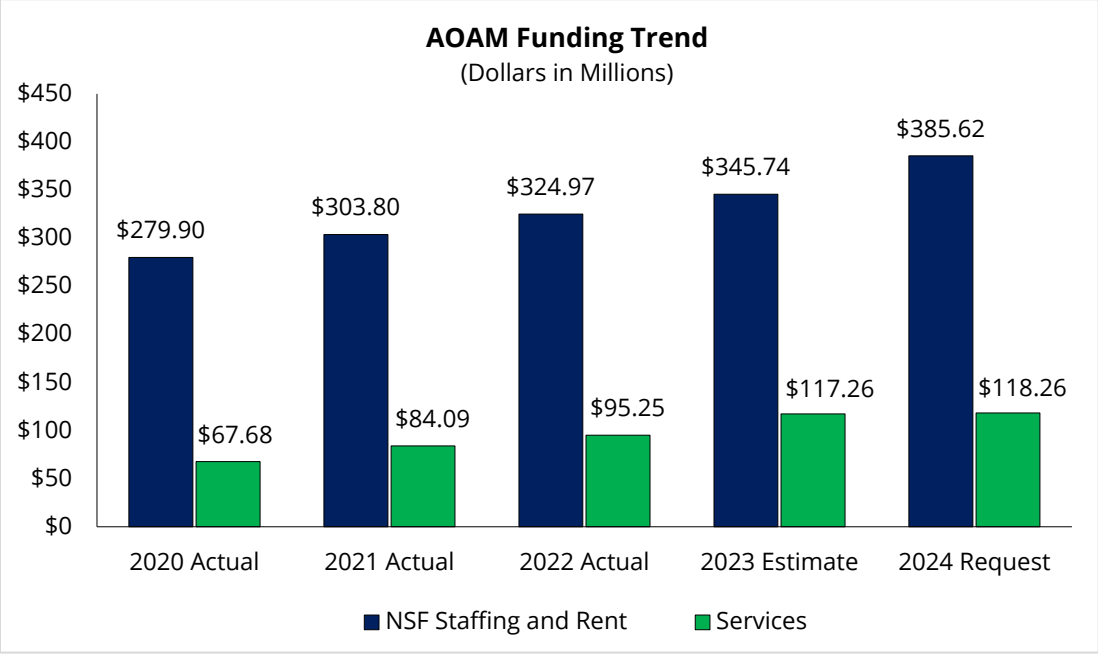
Vera C. Rubin Observatory ($7.61 million) will be an 8-meter-class wide-field optical telescope capable of carrying out surveys of the entire southern sky. It will collect nearly 40 terabytes of multi-color imaging data every night to produce the deepest, widest-field sky images ever. It will also issue alerts for moving and transient objects within 60 seconds of their discovery so that follow-up can be conducted by other optical and radio telescopes and gravitational-wave detectors. FY 2024 will be the eleventh and final year of funding, as the project comes to completion.

ORGANIZATIONAL EXCELLENCE - AGENCY OPERATIONS AND AWARD MANAGEMENT (AOAM)

The $11.314 billion in funding that NSF will support in FY 2024 is managed by the staff at NSF who enable research and steward the taxpayer investment. Investments in the Agency Operations and Award Management (AOAM) account provide the fundamental framework through which the Foundation's science and engineering research and education programs are administered. AOAM is the avenue by which NSF directly supports and responds to the Administration's management and performance priorities, including a growing research science and security framework vital to the well-being of the NSF-funded scientific enterprise. AOAM funds the essential services NSF needs to operate, and investments in the AOAM account continue to be an NSF priority.

In FY 2024, NSF requests a total of $503.87 million for AOAM, an increase of $40.87 million or 8.8 percent above FY 2023 Current Plan level for the AOAM account. Even with this large increase, NSF continues to operate as a lean agency with AOAM costs representing about 4.5 percent of NSF's total FY 2024 budget.

In the AOAM account, over three-quarters of the total AOAM funding covers NSF personnel and NSF's headquarters location in Alexandria, VA with the remaining quarter going to mission support services. Over the last several fiscal year budget requests, NSF reduced or held flat mission support services costs to accommodate the year-over-year increases in the fixed costs for staffing and rent while minimizing growth to the AOAM account in the Request. NSF then exercised its transfer authority to restore funding for those reduced activities.



In FY 2024 NSF is continuing its recent practice of requesting the AOAM amount NSF estimates it needs and is commensurate with the overall plans and priorities for NSF. The requested level will enable NSF to maintain a current services level of funding across its mission support activities while at the same time expand agency staffing needs, to effectively and efficiently meet the needs of a $11.3 billion federal research agency.

RESEARCH SECURITY STRATEGY AND POLICY

NSF is expanding capabilities and competencies to protect the U.S. science and engineering enterprise through its Research Security Strategy and Policy activity. In January 2022, the National Science and Technology Council's Research Security Subcommittee, which is co-chaired by NSF, issued implementation guidance for National Security Presidential Memorandum 33 (NSPM-33) on National Security Strategy for United States Government-Supported Research and Development. The August 2022 CHIPS and Science Act contained several research security provisions that NSF is implementing. NSF participation in discussions with the U.S. research community and with international colleagues, and development of common frameworks for understanding research security are major components of the NSF Research Security activity that is expected to continue to grow in FY 2024. Specific activities for FY 2024 include:

- Per the CHIPS and Science Act, to provide needed information and tools to the research community, NSF is established a Research Security and Integrity Information Sharing and Analysis Organization (RSI-ISAO). NSF will ramp up the capabilities of this organization to provide additional tools, information and resources in FY 2024.

- NSF will establish a Research on Research Security funding program in FY 2024 using guidance from the JASON study and an NSF-funded workshop. Primary goals of the program will include assessment of the characteristics that distinguish research security from research integrity, improving the quantitative understanding of the scale and scope of research security risks, developing methodologies to assess the potential impact of research security threats, and assessing the additional research security risks in an innovation system that includes more use-inspired research rather than staying well within the bounds of fundamental research.

- Per the CHIPS and Science Act, NSF has established new analytic capabilities to proactively identify conflicts of commitment, vulnerabilities of pre-publication research, and risks to the merit review system. NSF will scale up the use of these analytics to analyze all NSF awards and contribute to NSF's SBIR due diligence process in FY 2024.

- Through a partnership with the federal government interagency community, NSF funded awards to develop research security training modules for the research community in FY 2023. These modules will be available by the beginning of FY 2024 and NSF will fund the delivery of these modules and their evaluation.

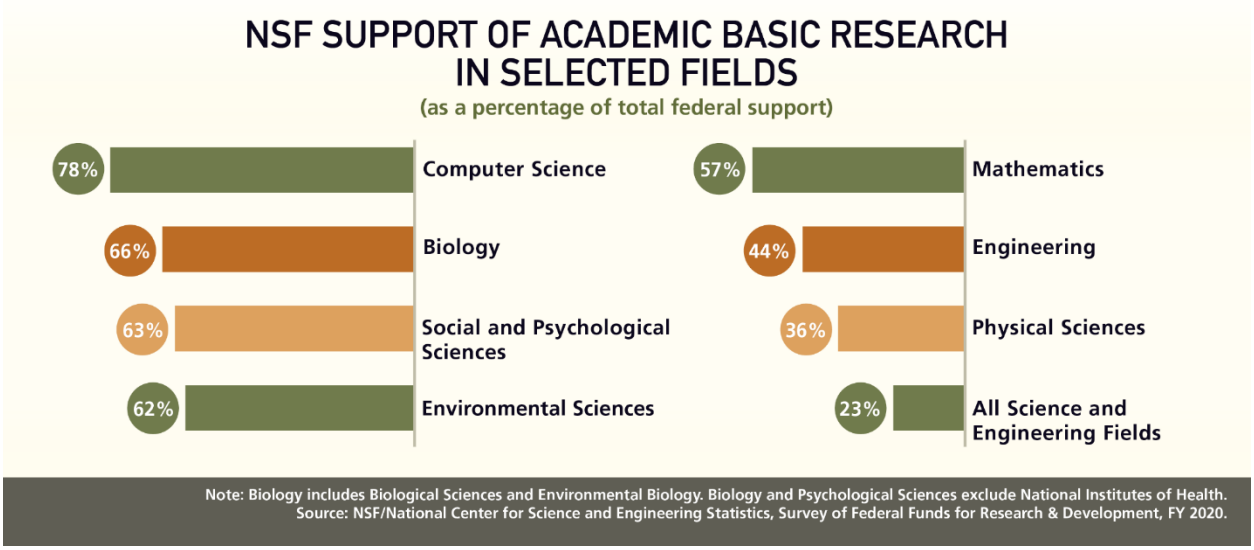
ORGANIZATION AND ROLE IN THE FEDERAL RESEARCH ENTERPRISE

NSF's comprehensive and flexible support of meritorious projects enables the Foundation to identify and foster both fundamental and transformative discoveries and broader impacts within and among fields of inquiry. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations, and research that pushes—and creates—the very frontiers of knowledge. In these ways, NSF's discoveries inspire the American public—and the world.

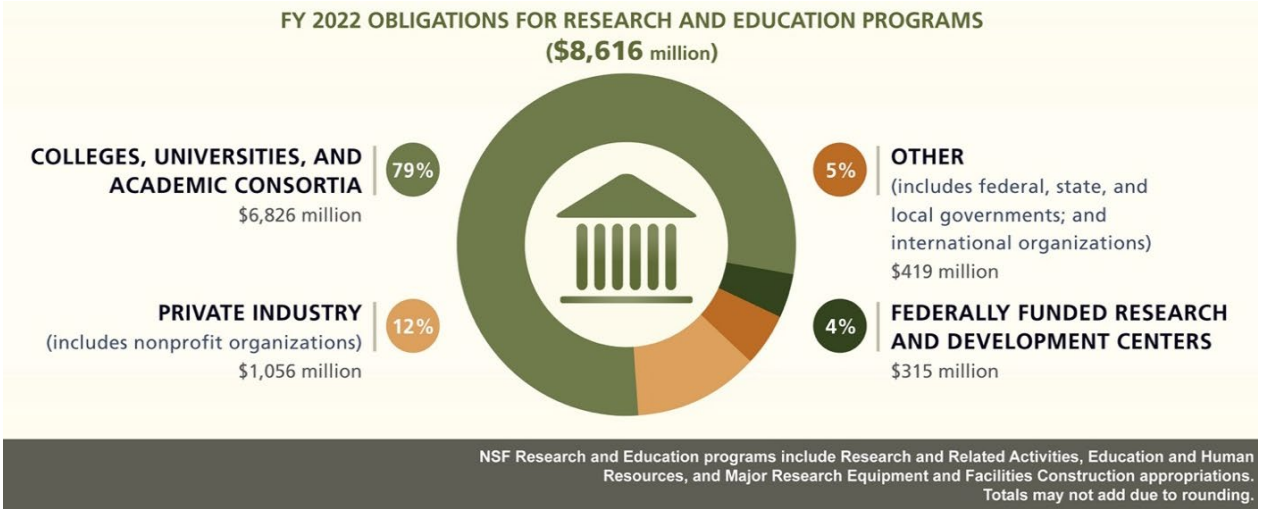
NSF's organization represents the major science and engineering fields, including biological sciences; computer and information science and engineering; engineering; geosciences; mathematical and physical sciences; and social, behavioral, and economic sciences. NSF also carries out specific responsibilities for education and human resources, integrative activities, and international science and engineering. The 25-member National Science Board approves the overall policies of NSF.

NSF BY THE NUMBERS

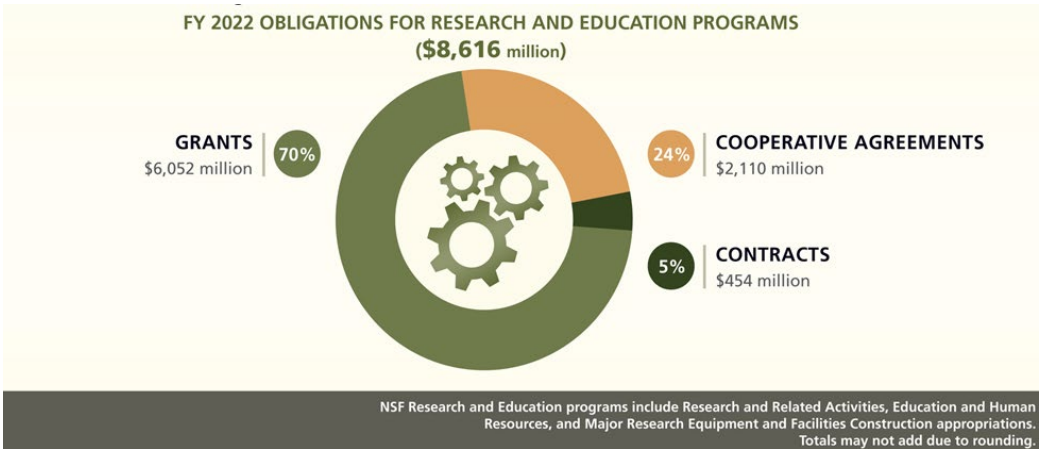
NSF's annual budget represents approximately 23 percent of the total federal budget for basic research conducted at U.S. colleges and universities. In many science and engineering fields, NSF is the primary source of federal academic support. In most major fields of science, NSF support of basic research at U.S. institutions is over 50 percent.



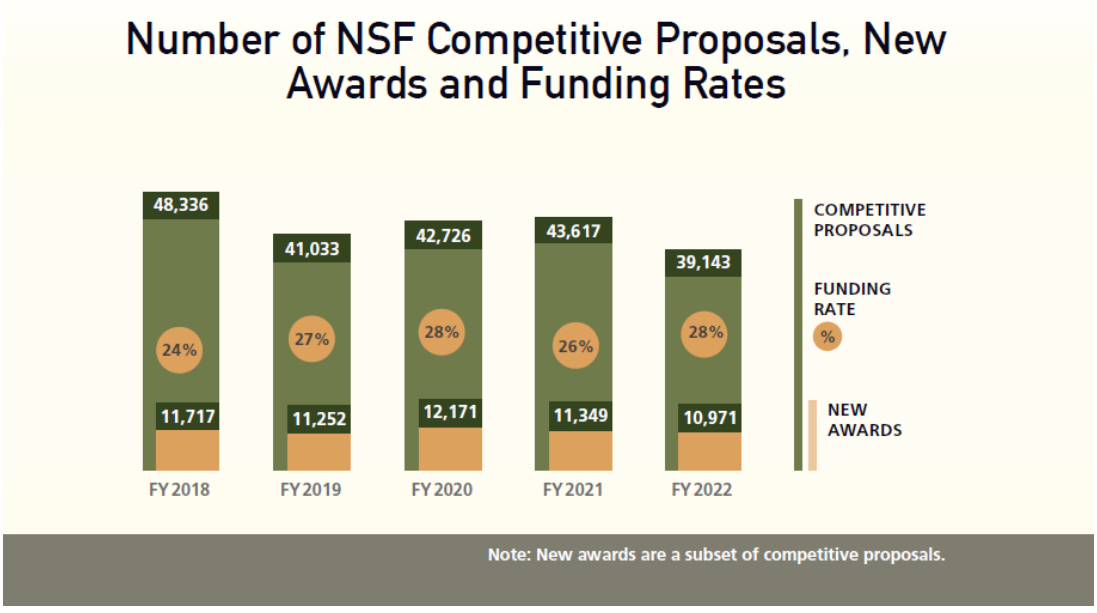
Most NSF awards are to academic institutions. In FY 2022, 79 percent of support for research and education programs ($6,826.0 million) was awarded to 822 different colleges, universities, and academic consortia. Private industry, including small businesses and non-profit organizations, accounted for 12 percent ($1,056.0 million), and support to Federally Funded Research and Development Centers accounted for 4 percent, or $315.0 million. Other recipients (federal, state, and local governments; and international organizations) received 5 percent ($419.0 million) of support for research and education programs. The distribution in FY 2024 is expected to be similar.



As shown below, 94 percent of NSF's FY 2022 projects were funded using grants or cooperative agreements. NSF grants are either standard or continuing awards. That is, the award is made during one fiscal year for the full amount of the award or made over several years in increments. Cooperative agreements are used when the project requires substantial agency involvement during the project performance. Contracts are used to acquire products, services, and studies required primarily for NSF or other government use. The distribution in FY 2024 is expected to be similar.



NSF continuously monitors key portfolio, proposal workload, and financial measures to understand short- and long-term trends and to help inform management decisions. The chart below presents a high-level, agency-wide estimate of funding rates, or proposal "success," as a comparison of the number of competitive proposals, new awards, and funding rate between FY 2018 and FY 2022. In FY 2024, NSF expects to evaluate over 46,500 proposals through a competitive merit review process and make over 12,900 new competitive awards, of which about 10,800 are expected to be new research grants and the remainder contracts and cooperative agreements.



HIGHLIGHTS

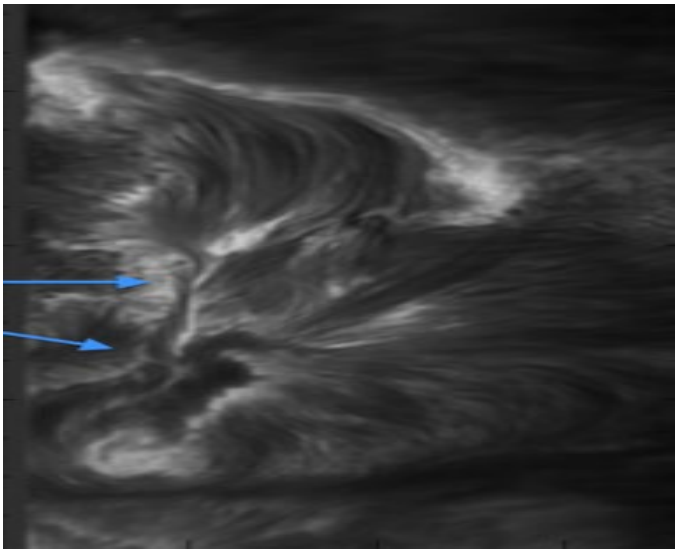
Research and Mentoring for Postbaccalaureates in Biological Sciences (RaMP)

Every year, millions of American students graduate with a degree in biology, but for some, it is hard to see a path forward toward a career in biotechnology, bioengineering, or other fields that require extensive research experience. This is especially true for individuals from groups underrepresented in STEM and first-generation college students, as well as for students at institutions with limited resources for research projects. To ensure talented students everywhere have the opportunity to join the STEM workforce and research community, NSF's Biological Sciences Directorate launched the Research and Mentoring for Postbaccalaureates in Biological Sciences program, known as RaMP. Based on research that shows how inclusive training, cohort-based mentoring, and personal networks can make a big difference in future career success, RaMP is helping colleges, universities, nonprofits, and other organizations build research opportunities that expand pathways into the biosciences for more students and help recent graduates get research experience that can boost their careers.

Members of the RaMP program discuss research equipment. *Credit Michael Reichert*

Magnetic reconnection breakthrough could help predict space weather

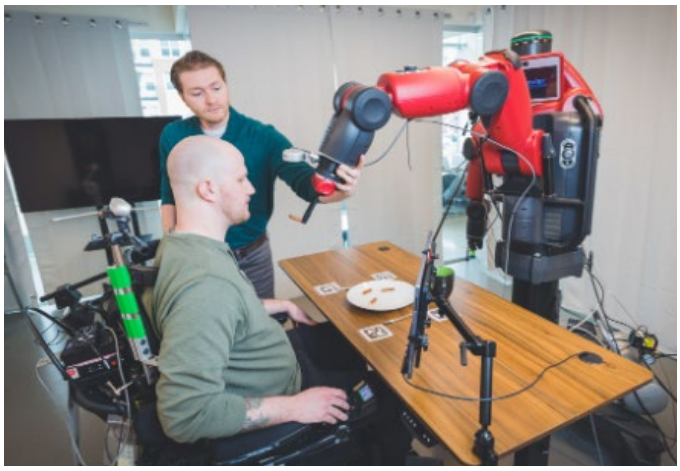
Space storms can wreak havoc on satellites and power grids, and magnetic reconnection plays a major role in the plasma eruptions on the sun's surface that spark space storms. NSF grantees at West Virginia University learned new information about magnetic reconnection and the physics of space-like plasmas by experimenting with lab-developed plasma. The research, part of the PHAse Space Mapping, or PHASMA, experiment, probed the plasma and light scattered from individual electrons in the plasma to assess how fast the particles were moving. PHASMA can accurately measure the motion and velocity of the ions and electrons on a very small scale, allowing the team to measure the actual speeds of individual electrons. The research will impact how space weather and solar storms are predicted and improve understanding of the universe's mechanics and dynamics.



The arrows point to a twisted filament, or magnetic flux rope, before magnetic reconnection occurs. *Credit: K. Reardon, NSF's National Solar Observatory and L. Kleint, University of Bern.*

NSF Research Traineeship Human-Machine Systems for Physical Rehabilitation

People with disabilities abandon assistive technologies at high rates, largely because their perspectives are not included in the development process. The NRT Program at Cleveland State University trains graduate students to work on transdisciplinary research teams in direct collaboration with the disability community. The goal is to ground new, accessible rehabilitation and assistive technologies in the unique perspectives and experiences of those living with disabilities. In the program, the students learn to span diverse perspectives in human-machine systems and develop human-centered approaches to research and design. This NRT program hopes to establish a new model for engineers, psychologists, and urban experts to collaborate with therapy professionals and the disability community to deliver future technologies for the most complex rehabilitation challenges.



A person controls a robot to feed himself. *Credit: Cleveland State University Center for Human-Machine Systems.*

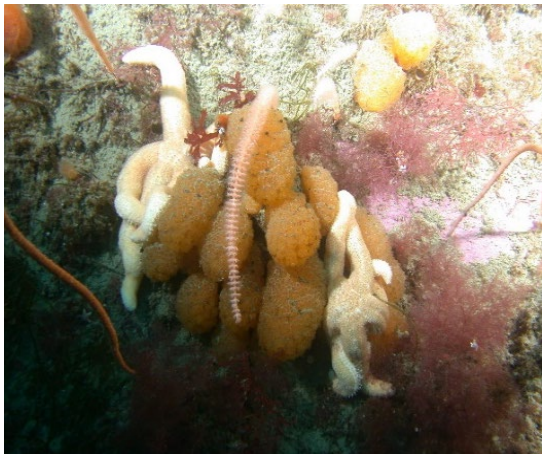
National Science Foundation announces multi-million dollar partnership with leading foundations to improve U.S. STEM education

Credit: NSF.

At the core of NSF's approach to accelerating discovery, innovation, and STEM education is a commitment to building strong partnerships across an array of agencies, industries, and organizations. That is why NSF, together with the Bill & Melinda Gates Foundation, Schmidt Futures, and Walton Family Foundation, have developed a new partnership to fund unique initiatives that will improve the quality of U.S. STEM education for all students, particularly those whose talents, intelligence, and entrepreneurship have been underutilized in the nation's STEM enterprise. This historic collaboration brings together some of the largest public and private funders committed to STEM education and is one of the first of its kind involving these organizations. NSF is proud to match the money from the foundations for each funded activity and help researchers answer some of the most pressing challenges in U.S.

Promising anti-melanoma properties discovered in a sea squirt

Researchers identified a compound produced by bacteria living on the sea floor near Antarctica that could be used to create a naturally derived treatment for melanoma. A team of NSF grantees from the Desert Research Institute at Los Alamos National Laboratory and the University of South Florida, traced the compound, palmerolide A, to a microbe that shares a symbiotic relationship with a species of ascidian, or sea squirt, common to the waters of Antarctica's Anvers Island archipelago. To survive, ascidians and other invertebrates developed relationships with microbes that play a role in photoprotective pigments, bioluminescence, and chemical defenses. The compounds produced by these microbes may also have other applications in science, health, and industry.



Synoicum adareanum pictured with a starfish in 80 feet of water near Bonaparte Point, Antarctica. *Credit: Bill J. Baker/Department of Chemistry, USF.*

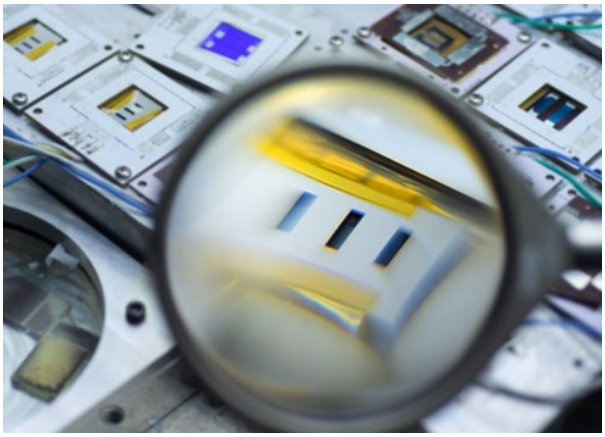
CIVIC Innovation Challenge

Mitigating the effects of disasters or bridging the gap between essential resources and services and nearby populations is the driving force behind the Civic Innovation Challenge. Led by NSF in partnership with the Department of Energy and Department of Homeland Security, researchers worked with civic partners to identify and address community challenges with research-based pilot projects. The two focus areas were resilience to natural disasters, and mobility and access to jobs and services. In the first stage, teams of local, state, and tribal officials as well as nonprofit and community leaders, refined the projects. In Stage 2, 11 disaster resiliency teams and six mobility teams received awards of up to $1 million to develop ready-to-implement pilot projects in a 12-month time frame. The solutions were also designed to become templates to address community issues across the U.S.

Map of Civic Innovation Challenge awards supporting community-based solutions. *Credit: NSF.*

New technology surpasses long-sought solar energy milestone

Engineers supported by NSF developed a new class of renewable solar energy technology that is as efficient as silicon-based solar cells but can be produced at lower cost and more sustainably. The new technology is based on perovskites, semiconductors that have a crystal structure compatible with solar cell technology – but that are also fragile and have a short lifespan. The team designed an accelerated aging process to improve testing and forecast long-term performance, and the perovskites can operate for nearly 30 years, a significant increase over the prior threshold of 20 years. As the technology becomes more efficient and long-lasting, competing designs will result in more durable and commercially viable technologies**.**



Engineers have developed an accelerated aging process to forecast long-term solar cell performance*. Credit: Bumper DeJesus.*

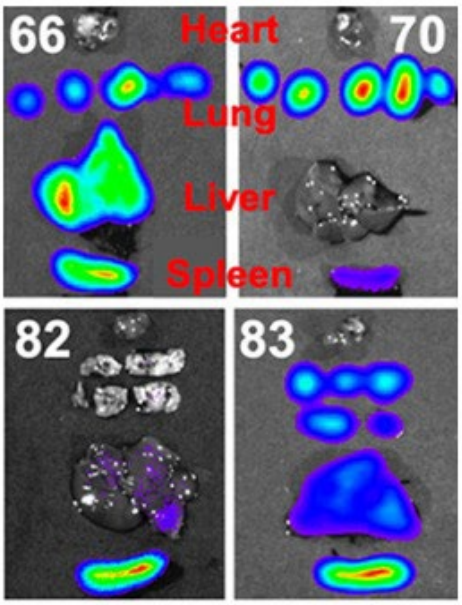
Low-cost, paper-based sensor conducts multiple tests at once

In medicine, diagnosing disease rapidly and reliably is a crucial first step in providing effective care. However, many communities lack the centralized infrastructure and trained personnel to perform these critical and costly tests. This disparity is driving researchers at the NSF-funded Precise Advanced Technologies and Health Systems for Underserved Populations (PATHS-UP) Engineering Research Center (ERC) to develop easy-to-read diagnostic tests constructed from paper. The new sensors developed by the PATHS-UP ERC employ a specially designed 'sensing membrane' that can detect dozens of diseases simultaneously while using only $0.30 worth of paper materials. And with simple operating steps, these tests can be performed in under 20 minutes with minimal training, helping bring critical healthcare access to underserved communities worldwide.

A multiplexed biomarker sensor that is quantified and read through a mobile phone for patient testing in clinical settings and even at home. *Credit: Ozcan Lab at UCLA.*

Targeted Delivery of mRNA with One-Component Ionizable Amphiphilic Janus Dendrimers

NSF investments are about to make mRNA vaccines more effective and easier to store. Designing mRNA vaccines, like those used to protect against COVID, is a complex process. One of the key tools is macromolecules, large and complex molecular structures that play a role in countless biological processes and are critical to mRNA vaccine delivery systems. Currently, all COVID vaccines require an assembly of four different macromolecules to ensure the vaccine works. But this combination of macromolecules is unstable, and therefore the vaccine needs to be stored at extremely low temperatures to be effective—and they don't always agree on the right temperature or solubility and therefore need to be stored at extremely low temperatures. That is about to change, though, thanks to NSF-funded researchers who have found a single new macromolecule that can replace all four currently being used. In addition to increasing stability and eliminating the need for ultra-cold storage, this revolutionary approach delivers the mRNA payload more efficiently and has the new capability to target specific organs. The major vaccine producers are already working to integrate this research into future production.



Representative images of mRNA delivery to different organs. *Credit: J. Am. Chem. Soc.*

From Yellowstone to Your Table

Nature's Fynd, formerly known as Sustainable Bioproducts, was initiated by a Montana State University postdoc and received initial funding from NSF in 2010. Nature's Fynd is committed to creating sustainably sourced food that is nutritious and tastes great such as vegan breakfast patties and dairy-free cream cheese. These foods are made using nutritional fungi proteins that originated in the hot springs of Yellowstone National Park. The company received Phase I NSF SBIR/STTR funding in 2013 and its products are now sold in Whole Foods markets in 10 states. The current valuation of Nature's Fynd is $1.75+ billion and the company has 100+ employees.

Bison grazing near Rose Creek in Lamar Valley. *Credit: NPS / Neal Herbert.*

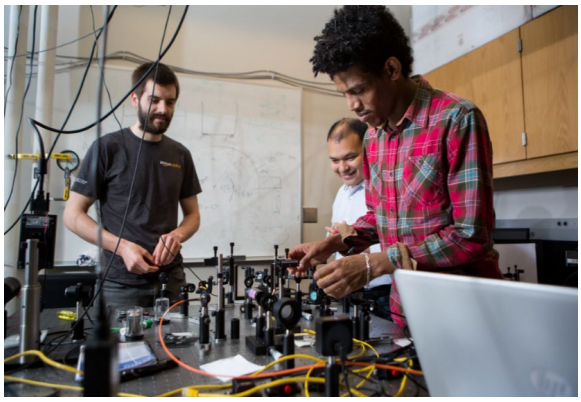
Extreme weather research shows income impacts of Hurricane Katrina and Superstorm Sandy

A new analysis of the economic impacts of Hurricane Katrina and Superstorm Sandy could help improve climate resilience planning for cities anticipating severe weather events. While many studies have examined the storms' economic impacts through loss of business revenue, Illinois Institute of Technology social scientists focused on households' income and properties by looking at which populations saw the most economic harm from the storms and why. The researchers hope to understand how to mitigate future economic losses caused by extreme weather, especially among lower-income households.

Damage and destruction to houses in Biloxi, Mississippi, from Hurricane Katrina. *Credit: FEMA/Mark Wolfe.*

NSF and SRC partner to support semiconductor research experiences for undergraduates

The National Science Foundation and Semiconductor Research Corporation (SRC) recently signed a memorandum of understanding to support hands-on research opportunities for undergraduate students in research areas related to semiconductors. This partnership will advance the fundamental science and engineering of semiconductors and the development of a diverse science and engineering workforce for an area of high national priority. Under the new, five-year agreement, NSF and SRC will jointly support awards through the NSF Research Experiences for Undergraduates (REU) program for REU sites on semiconductor-related topics. In addition, to help introduce the industry perspective to faculty and students, SRC may invite awardees to share information with students about semiconductor industry career paths and conferences, to connect with representatives of SRC member companies, or to interact in other ways. Participating SRC member companies include Analog Devices, Arm, EMD Electronics, HRL-Boeing, IBM, Intel, MediaTek, Micron, Qorvo, Raytheon Technologies, Samsung, SK hynix, and TSMC.



REU student working with mentor and supervisor in the lab. *Credit: Arka Majumdar, University of Washington.*

NSF Programs help transform discoveries into cutting-edge solutions

Credit: NSF

NanoView Biosciences' journey shows how NSF's lab-to-market programs can help breakthrough technologies make the leap from research to commercialization. In 2011, NanoView Biosciences' cofounders received a Partnerships for Innovation grant to develop a prototype for diagnostic technology capable of rapidly detecting exosomes—messenger particles in blood, serum, and other samples that provide information about diseases. They completed NSF Innovation Corps™ training in 2013 and went on to receive a SBIR Phase I award in 2015, followed by a SBIR Phase II award in 2018. As its business grew, so did its technology, with new tools aimed at the rapidly expanding gene therapy sector. In 2022, NanoView Biosciences was acquired by Unchained Labs, a leading life sciences company. With help from three NSF programs, NanoView Biosciences was able to transform its research into cutting-edge solutions for gene therapy, biologics, and diagnostics.

Dimensional Energy, launched with the help of NSF's SBIR/STTR programs, produces sustainable aviation fuels. *Credit: Dimensional Energy.*

Recycling CO2 into sustainable aviation fuels

Dimensional Energy, launched with help from NSF's SBIR/STTR programs, known as America's Seed Fund, has developed a method to use sunlight to convert carbon dioxide into energy. Co-founded by two Cornell faculty members, the company gathers carbon dioxide from a sources like industrial sites (cement plants) or from direct-air capture, then adds renewable energy and hydrogen to their system of reactors, to transform it into an environmentally friendly fuel. The goal of the founders is to decarbonize the aviation industry with sustainable jet fuel and, in June 2022, United Airlines agreed to purchase at least 300 million gallons of their product over 20 years from the company.

National AI Research Institutes

As the primary non-defense federal funder of basic AI research, the U.S. National Science Foundation (NSF) is leading the Nation in making critical AI investments that will enable breakthroughs across nearly every sector of society, ensuring American health, wellbeing, and security.

Credit: Shutterstock/everything possible