AN OVERVIEW OF THE NATIONAL SCIENCE FOUNDATION BUDGET PROPOSAL FOR FISCAL YEAR 2024

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

OF THE

HOUSE OF REPRESENTATIVES

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AN OVERVIEW OF THE NATIONAL SCIENCE FOUNDATION BUDGET PROPOSAL FOR FISCAL YEAR 2024

WEDNESDAY, APRIL 26, 2023

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Committee met, pursuant to notice, at 10 a.m., in room 2318, Rayburn House Office Building, Hon. Frank Lucas [Chairman of the Committee] presiding.

COMMITTEE ON
SCIENCE, SPACE AND TECHNOLOGY
CHAIRMAN FRANK LUCAS

FULL COMMITTEE

HEARING CHARTER

"An Overview of the Budget Proposal for the National Science Foundation for Fiscal Year 2024"

Wednesday, April 26, 2023
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

The purpose of the hearing is to review the Administration's fiscal year (FY) 2024 budget request for the National Science Foundation (NSF) and related policy and management issues. The hearing will cover the priorities of NSF and the National Science Board (NSB), including a discussion of the construction and operation of cutting-edge research facilities and instrumentation; investments in STEM education and workforce development; the establishment of the Directorate for Technology, Innovation, and Partnerships; increasing support for research security; and the plans and progress in implementing the CHIPS and Science Act of 2022. The hearing is an opportunity for Members to ask questions about research and STEM education interests in their states and communities, international competition in science and technology (S&T), and important oversight issues for the Foundation.

Witnesses

- **Dr. Sethuraman Panchanathan**, Director, National Science Foundation
- **Dr. Dan Reed**, Chair, National Science Board

Key Questions

- How will NSF balance its core directorate research programs with the addition of the new Technology, Innovation and Partnerships Directorate?
- How is NSF coordinating its STEM education activities with STEM programs across the federal government, and meeting workforce needs of the private sector?
- How is the NSF addressing increased international competition in S&T, as well as foreign espionage and theft of NSF funded research at U.S universities and research institutions?
- What progress has been made implementing reforms on oversight of large facilities construction projects, and what is the status of the construction projects currently in progress?
- How is the Board working with NSF to address the Foundation's priorities?

Background

The National Science Foundation (NSF) is an independent federal agency established by Congress in 1950 and is the primary source of federal funding for non-medical and non-defense basic research. NSF supports fundamental research that is not funded by the private sector. NSF is also responsible for the majority of the federal science, technology, engineering, and mathematics (STEM) education programs.

Through more than 11,200 competitive awards per year, NSF supports approximately 352,000 scientists, engineers, educators and students at universities, laboratories, and field sites. NSF is the funding source for over 23 percent of all federally supported basic research conducted at 2,000 American colleges, universities, and other research institutions. These grants fund specific research proposals that have been judged the most promising by NSF's peer merit-review system. On average only one out of four proposals submitted to NSF is awarded funding.[1]

Governance

As an independent agency, NSF does not fall within a cabinet department. The agency's activities are governed jointly by the NSF Director and the National Science Board (NSB). The Director is appointed to a six-year term by the President and confirmed by the Senate. The current NSF Director, Dr. Sethuraman Panchanathan, was nominated by President Trump in 2019 and subsequently unanimously confirmed by the U.S. Senate on June 18, 2020.[2]

The Board consists of 24 members appointed to six-year terms by the President.[3] The NSB performs two primary functions: (1) provides policy direction to NSF, including approval of the annual budget submission to the Office of Management and Budget (OMB) and new major programs and awards, and (2) serves as an external advisory body to Congress and the President on policy issues pertaining to science and engineering and STEM education. The Board also publishes a biennial report on indicators of the state of science and engineering in the United States.[4] The Board Chair and Vice Chair are elected to two-year terms by the Board membership. The current Chair, Dr. Dan Reed, was elected in May 2022.[5,6]

Research and Education

NSF supports fundamental non-biomedical research and education across all fields of science and engineering. Research and education activities are managed through seven research directorates under the Research and Related Activities (RRA) appropriations account – Biological Sciences (BIO); Computer and Information Science and Engineering (CISE); Engineering (ENG); Geosciences (GEO); Mathematical and Physical Sciences (MPS); Social, and Behavioral and

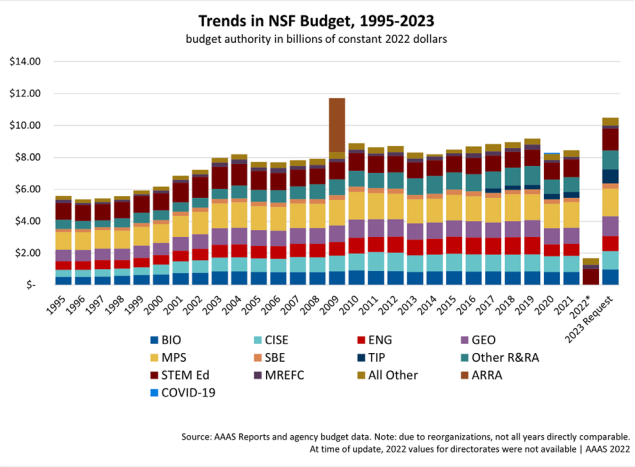
[1] National Science Foundation. "FY 2024 Budget Request to Congress," March 13, 2023. https://nsf-gov-resources.nsf.gov/2023-03/NSF%20FY24%20CJ_Entire%20Rollup-revised.pdf?VersionId=piT6beLuOyugsHnEnBgrvdTknW8564PZ.
[2] NSF, "New director takes helm at National Science Foundation", https://beta.nsf.gov/news/new-director-takes-helm-national-science.
[3] NSB appointments are staggered so that every two years one-third of the Board is appointed.
[4] The most recent Indicators report was released in January 2022 and can be found here: https://ncses.nsf.gov/pubs/nsb20221.
[5] National Science Board, "New Leadership of the National Science Board," https://www.nsf.gov/nsb/news/news_summ.jsp?cntn_id=305154.
[6] The current Vice-Chair of the NSB is Dr. Victor McCrary.

Economic Sciences (SBE); Technology, Innovation and Partnerships (TIP) – and the STEM Education (EDU) directorate under its own account. Each directorate is headed by an Assistant Director (AD) and further organized into divisions. In addition to these eight directorates, two offices administer agency-wide programs – the Office of International Science and Engineering (OISE) and the Office of Integrative Activities (OIA), both of which are housed in the Office of the Director. NSF is the primary source of support for academic research in several scientific disciplines, accounting for more than 60% of federal funding in computer science, biology, environmental sciences, mathematics, and social sciences.[7]

Institutions and People

To support research and education activities, NSF typically enters into grant agreements with universities or other non-profit organizations. In FY 2022, NSF received 32,100 research grant proposals and made about 8,700 new awards to colleges, universities, and other institutions across all 50 states. Across the agency, 27 percent of proposals were selected for grant awards in FY 2022. The average award size that year was $214,500 over 3 years. Activities funded by NSF in FY 2022 involved an estimated 52,700 senior researchers, 6,100 postdoctoral associates, 43,600 graduate students, 39,200 undergraduate students, and 181,000 K-12 teachers and students.[8]

Approximately 80% of NSF research and education funds are awarded to colleges, universities, and academic consortia. The remainder goes to private industry, including small businesses and non-profits (12%), Federally Funded Research and Development Centers (4%), and other recipients (5%).[9]



[7] National Science Foundation, *supra* note 1.
[8] *Id.*
[9] National Science Foundation, "FY 2022 Performance and Financial Highlights," https://nsf-gov-resources.nsf.gov/2023-03/FY22_PerfFinHighlights_web-Final-3-9-23.pdf?VersionId=xkiMiW2aY1HAL9Y0J2zDgd0._9XeLd53.

Facilities

In addition to research grants, NSF funds the construction, operations, and maintenance of research facilities and equipment. NSF typically enters into cooperative agreements with universities or other non-profit organizations for the construction and management of major facilities. The construction phases of such projects usually span multiple years, with extensive planning and oversight. Large equipment and facility projects include multi-user facilities, such as astronomical observatories and ocean research vessels; networked instrumentation and equipment; and large-scale computational infrastructure.

Merit-Review

The NSF proposal review and award process is based on competition between proposals within a specific scientific discipline or under an interdisciplinary initiative. Award selection involves input from individuals outside and within NSF, starting with a review panel made up of scientists and engineers with expertise in the relevant research area.

Every proposal is reviewed by multiple experts in the field and confidential feedback is made available to each proposer, allowing them to refine their proposal and increase their chance of success in the future. The panel evaluates proposals using two, NSB-approved criteria: (1) Intellectual Merit and (2) Broader Impacts. The NSF Merit Review Process is rigorous, highly competitive, and widely regarded as the "gold standard" for reviewing proposals in a competitive environment.

Research Security

U.S. research agencies have worked for decades to foster openness, transparency, and reciprocal international collaboration on basic research. However, in recent years, several incidents have led to the concern that other countries are taking advantage of the openness of the academic research environment in the United States.[10] This exploitation of U.S. research is entwined with concerns about our economic and national security. Threats to research security primarily arise from the failure of researchers applying for federal funding to disclose foreign affiliations, commitments, and sources of funding that may present a conflict of interest. Foreign talent recruitment programs have been found to incentivize or coerce participants to acquire "through illicit as well as licit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government."[11]

Research agencies, law enforcement and intelligence agencies, and universities are actively engaging to identify and mitigate threats to research security while preserving the U.S. system of scientific openness, transparency, and international collaboration.

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[10] JASON, The MITRE Corporation. *Fundamental Research Security*. December 2019. McLean, VA. Available at https://www.nsf.gov/news/special_reports/jasonsecurity/JSR-19-2IFundamentalResearchSecurity_12062019FINAL.pdf.

[11] National Science & Technology Council. Recommended Practices for Strengthening the Security and Integrity of America's Science and Technology Research Enterprise. January 2021. Available at https://trumpwhitehouse.archives.gov/wp-content/uploads/2021/01/NSTC-Research-Security-Best-Practices-Jan2021.pdf.

At NSF, a new Chief of Research Security Strategy and Policy position was created in March 2020 to lead the agency's response to this challenge. NSF employees and IPA Program staff are prohibited from participating in foreign talent recruitment programs. Disclosure requirements for researchers seeking a grant were clarified to include participation in foreign talent recruitment programs and an electronic form was created to facilitate and streamline such disclosures.

In January 2021, OSTP provided guidance to research organizations on best practices for protecting the security and integrity of Federally funded research.[12] President Trump also issued a National Security Presidential Memorandum (NSPM-33) outlining steps agencies should take.[13] The Biden Administration has indicated it plans to move forward with implementation of NSPM-33. 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.[14]

The CHIPS and Science Act of 2022 contained several research security provisions that NSF is implementing. These include establishing an Office of Research Security and Policy at NSF, developing online resources to inform institutions and researchers of security risks and best practices, conducting risk assessments, and providing training and mentoring in responsible research to awardees.

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 (1) ramping up the capabilities of the Research Security and Integrity Information Sharing and Analysis Organization to provide additional tools, information and resources; (2) establishing a Research on Research Security funding program using guidance from the JASON study[15] and NSF-funded workshops; (3) scaling up analytic capabilities to proactively identify conflicts of commitment, vulnerabilities of pre-publication research, and risks to the merit review system; and (4) making available and deliver research security training modules for the larger research community.[16]

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[12] National Science and Technology Council, Office of Science and Technology Policy, "Recommended Practices for Strengthening the Security and Integrity of America's Science and Technology Research Enterprise," https://trumpwhitehouse.archives.gov/wp-content/uploads/2021/01/NSTC-Research-Security-Best-Practices-Jan2021.pdf.

[13] White House, "Presidential Memorandum on United States Government-Supported Research and Development National Security Policy," https://trumpwhitehouse.archives.gov/presidential-actions/presidential-memorandum-united-states-government-supported-research-development-national-security-policy/.

[14] National Science and Technology Council, Office of Science and Technology Policy. "Guidance for Implementing National Security Presidential Memorandum 33 (NSPM-33) on National Security Strategy for United States Government-Supported Research and Development," https://www.whitehouse.gov/wp-content/uploads/2022/01/010422-NSPM-33-Implementation-Guidance.pdf.

[15] JASON, The MITRE Corporation. *Research Program on Research Security*. March 2023. McLean, VA. Available at https://nsf-gov-resources.nsf.gov/2023-03/JSR-22-08%20NSF%20Research%20Program%20on%20Research%20Security_03152023_FINAL_1.pdf.

[16] National Science Foundation, *supra* note 1.

Strategic Planning

In January 2022, the NSB released its biennial Science and Engineering Indicators report which found that the global position of the U.S. science and engineering enterprise has shifted due to rapid growth in Asia's research and development investments and science and technology capabilities. The report highlights the importance of building capacity through investing in research and development, enhancing education and training opportunities, and bringing in underrepresented groups into a STEM-educated labor force.[17]

On March 28, 2022, NSF released its 2022-2026 Strategic Plan. The Plan builds on 70 years of NSF driving critical research across all disciplines. The four strategic goals identified in the Plan are to (1) empower STEM talent to fully participate in science and engineering, (2) discover new information about our universe, the world and ourselves, (3) positively impact society by translating knowledge into solutions, and (4) excel at NSF operations and management. These goals will serve as a foundation for ensuring American leadership in science and technology innovation.[18]

Budget Request Overview

The President's FY24 budget request for NSF is $11.3 billion, a 14.6% increase of $1.438 billion above the FY23 total enacted level of $9.877 billion.[19]

National Science Foundation (NSF) FY24 Budget Request
(Dollars in millions)

Account	FY22 Enacted*	FY23 Enacted	FY24 Request	FY24 Request Over FY23 Enacted**	
				$	%
Research and Related Activities (RRA)	6964.66	7826.80	9029.90	1415.60	18.59%
STEM Education	1146.72	1371.00	1444.18	198.18	14.46%
Major Research Equipment & Facilities Construction (MREFC)	120.60	187.23	304.67	117.44	62.72%
Agency Operations & Award Management (AOAM)	420.21	463.00	503.87	40.87	8.83%
Office of Inspector General (OIG)	18.89	23.39	26.81	3.42	14.62%
National Science Board (NSB)	4.52	5.09	5.25	0.16	3.14%
Totals:	**8675.61**	**9876.51**	**11314.68**	**1775.67**	**18.61%**

* Excludes $360.65 million provided by the American Rescue Plan supplemental appropriation and $23.45 million provided by the "Extending Government Funding and Delivering Emergency Assistance Act", for necessary expenses related to RCRV construction impacted by Hurricane Ida.

** Captures both the FY 2023 Omnibus appropriation and the Disaster Relief Supplemental Base, excluding CHIPS and Science supplemental funds.

[17] National Science Board, National Science Foundation. 2022. Science and Engineering Indicators 2022: The State of U.S. Science and Engineering. NSB-2022-1. Alexandria, VA. Available at https://ncses.nsf.gov/pubs/nsb20221.
[18] National Science Foundation, "2022-2026 Strategic Plan," March 2022. https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf.
[19] National Science Foundation, *supra* note 1.

Budget Request Highlights

The NSF Director's vision for the future can be summarized in three pillars that point to opportunities to continue building on recent investments, such as the CHIPS and Science Act[20] and the FY 2023 Omnibus and the Disaster Relief Supplemental Appropriations. [21] These pillars[22] include:

1. ***Strengthening Established NSF*** – For more than seven decades, NSF has been making investments to expand the frontiers of science and technology. This mission to accelerate discovery and enhance U.S. research capabilities will continue to be a central focus.
2. ***Inspiring the Missing Millions*** – In its *Vision 2030*[23] report, the NSB identified a significant talent gap in the science and engineering workforce which they names the "Missing Millions." Every geographic region of the country has talented people who can participate in STEM and contribute too the innovation enterprise. In an effort to address the talent gap, NSF plans to increase investments in existing programs and create new pathways into STEM fields to expand opportunities that will lead to a well-paid workforce and vibrant economy.
3. ***Accelerating Technology and Innovation*** – Global competition for leadership and talent in science, engineering and technology is at an all-time high. To maintain global leadership, the U.S. 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 types of investments, NSF plans to accelerate partnerships with other agencies, private industry, nonprofits, and foreign allies to foster innovation through the leveraging of resources.

Broadening Participation

In FY 2022, NSF supported $630 million of broadening participation activities through 30 focused and geographic diversity programs. NSF is requesting $1.02 billion, a 20% increase from FY 2023 total enacted level, for programs that create and expand opportunities for underrepresented individuals in STEM. These programs include the Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED) which supports the enhancement of research administration and post-award management at underserved institutions[24]; the Centers of Research Excellence in Science and Technology (CREST) which provides support for the establishment of centers that effectively integrate education and research to enhance the research capabilities of minority-serving institutions (MSI) [25]; the Eddie Bernice Johnson INCLUDES Initiative (NSF INCLUDES) which is a comprehensive national initiative to enhance U.S. leadership in STEM discoveries and innovations through catalyzing the STEM enterprise to work collaboratively for

[20] P.L. 117-167
[21] P.L. 117-164
[22] National Science Board, *supra* note 1.
[23] National Science Board. "*Vision 2030*," May 2020. https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf.
[24] NSF, "GRANTED, Broadening Participation in STEM," https://beta.nsf.gov/funding/initiatives/broadening-participation/granted.
[25] NSF "Centers of Research Excellence in Science and Technology (CREST) and HBCU Research Infrastructure for Science and Engineering (HBCU-RISE)," https://beta.nsf.gov/funding/opportunities/centers-research-excellence-science-technology-0.

inclusive changes to the STEM workforce demographics[26]; the Louis Stokes Alliances for Minority Participation (LSAMP), an alliance based program that works to increase the number of STEM baccalaureate and graduate degrees awards to historically underrepresented populations in STEM disciplines[27]; the Established Program to Stimulate Competitive Research (EPSCoR) which builds research competitiveness in targeted states and territories[28]; and targeted programs to strengthen STEM undergraduate education and research at MSIs.[29]

The FY 2024 proposed investments will advance the priorities of the CHIPS and Science Act to support diversity at the individual, institutional, and geographic levels. These include provisions originally introduced as H.R. 210, the Rural STEM Education Research Act, which authorized activities at NSF that would support research and development activities to improve understanding of the challenges facing rural communities in providing sustaining quality STEM education programs.

Building a Resilient Planet

NSF supports research related to climate change through agency-wide initiatives and targeted funding opportunities across the seven research directorates. NSF participates in the government-wide U.S. Global Change Research Program (USGCRP)[30] by supporting interdisciplinary research in the biological, geological, and social and behavioral sciences to study Earth system processes and the consequences of climate change. In FY 2022, NSF invested $781 million in its contribution to USGCRP and is requesting $1.05 billion for FY 2024.

In addition to studying the impacts of climate change, NSF supports basic research in materials science and engineering, nanoscience, computing, chemical sciences, quantum science, and biosciences that lay the foundation for improving existing or developing new renewable energy technologies. This includes a proposed investment of $550 million in FY 2024 for Clean Energy Technology (CET) which are designed to identify and support transformative research to advance U.S. leadership in the transition to clean energy, as well as the creation of two new programs – the National Discovery Cloud (NDC) for Climate and the OISE Global Centers (GC) program – whose aim is to provide cyberinfrastructure ecosystems to further climate-related science and engineering, and support federal and international interdisciplinary collaboration to address grand societal challenges, respectively.

Advancing Emerging Industries for National and Economic Security

NSF has supported research to advance emerging technologies for decades. As the U.S. faces intensifying global competition for science and technology leadership, the investments of NSF in emerging technology research are imperative for strengthening and scaling innovation and translation of basic research to commercial markets.

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[26] NSF, "Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science," https://beta.nsf.gov/funding/opportunities/inclusion-across-nation-communities-learners.
[27] NSF, "Louis Stokes Alliance for Minority Participation," https://beta.nsf.gov/funding/opportunities/louis-stokes-alliances-minority-participation.
[28] NSF, "Estab-lished Program to Stim-u-late Com-pet-i-tive Research (EPSCoR)," https://beta.nsf.gov/funding/initiatives/epscor.
[29] National Science Foundation, *supra* note 1.
[30] U.S. Global Change Research Program. "About USGCRP," https://www.globalchange.gov/about.

As the newest NSF Directorate, TIP advances emerging technologies to address societal and economic challenges and opportunities; accelerates the translation of research results from the lab to market and society; and cultivates new education pathways leading to a diverse and skilled future technical workforce comprising researchers, practitioners, technicians, and entrepreneurs. 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 and education by catalyzing strategic partnerships that link 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 jobs and enhance the Nation's long-term competitiveness.

The FY 2024 budget request for TIP is $1.19 billion[31]. The major TIP investments in FY 2024 include:

- *NSF Regional Innovation Engines,* which was authorized in the CHIPS and Science and aims to catalyze new business and economic growth in those regions of America that have not fully participated in the technology boom of the past few decades.
- *Experiential Learning in Emerging Industries (ExLENT)*, which supports inclusive experiential learning opportunities for cohorts of diverse learners with the crucial skills needed to prepare them to enter the workforce or pivot into new jobs in key technology focus areas.
- *NSF Entrepreneurial Fellows* was authorized in the CHIPS and Science Act, and provides Ph.D.-trained scientists and engineers with resources to mature promising ideas and technologies from the lab to the market and society.
- *Accelerating Research Translation (ART)* which will support institutions of higher education to build necessary infrastructure to boost their overall capacity to accelerate the pace and scale of translational research, in alignment with the intent of the CHIPS and Science Act.
- *NSF Convergence Accelerator* which will focus on regional acceleration of the translation of use-inspired research pursuing technology solutions to location-specific challenges in a variety of research areas (i.e. food and agriculture, disaster response and mitigation, transportation, etc.).

NSF investments in key technology focus areas remain crucial to securing American leadership in the future. NSF has identified six focus areas for proposed funding increases including advanced manufacturing, advanced wireless, artificial intelligence, biotechnology, microelectronics and semiconductors, and quantum information science.

[31] National Science Foundation, *supra* note 1.

NSF Emerging Industries Funding[32]
(Dollars in Millions)

Emerging Industry	FY22 Actual	FY23 Enacted	FY24 Request
Advanced Manufacturing	$364.89	$367.43	$453.86
Advanced Wireless	$131.76	$161.31	$179.17
Artificial Intelligence	$679.23	$687.70	$796.48
Biotechnology	$315.22	$401.28	$470.05
Microelectronics & Semiconductors	$106.46	$164.24	$209.68
Quantum Information Science	$252.48	$275.91	$332.67

*Investments may overlap and should not be summed.

Research Infrastructure

Research infrastructure is foundational to science and innovation and enables advances in all areas of research. The FY 2024 request includes funds for ongoing Major Research Equipment and Facilities Construction (MREFC) ($304.67 million) which supports construction projects that require an investment of more than $100 million. This funding would support three ongoing projects – the Antarctic Infrastructure Recapitalization program[33], the two detector upgrades to operate the High Luminosity-Large Hadron Collider, and the Vera C. Rubin Observatory – and one new project – the Leadership-Class Computing Facility. The MREFC account also supports the Mid-scale Research Infrastructure Track 2 program which funds projects in the $20 million to $100 million range.

MREFC Account Funding, by Project[34]
(Dollars in Millions)

Project	FY23 Estimate	FY24 Request
Antarctic Infrastructure Recapitalization	$60.00	$60.00
HL-Large Hadron Collider Upgrade	$33.00	$38.00
Leadership-Class Computing Facility	-	$93.00
Mid-scale Research Infrastructure, Track 2	$76.25	$105.06
Regional Class Research Vessel	$1.98	-
Vera C. Rubin Observatory	$15.00	$7.61
Dedicated Construction Oversight	$1.00	$1.00
Totals	**$187.23**	**$304.67**

[32] National Science Foundation, *supra* note 1.
[33] United States Antarctic Program, "Background of AIMS," https://future.usap.gov/foundation-of-aims/.
[34] National Science Foundation, *supra* note 1.

The FY 2024 budget proposal also includes increases for Major Facilities operations and maintenance. In addition to regular upkeep, support for upgrades and periodic maintenance must be addressed within the budget for facilities operations and management, which accounts for 10 percent of NSF's total request in FY 2024.[35]

CHIPS and Science Act of 2022

Title III of the CHIPS and Science Act was based on the bipartisan NSF for the Future Act, which takes important steps to improve NSF's capabilities and ensure the U.S. maintains its edge against rising global competition, while protecting NSF's primary mission of supporting fundamental research--the kind of groundbreaking exploration that industry cannot afford to fund. It also expands our STEM workforce, supports geographic diversity of research in the U.S., and secures our research from theft.

Summary of Major Provisions[36]

- Authorizes $81 billion over the next five years for the Foundation, prioritizing basic research, STEM education, and major research equipment.
- Directs investments in critical research-enabling infrastructure and directs a roadmap for meeting the research community's growing need for advanced computing capabilities.
- Codifies a new NSF directorate to support translational research, accelerate the development and use of federally funded research, strengthen U.S. competitiveness through development of key technologies, and expand student and researcher participation and the U.S. workforce in key technologies and in areas of societal, national, and geostrategic importance. Authorizes $20 billion over five years for initiatives.
- Supports strategic investments in the STEM workforce to expand and enhance the American talent pipeline, including efforts to align undergraduate STEM education with workforce needs.
- Supports geographic diversity of research in the U.S., including bolstering opportunities for Minority-Serving Institutions and rural communities.
- Secures taxpayer-funded research and technologies from adversaries like the CCP. Includes a prohibition on grantees' participation in malign foreign talent programs and a requirement for annual training on research security threats.

[35] National Science Foundation, *supra* note 1.
[36] National Science Foundation, "CHIPS and Science," accessed April 24, 2023, at https://new.nsf.gov/chips.

Chairman LUCAS. Before we begin today's hearing, I'd like to take a moment to acknowledge the loss of one of our own. Our Deputy Staff Director Jennifer Wickre passed away this weekend after a long battle with cancer. Jenn had been with the Science Committee since 2015, and I know a lot of people here worked with her often and knew her well. Jenn was passionate about the work we do here, and she represented the very best principles of public service. I relied on her, as I know many of you in this room did, for good advice, always delivered with good humor. She was diligent, smart, and always sought solutions, finding ways to come to consensus so we could work together to pass bipartisan bills in the best interests of our country. She was instrumental in helping us develop and pass the *CHIPS and Science Act,* which will be a big focus of our discussion here today. That's just one way in which her impact will be felt for years to come.

A number of Members—and I'm very appreciative for the Ranking Member—joined me on the floor—House floor last week in a special order paying tribute to Jenn, and I'd like to thank all of those who were able to take part. And I encourage everyone here to watch that tribute to fully understand what Jenn has meant to this Committee. We will miss her dearly. And I hope we'll—I hope you'll all join me in extended condolences to her family.

Ms. LOFGREN. Mr. Chairman?

Chairman LUCAS. The Ranking Member is recognized.

Ms. LOFGREN. Mr. Chairman, I am so grateful to you for starting this meeting, remembering the tremendous service of Jenn Wickre. Just briefly, staff and Members on the Democratic side are in mourning, as are all of the Members and staff. She was admirable, smart, funny, bipartisan, and productive person. And I thank you for letting us pay tribute to her today.

And with that, I would yield back.

Chairman LUCAS. I thank the Ranking Member. And with that, the Committee will come to order.

Without objection, the Chair is authorized to declare recess of the Committee at any time.

Welcome to today's hearing entitled "An Overview of the Budget Proposal for the National Science Foundation (NSF) for Fiscal Year (FY) 2024." And I recognize myself for 5 minutes for an opening statement.

Good morning. Today's hearing focuses on the National Science Foundation's budget proposal for Fiscal Year 2024. And I want to thank Dr. Sethuraman Panchanathan and note that he is a person of effervescent personality and a wonderful individual to work with. And I'm phonetically challenged, so for the rest of the hearing, it's Dr. Panch if that's OK, Doctor, and Dr. Reed for taking time to participate. I'm looking forward to hearing your testimony and thoughts on how the National Science Foundation can support America's scientific progress.

Thanks in part to NSF's work, America has long led the world in science and technology innovation. To maintain that leadership, we have to adapt to a changing reality. And we're all aware the pace of innovation is accelerating. Global competition has increased, and the United States risks losing its edge. We face a particularly challenging threat from the Chinese Communist Party

(CCP), which is aggressively pursuing technological supremacy through foreign acquisitions, forced technology transfers, and, frequently, cyber espionage.

Beyond the threats from our adversaries, we're also facing a technological revolution. Advances in artificial intelligence (AI), quantum technology, and biotechnology are going to change the way we live and work, how we grow our food, treat diseases, and even how we defend ourselves against foreign threats. I strongly believe that the Nation that leads in science and technology will shape the world order for the next century. I'd like that Nation to be ours, and I'd like for emerging technologies to be developed with our values of transparency and fairness.

The *CHIPS and Science Act* authorized critical investments and modernizations at the NSF to tackle the challenges of reinvigorating American innovation and leadership in science and technology. It doubles down on NSF's world-leading basic research, while enhancing NSF's ability to move research from lab to market through the establishment of the Technology, Innovation, and Partnerships (TIP) Directorate. The new TIP Directorate aims to take fundamental research funded by NSF and help apply those discoveries to solving national challenges from artificial intelligence to climate change. The TIP Directorate will also foster strategic partnerships with industry, including small businesses and startups, to cultivate innovative—innovation ecosystems, which will enhance America's long-term competitiveness.

Another goal of *CHIPS and Science* was to improve the geographic diversity of our scientific workforce and ensure all Americans who—have opportunities to participate and excel in STEM (science, technology, engineering, and mathematics) education and employment. *CHIPS and Science* authorized a number of activities to ensure that investments aren't just happening in places like San Francisco or Boston, but also in places like Stillwater, Oklahoma. We're ensuring that funding isn't just going to a handful of universities, but also the land grant institutions like Oklahoma State and historically Black colleges and universities (HBCUs) like Langston University. I look forward to hearing about how NSF is working to improve geographic diversity and STEM through various programs and initiatives like the Regional Innovation Engines (RIE) and the Missing Millions. These investments also have the potential to inspire the next generation of researchers and scientists, and those individuals will be the key to maintaining American leadership for decades to come.

In addition to expanding the geography of our research infrastructure, we also need cutting-edge facilities for our Federal scientists and researchers from academia and industry to conduct big science research that can't be done in individual labs and requires massive equipment that industry cannot provide. So I'm looking forward to hearing more about those investments today.

Any discussion of NSF's work right now must include a significant focus on research security. Research theft and malign foreign influence are explicit strategies within the CCP's plan to become a global leader in science and innovation. This Committee has carefully worked with Federal research and national security agencies, as well as universities and other stakeholders, to identify and pro-

vide the resources, authority, and tools needed to identify and address malign foreign influence and research theft. We've worked to strike the correct balance between keeping our research enterprise open, but also protecting it from adversaries who seek to take advantage of our open system. I look forward to hearing from our witnesses today about how the Foundation is utilizing these authorities and tools to address the challenges of research security and protect America's intellectual property.

As we look at the President's budget request for the Foundation, we in Congress have the responsibility to ensure that it offers a sustainable path forward for U.S. research enterprises. I have concerns about the use of supplemental funds last Congress that may create a situation that fosters feast and famine for our research enterprises, so to speak. We must do everything we can to avoid this. Innovation thrives on a stable, predictable funding, and our Nation's students, scientists, and research institutions depend on it.

Again, I thank our witnesses for being here today, and I look forward to your testimony.

[The prepared statement of Chairman Lucas follows:]

Good morning. Today's hearing focuses on the National Science Foundation's budget proposal for fiscal year 2024. I'd like to thank Dr. Panchanathan and Dr. Reed for taking the time to participate. I'm looking forward to hearing your testimony and thoughts on how the National Science Foundation can best support America's scientific progress.

Thanks in part to NSF's work, America has long led the world in science and technology innovation. To maintain that leadership, we have to adapt to a changing reality. As we're all aware, the pace of innovation is accelerating, global competition has increased, and the United States risks losing its edge.

We face a particularly challenging threat from the Chinese Communist Party (CCP), which is aggressively pursuing technological supremacy through foreign acquisitions, forced technology transfers, and frequently, cyber espionage.

Beyond the threats from our adversaries, we are also facing a technological revolution. Advances in artificial intelligences, quantum technology, and biotechnology are going to change the way we live and work, how we grow food and treat diseases, and even how we defend ourselves against foreign threats.

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The *CHIPS and Science Act* authorized critical investments and modernizations at the NSF to tackle the challenges of reinvigorating American innovation and leadership in science and technology.

It doubles down on NSF's world-leading basic research, while also enhancing NSF's ability to move research from lab to market through the establishment of the Technology, Innovation and Partnership Directorate (TIP).

The new TIP Directorate aims to take fundamental research funded by NSF and help apply those discoveries to solving national challenges from artificial intelligence to climate change.

The TIP Directorate will also foster strategic partnerships with industry, including small businesses and startups, to cultivate innovation ecosystems that will enhance America's long-term competitiveness.

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I have concerns that the use of supplemental funds last Congress may create a situation of feast and famine for our research enterprise. We must do everything we can to avoid this.

Innovation thrives on stable and predictable funding, and our nation's students, scientists, and research institutions depend upon it.

Again, I thank our witnesses for being here today, and I look forward to your testimony.

I now recognize the Ranking Member for her opening statement.

Chairman LUCAS. I now recognize the Ranking Member, the gentlewoman from California, for an opening statement.

Ms. LOFGREN. Thank you, Chairman Lucas, for holding today's hearing, and Dr. Panchanathan and Dr. Reed, thank you both for being here.

As the Chairman has mentioned, the Science Committee led the development and enactment of the *CHIPS and Science Act,* which revitalized our Nation's commitment to science. I'm encouraged by the President's budget request, which seeks to carry out these critical investments. Obviously, however, the request for funding has not yet been appropriated, and in the face of global competition and major societal challenges that can be addressed through our science and technology enterprise, we have to follow through on these investments. We can't resort to cutting scientific funding to meet arbitrary spending goals.

One of the Nation's premier science agencies, of course, is the National Science Foundation. NSF has actually an astounding record of achievement for more than 70 years. As the global environment is evolving, the agency, under the leadership of our esteemed witnesses, is evolving with it.

CHIPS and Science legislation included a comprehensive reauthorization of NSF, and to help the agency meet the opportunities and challenges of the 21st century, the law also created the first-of-its-kind Directorate for Technology, Innovation, and Partnerships, or the TIP Directorate. Now, this is to buildupon investments of other research directorates by supporting new kinds of partnerships and promoting use-inspired and translational re-

search at a larger scale. This new directorate provides an opportunity to think differently about the kinds of partnerships that will further its mission, but it would be incorrect to ignore the anxiety that the creation of this directorate stimulated among some in the science community. So I'm looking forward to hearing more about this and how we can make sure that all components of NSF continue to flourish and that the breakthrough discoveries that are endorsed and supported by NSF continue on.

I would like to note there are critical investments that are being made on a variety of topics, but as many know, I have a special interest in how we are assisting the development of fusion with the hope of fusion energy. Now, NSF-supported research is foundational to our capacity, and I'm hopeful that we can hear more about that.

Again, I'm very happy with President Biden's continued to commitment to science, as reflected in his proposed budget. And again, I thank the witnesses for being here. I look forward to your testimony today.

[The prepared statement of Ms. Lofgren follows:]

Thank you, Chairman Lucas, for holding today's hearing. And Dr. Panchanathan and Dr. Reed, thank you both for being here.

Last year, the Science Committee led in the development and enactment of the landmark *CHIPS and Science Act,* which revitalized our nation's commitment to science. I am encouraged by the President's budget request, which seeks to carry out these critical investments. But I will remind my colleagues that funding for the "Science" part of the *CHIPS and Science Act* has not yet been appropriated. In the face of global competition and major societal challenges that can be addressed through our science and technology enterprise, we must follow through on these investments. We cannot resort to cutting scientific funding to meet arbitrary spending goals.

One of our nation's premier science agencies is the National Science Foundation. NSF has a truly astounding record of achievement for more than 70 years. But the global context is evolving, and the agency, under the leadership of our esteemed witnesses, is evolving with it.

The *CHIPS and Science* legislation included a comprehensive reauthorization of NSF. To help the agency meet the opportunities and challenges of the 21st century, the law also created the first-of-its-kind Directorate for Technology, Innovation, and Partnerships, or "TIP" Directorate. The TIP Directorate builds upon the investments of the other research directorates by supporting new kinds of partnerships and promoting use-inspired and translational research at a larger scale.

TIP presents an opportunity for NSF to think differently about what kinds of partnerships will help further its mission, not just to promote the progress of science, but also - as is written into the agency's mission statement - to promote the national health, welfare, prosperity, and defense. Strengthening and expanding industry partnerships is essential. So is engaging nontraditional stakeholders and diverse voices in NSF research.

NSF also has some management challenges I hope to discuss today. NSF has a long history of sustained investment in major scientific research facilities that enable breakthrough discoveries. Today, NSF faces enormous pressure as multiple scientific disciplines have concurrently prioritized investments in major new facilities, and operations budgets for increasingly sophisticated facilities threaten research budgets.

This issue is particularly apparent in astronomy. The most recent decadal survey in astronomy and astrophysics recommended that NSF invest in several new major research facilities, with the highest priority given to the US-Extremely Large Telescope Program. There is also a new Antarctic Research Vessel waiting for approval. I would like to better understand how the agency plans to balance these lofty priorities and strengthen lifecycle planning to account for ever-increasing operations budgets.

Yet another management challenge that we will discuss further today is ensuring that the research environment is safe and free of harassment. While NSF has been a leader in promoting safe environments on university campuses, further steps are

needed to protect women and gender minorities in remote research environments. This is particularly so for the U.S. Antarctic Program.

Finally, I am interested to learn more about NSF's investments in critical industries, including artificial intelligence, microelectronics, synthetic biology, and fusion energy. NSF supported research is foundational to our capacity as a nation to innovate and compete. And that brings me full circle to my earlier comment that now, more than ever, is the time to invest in NSF's full potential. Let us not cut our nose to spite our face.

I am very happy with President Biden's continued commitment to science as reflected in the fiscal year 2024 budget request. Again, I thank the witnesses for being here, and I look forward to your testimony today.

I yield back.

Chairman LUCAS. I always appreciate the Ranking Member's thoughtful comments, and she yields back.

Let me introduce our witnesses. Our first witness today is the Director of the National Science Foundation, Dr. Panch, as I like to affectionately call him. He became the 15th Director of the Foundation in June 2020. And prior to becoming Director, he was the Executive Vice President of the Arizona State University (ASU) Knowledge Enterprise. Under his leadership, ASU increased research performance fivefold, earning recognition as the fastest growing and most innovative research university in the United States. He also served as a member of the board of the National Science Board (NSB) before becoming Director.

Our next witness is Dr. Daniel Reed. Dr. Reed is the current Chair of the National Science Board, elected in May of 2022. And before becoming Chair of the National Science Board, Dr. Reed served as a Provost at the University of Utah, where he is now a Presidential Professor of Computational Science and a Professor of Computer Science and Electrical and Computer Engineering. That sounds like all hard stuff, Doc.

I would love to now recognize our first witness, Dr. Panch, for 5 minutes to present his testimony.

TESTIMONY OF DR. SETHURAMAN PANCHANATHAN, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. PANCHANATHAN. Thank you, Mr. Chairman. Good morning, Chairman Lucas, Ranking Member Lofgren, and the Members of the Committee. It is an honor to appear before you to discuss the President's FY 2024 budget request for NSF and how our agency is inspiring the talent and unleashing the innovations that will keep our Nation the global leader in science, engineering, and technology for decades to come.

First, I want to start by thanking this Committee for your work on the *CHIPS and Science Act* and for your continued strong support of NSF. Your leadership is central to ensuring that the Nation can meet the challenge of what is surely a defining moment in global competition. For more than 70 years, NSF has been an important component of our Nation's success by investing in the amazing talent in our country and by attracting the brightest minds from around the world. NSF has been a catalyst for countless scientific breakthroughs, major advancements in engineering and manufacturing and so much more. In doing so, NSF has powered the economy, transformed lives, and help secure our national defense.

Many of the key technology areas we will discuss today are rooted in decades of sustained NSF investment in exploratory research that has transformed the way we see the world and expanded the frontiers of knowledge. Today, we are currently facing intense global competition like never before. Our competitors are investing heavily in artificial intelligence, quantum information science, and other technologies. Our ability to achieve scientific breakthroughs and unlock the promise of technological developments will determine our continued global leadership, and our success is vital to our economic and national security.

With the passage of the *CHIPS and Science Act of 2022,* Congress put in place a roadmap to meet this challenge, and to do so while spurring innovation in communities in every region of our country. Mr. Chairman, the law positions the agency to quickly translate research into impacts that benefits the Nation.

The FY 2024 budget request of $11.3 billion invests in the three pillars central to achieving the goals of the *CHIPS and Science Act.* First, we must strengthen our commitment to funding the fundamental exploratory-based research that is the heart of NSF's mission.

Second, we must realize the promise of the Technology, Innovation, and Partnerships Directorate, or TIP as we call it, to accelerate the Nation's technology and innovation enterprise through investments in use-inspired translational breakthroughs.

Finally, it is exceedingly important that we inspire talent by creating opportunities for every demographic and socioeconomic group in every geographic region in our country.

The FY 2024 request includes 1.2 billion in funding for TIP. This investment will strengthen and scale investments in breakthrough technologies, innovation, and translation. The request includes $300 million for the NSF Regional Innovation Engines Program, and we are very excited by the strong interest and amazing proposals we have received. When we first announced this funding opportunity, we receive hundreds of concept papers spanning every part of our Nation, in every State, in every region, and even the territories. In a couple of weeks, we will make the first planning grants and in the fall the first award for full-scale engines. These investments will empower partnerships to catalyze innovation all across the country.

In addition, NSF's role in workforce training has become increasingly important as the country makes significant investments in technology R&D, including semiconductor manufacturing. The *CHIPS and Science Act* recognized this, and in just the past few months, NSF has announced partnership with Micron, Intel, Ericsson, Samsung, and exactly for this purpose, how do we get public-private partnerships to work for our Nation? This budget also supports critical research infrastructure, including a new MREFC (Major Research Equipment and Facilities Construction) project, the Leadership-Class Computing Facility at the University of Texas at Austin.

Finally, the request invests heavily in broadening participation in STEM. The request includes over $1.8 billion to create opportunities everywhere and to increase the participation of underserved groups in STEM. These activities include programs focused on

building research capacity at HBCUs, minority-serving institutions (MSI), investing in EPSCoR (Established Program to Stimulate Competitive Research) jurisdictions, building capacity in emerging research institutions, and finding new approaches to ensure that everyone has a chance to participate in the innovations of the future.

Mr. Chairman and Ranking Member Lofgren, I would like to end by joining the Committee in honoring the memory of Jenn Wickre. Jenn was truly a remarkable person, and I was so blessed to meet her, interact with her, work with her. And she will be remembered fondly at NSF for her keen intellect, her quick wit, and her honesty and integrity. Her contributions to science policy, dedication to public service, and her impact on so many people cannot be overstated by NSF, and the entire research enterprise in the Nation would not be what we are today without her. On behalf of the entire agency, I offer our deepest condolences to Jenn's family and friends and everyone who was fortunate enough to be touched by her and part of her life.

Thank you, Mr. Chairman and Ranking Member.

[The prepared statement of Dr. Panchanathan follows:]

Dr. Sethuraman Panchanathan
Director
National Science Foundation

Before the
Committee on Science, Space, and Transportation
United States House of Representatives

"An Overview of the National Science Foundation Budget Proposal for Fiscal Year 2024"

April 26, 2023

Introduction

Chairman Lucas, Ranking Member Lofgren, and Members of the Committee, it is a privilege to appear before you today to discuss the National Science Foundation's Fiscal Year (FY) 2024 Budget Request to Congress, and how it builds upon decades of successful investments and breakthroughs in science, engineering, and technology to ensure that the United States remains the global leader in innovation into the future.

Established by the National Science Foundation Act of 1950 (P.L. 81-507), the National Science Foundation (NSF) is an independent federal agency charged with the mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF is unique in carrying out its mission by supporting research across all fields of science, technology, engineering, and mathematics, and at all levels of STEM education. NSF investments contribute significantly to the economic and national security interests of the nation, and development of a future-focused science and engineering workforce that draws on the talents of all Americans resulting in the creation of new businesses, new jobs, and more exports.

For more than seven decades, NSF has been a critical component in powering the United States economy, transforming American lives, and securing the national defense. Many of the technological advances we are benefiting from today such as Artificial Intelligence, Quantum Information Science, and Biotechnology are rooted in sustained investment over many decades. However, we currently face intense global competition in the race to develop these key technology areas and to develop the workforce needed to secure the future of innovation. Our success in

unlocking the promise of these and other technological developments and scientific breakthroughs will determine our continued global leadership and are central to our economic and national security.

With the passage of the CHIPS and Science Act of 2022, Congress put in place a roadmap for meeting this challenge while also spurring innovation in communities throughout the country. The law codifies NSF's new Directorate for Technology, Innovation and Partnerships (TIP), and positions the agency to capitalize on the uniquely American research ecosystem that includes academia, private industry, the government, and other partners to quickly translate research into impacts that benefit the Nation. NSF is unique in how the agency invests in research across every discipline of science, engineering and technology. Through these investments, NSF plays a major role in inspiring and training the next generation STEM workforce – through K-12 informal STEM education, technical training, support for graduate and PhD students, and experiential learning. NSF's role in workforce training has become increasingly important with the significant investments in semiconductor manufacturing, which will require strong partnerships between the federal government, academia, and private industry to training the needed workforce.

The President's FY 2024 Budget Request of $11.3 billion for NSF makes historic investments in these priority areas and these increases are essential to realizing the goals of the CHIPS and Science Act. In FY 2024, NSF will accelerate advancement in key technologies while strengthening support for the exploratory basic research and use-inspired innovations that have been the foundation of NSF investments for 73 years.

NSF's Three Pillars

NSF's vision for the future of science and engineering research, the CHIPS and Science Act of 2022, and the FY 2024 Budget Request all stand on three core pillars. These three pillars are essential to the Nation's continued global leadership in innovation. First, we must strengthen NSF's ability to accelerate discovery and enhance state-of-the-art research capabilities through continued investment in fundamental, exploratory research. Second, we must inspire the Missing Millions by providing Science, Technology, Engineering and Math (STEM) opportunities to every demographic and socioeconomic group in every geographic region of the country. Finally, we must accelerate the Nation's technology and innovation enterprise through NSF's investments in use-inspired, translational breakthroughs by fostering partnerships and nurturing talent so the U.S. can remain a global leader in STEM.

Four Strategic Themes

These three pillars are the foundation for four major themes in the FY 2024 President's Budget Request for NSF — 1. Advance Emerging Industries for National and Economic Security; 2. Build a Resilient Planet; 3. Create Opportunities Everywhere; and 4. Strengthen Research Infrastructure. These themes align with the Administration's priorities of expanding basic research to tackle grand national challenges and empowering new approaches to applied research that spur technology transfer. The themes, expanded upon below, span the broad portfolio of fundamental research that is the heart of NSF's mission. They also stimulate new efforts and

connect existing efforts throughout the research portfolio and implement requirements of the CHIPS and Science Act.

Advance Emerging Industries for National and Economic Security

As the U.S. faces intensifying global competition for science and technology leadership, NSF will implement the CHIPS and Science Act to 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, NSF will 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 to society and by targeting investments in new industries and people.

With the support of the Administration and Congress, NSF has launched its first new directorate in more than thirty years. The new Directorate for Technology, Innovation and Partnerships (TIP) sits at the crossroads of exploratory, curiosity-driven research, use-inspired, solutions-oriented research, and translational research across all disciplines of science and engineering. In FY 2024, $1,185.63 million is requested for the TIP Directorate to ensure that TIP will have the transformative impacts it is designed to achieve. The TIP Directorate, 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, 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.

Partnerships within the agency, with other agencies, industry, non-profit organizations, and like-minded international partners are also crucial to our success. TIP will leverage NSF's unique relationships with the academic community and grow the agency's collaboration with industry to spur innovation throughout the nation. Specific programs include:

- The NSF **Regional Innovation Engines** (NSF Engines) will catalyze new business and economic growth in diverse regions of America that have not fully participated in the technology boom of the past several decades. $300 million is requested in FY2024 for the NSF Engines.
- NSF's **Experiential Learning in Emerging Industries** (ExLENT) program 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. $50 million is requested for ExLENT in FY 2024.

- The NSF **Entrepreneurial Fellows** program 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. The FY2024 Request includes $10 million for the Entrepreneurial Fellows program.
- The **Accelerating Research Translation** (ART) program 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. $45 million is requested in FY 2024 for the ART program.
- NSF's **Convergence Accelerator** 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. $100 million is requested in FY2024 for the Convergence Accelerator.

The FY 2024 Budget Request also proposes robust funding in six Emerging Industries where continued investment in both exploratory, curiosity-driven research and use-inspired, solutions-oriented research is needed to sustain U.S. leadership, support economic development, and secure our national security.

(1) Advanced Manufacturing investments will accelerate breakthroughs in manufacturing materials, technologies, and systems through fundamental, multidisciplinary research that transforms manufacturing capabilities, methods, and practices. The FY 2024 Request includes $453.86 million for NSF investments that 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.

(2) Advanced Wireless 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. In FY 2024, the $179.17 million requested for this research will provide the backbone that connects users, devices, applications, and services that will continue to enrich America's national and economic security.

(3) Artificial Intelligence (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. In FY 2024, $796.48 million is requested for NSF investments that 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.

(4) Biotechnology investments will support fundamental research, infrastructure, and education to understand and harness biological processes for societal benefit. In FY 2024, $470.05 million is requested to 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.

(5) Microelectronics and Semiconductors 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. In FY2024, $209.68 million is requested to 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.

(6) Quantum Information Science (QIS) 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. In FY 2024, $332.67 million is requested to 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.

Build a Resilient Planet

As the U.S. and the world continue to feel the impacts of a changing climate and the growing need for clean, reliable, sustainable energy, it is critical that we invest in knowledge and innovations that can make us more resilient to these impacts. Without resilience we are at the mercy of heat waves, droughts, floods, wildfires, rising oceans, and other extreme events, as well

as the power disruptions, economic instability, food insecurity, and deleterious effects on human health that accompany them. 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 investments will advance the priorities of the CHIPS and Science Act and focus on action to meet the urgent demands of people, places, and economies.

Clean Energy Technology (CET) 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. In FY 2024, $550.51 million is requested to invest in integrated clean energy research and education. These investments will advance the fundamental science and engineering underlying clean energy technologies and infrastructure 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.

The **U.S. Global Change Research Program** (USGCRP) supports research that (1) advances scientific knowledge of the integrated natural and human components of the Earth system and (2) informs decisions by providing the scientific basis to inform and enable timely decisions on adaptation and mitigation. In FY 2024, $1,047.06 million is requested for NSF to continue to engage with other USGCRP agencies on priorities such as 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; and understanding the impacts of global change on the Arctic region and effects on global climate. 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.

NSF's **Climate Equity Fellowships** 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. $15.0 million is requested in FY 2024 for the program to 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.

The FY 2024 Request also includes $30.0 million to further develop the **National Discovery Cloud** (NDC) for Climate, a resource that will federate advanced computing, data, software and networking resources, democratizing access to a cyberinfrastructure ecosystem that is increasingly necessary to further climate-related science and engineering. $25.0 million is also requested for NSF's Office of International Science and Engineering (OISE) **Global Centers** (GC) program, 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.

Create Opportunities Everywhere

NSF is fully committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans, in every region of the country. Create Opportunities Everywhere (COE) is a comprehensive approach for attracting, supporting, and advancing the opportunities for 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. 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. For institutions, NSF will be more intentional in engaging Minority Serving Institutions (MSIs) and Emerging Research Institutions (ERIs) in our programming. For 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 authorizes NSF to support 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. The FY 2024 Request includes investments to address each of these priorities, including:

- NSF's **Established Program to Stimulate Competitive Research (EPSCoR)** enhances the competitiveness of EPSCoR jurisdictions in the disciplinary domains supported by NSF. $280.68 million is requested for EPSCoR in FY 2024.
- NSF's **Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED)** program will improve the Nation's research support and service capacity at emerging and underserved research institutions. $50 million is requested for GRANTED in FY 2024.
- The **Alliances for Graduate Education and the Professoriate (AGEP)** 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. $15.5 million is requested for AGEP in FY 2024.
- NSF's **Centers of Research Excellence in Science and Technology (CREST)** program enhances the research capabilities of minority-serving institutions (MSI) through the

establishment of centers that effectively integrate education and research. The FY 2024 Request includes $41 million for CREST.

- The **Eddie Bernice Johnson INCLUDES Initiative** 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. $50.50 million is requested for INCLUDES in the FY 2024 Request.
- NSF's **Hispanic-Serving Institutions Program (HSI)** builds capacity at HSIs and enhances the quality of undergraduate STEM education and increases retention and graduation rates of undergraduate students pursuing degrees in STEM fields at HSIs. $60.5 million is requested for the HIS program in FY 2024.
- NSF's **Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)** enhances the quality of undergraduate STEM education and research at HBCUs. The FY 2024 Request includes $48.50 million for HBCU-UP.
- The **Historically Black Colleges and Universities Excellence in Research (HBCU-EiR)** program complements HBCU-UP by enabling STEM and STEM education faculty to further develop research capacity at HBCUs. $37.93 million is requested for the HBCU-EiR program in FY2024.
- NSF's **Louis Stokes Alliances for Minority Participation (LSAMP)** program works to increase the number of STEM baccalaureate and graduate degrees awarded to populations historically underrepresented in STEM disciplines. $70.50 million is requested in FY 2024 for LSAMP.
- The **Tribal Colleges and Universities Program (TCUP)** 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. The FY 2024 Request includes $23.0 million for TCUP.

Strengthen Research Infrastructure

Research infrastructure (RI), from individual instruments to major research facilities, is foundational to the scientific endeavor. RI has 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.

NSF invests in RI across this spectrum, including:

- NSF's **Major Research Instrumentation (MRI)** 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. $92.75 million is requested for MRI in FY 2024.

- NSF's **Mid-scale Research Infrastructure (Mid-scale RI)** program is 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 1) provide access to cutting-edge mid-scale research infrastructure, including instrumentation, 2) enable agile development and implementation of frontier scientific and engineering research infrastructure with a high potential to significantly advance the Nation's research capabilities, and 3) train early-career scientists and engineers in the development and use of advanced research infrastructure. In FY 2024, $155.06 million is requested for the Mid-scale RI programs Track 1 and Track 2.

- NSF's **Major Research Equipment and Facilities Construction (MREFC)** ($304.67 million) MREFC supports construction projects that require an investment of more than $100 million. The FY 2024 Request includes $105.61 million in funding for three ongoing projects:

    1. The Antarctic Infrastructure Recapitalization program, an enduring program that replaces the Antarctic Infrastructure Modernization for Science or AIMS project. ($60.0 million)
    2. The two detector upgrades to operate at the High Luminosity-Large Hadron Collider (HL-LHC). ($38.0 million)
    3. The Vera C. Rubin Observatory ($7.61 million).

- The FY 2024 Request includes funding for one new MREFC project -- the **Leadership-Class Computing Facility (LCCF)**. Led by the Texas Advanced Computing Center (TACC) at the University of Texas at Austin, LCCF is envisioned as a distributed facility that will provide unique computational and data analytics capabilities, as well as critical software and services, for the nation's S&E research community to enable discoveries that would not be possible otherwise. Furthermore, the project will deploy a comprehensive range of education and outreach activities that will expand and nurture our nation's future S&E workforce in data and computational science. $93 million is requested in FY 2024 to begin work on LCCF.

- The FY 2024 **Major Facilities Operations and Maintenance (O&M)** request of $1,069.80 million supports regular O&M needed to keep a facility functional, upgrades, significant periodic maintenance, and infrastructure renewal.

Research Security

The future of U.S. competitiveness requires that we safeguard these investments and take steps to address research security while also cultivating vibrant international partnerships that are critical to successes such as the first-ever imaging of a black hole. NSF plays a leading role in federal efforts to address research security and is expanding capabilities and competencies to protect the U.S. science and engineering enterprise. 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. In addition, the CHIPS and Science Act contained several helpful research security provisions, which NSF is in the process of implementing. NSF has engaged in robust discussions with the U.S. research community and with like-minded international colleagues to develop common frameworks for understanding and addressing research security and NSF will continue to enhance this work in FY 2024. These activities include:

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

- Establish a **Research on Research Security** funding program in FY 2024 that will include assessment of the characteristics that distinguish research security from research integrity and improving the quantitative understanding of the scale and scope of research security risks. This program will also seek to develop methodologies to assess the potential impact of research security threats, and assess the additional research security risks in an innovation system that includes more use-inspired research.

- 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 Small Business Innovation Research (SBIR) due diligence process in FY 2024.

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

Conclusion

At a time of intense international competition, the President's Fiscal Year 2024 Budget Request is an investment in NSF's ability to generate more breakthroughs, foster more innovations that strengthen our economy and national security, and support the individuals who keep the United States a global leader in science, engineering, and technology. The FY 2024 Request reaffirms the Administration's commitment to investing in science and engineering research, creating new partnerships to keep America competitive, and breaking down barriers to participation in STEM. It is an investment in ensuring that those advances in research lead to economic impacts and good jobs, and that the STEM enterprise reflects the tremendous diversity of the Nation.

Thank you for the opportunity to testify before you today. With the continued support of this Committee and Congress, and by building upon the CHIPS and Science Act, NSF stands ready to strengthen our national and economic security and create innovation anywhere and opportunities everywhere.

Updated: February 2023

Dr. Sethuraman 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 a $9.5 billion 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.

As director, Panchanathan maintains leadership roles on several key interagency councils and committees, including as co-chair of the National Advisory Council on Innovation and Entrepreneurship and is a member of the White House CHIPS Implementation Steering Council and the White House Gender Policy Council. He is also chair of the Interagency Arctic Research Policy Committee and co-vice chair of the Council for Inclusive Innovation.

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 was appointed by the President to serve on the National Science Board where he was a chair of the Committee on Strategy and a member of the External Engagement and National Science and Engineering Policy committees. Additionally, 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 and associate editor of several international journals.

Panchanathan's scientific contributions have advanced the areas of human-centered multimedia computing, haptic user interfaces and ubiquitous computing technologies for enhancing the quality of life for individuals with different abilities; machine learning for multimedia applications; 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 who now occupy leading positions in academia and industry.

For his scientific contributions, Panchanathan has received numerous awards, including Honorary Doctorates from prestigious universities, Distinguished Alumnus Awards, the Governor's Innovator of the Year for Academia Award, the Washington Academy of Sciences Distinguished Career Award and the IEEE-USA Public Service Award.

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 Association for Computing Machinery, 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.

Chairman LUCAS. Wise words, well-spoken, Doctor.

And with that, I now recognize our second witness, Dr. Reed, for 5 minutes to present his testimony.

TESTIMONY OF DR. DAN REED,
CHAIR, NATIONAL SCIENCE BOARD

Dr. REED. Chairman Lucas, Ranking Member Lofgren, Members of the Committee, thank you for the opportunity to speak with you as Chair of the National Science Board. Thank you as well for the *CHIPS and Science Act* and its bold blueprint for a brighter future. One of my favorite science fiction authors Neal Stephenson once wrote, "If we want to create a better future, we have to start with better dreams." The *CHIPS and Science Act* is the stuff of better dreams, and it arrives at a critical juncture for our Nation.

To ensure future breakthroughs and innovations are made in America, we must continue translating the act's vision into action, advancing scientific frontiers, developing STEM talent, expanding the geography of innovation, and delivering benefits to society. Fully funding the Administration's FY '24 budget request will help make the vision a reality. But we must do more.

Let me be clear, U.S. leadership in science and technology is imperil. China is charging ahead, and absent further action, it's not a question of if, but when the United States loses its STEM leadership with deep consequences for our country.

Here's why we must act and act now. First, China's announcement that it's ramping up government investment in basic research as, quote, "the only way to build a world scientific and technological power," unquote, both validates our strategy and highlights our challenges. It's time for us to double down, expand investment in basic research and cutting-edge scientific instruments nationwide and unleash American innovation.

Second, China continues to invest heavily in building its homegrown talent and now produces more STEM Ph.D.'s than the United States. Meanwhile, we face a STEM talent crisis. Students at all levels and all backgrounds are struggling in STEM. COVID simply made it much worse. And this crippling situation is even more challenging for students from a lower socioeconomic standing or underrepresented backgrounds. We're simply not producing enough STEM workers at all levels to meet the needs of a 21st century economy. And we're leaving millions of talented individuals behind.

For our STEM workforce to be representative of the U.S. population in 2030, the number of women must nearly double, Hispanic and Latinos must triple, Black or African Americans must more than double, and the number of American Indian or Alaskan Natives must quadruple.

Now, 48 years ago, I was a poor first-generation college student from the Arkansas Ozarks studying computer science. I was fortunate to graduate debt-free thanks to academic scholarships, a Basic Educational Opportunity Grant—now Pell—and my paltry savings. And while I'm extraordinarily grateful for the opportunities this has afforded, I'm alarmed that my educational path is no longer widely available. To grow our STEM talent base, we must do more to make higher education affordable and graduate STEM work

more financially viable. Hence, NSF's FY '24 budget request emphasizes broadening participation in STEM education and turning STEM career dreams into realities.

Third, and finally, we must deliver research benefits to society. NSF's new Directorate for Technology, Innovation, and Partnerships, TIP, will accelerate innovation by supporting use-inspired research and translation, by building institutional and regional innovation capacity, and enhancing academic, government, and industry partnerships.

At the end of World War II, the compelling rationale for Federal Government research investment was to advance the national health, wealth, and prosperity and to secure the national defense. Almost 80 years later, it still is. So my dream is simple. I dream that historians and, more importantly, our children and our grandchildren will mark now as the time we not only embraced better dreams, but we put aside our differences, we committed to our common goals, and we acted with compelling vision and unwavering resolution to create a better future for our country and for the world.

Thank you. I look forward to your questions.

[The prepared statement of Dr. Reed follows:]

Testimony of
Daniel A. Reed, PhD
Chair
National Science Board
National Science Foundation

Before the
Committee on Science, Space, & Technology
U.S. House of Representatives

April 26, 2023

Upgrading the Future: Realizing Better Dreams

Better Futures Start with Better Dreams

Chairman Lucas, Ranking Member Lofgren, and members of the committee, it is a privilege to testify before you. On behalf of myself and my 23 National Science Board colleagues, I thank you for the *CHIPS & Science Act* and its bold blueprint for a better, brighter future for science and engineering (S&E) in the United States. Fully funding the Administration's FY24 budget request for the National Science Foundation (NSF) advances the *CHIPS and Science Act* and is essential to our nation's global leadership in STEM. The FY24 budget request furthers NSF's original mission, which was inspired by renowned scientific and engineering visionary Vannevar Bush, who believed the core rationale for federal investment in research and talent development was to address pragmatic and important societal priorities: national security, economic well-being, and public health. At the end of World War II, the compelling rationale for federal research investment was to further the country's interests and address its needs. It still is.

Neal Stephenson, one of my favorite science fiction writers, wrote that "if we want to create a better future, we need to start with better dreams." The *CHIPS & Science Act* is the stuff of better dreams and better futures for U.S. S&T. We must own our destiny and respond accordingly. My testimony today underscores that the passage of *CHIPS & Science* was just the beginning. There is an urgent need to turn the dreams of the Act's science provisions into actual futures through appropriations. It is unrealistic to believe we can reverse our current trajectory – one that has us losing to China – without making substantial new federal investments in the foundational – basic and applied – elements of our S&E ecosystem: talent development and cultivation, use-inspired research and translation, research infrastructure, and curiosity-driven research. To that end, I believe it is imperative that Congress fully funds the President's FY24 budget request for NSF.

I come before you at a critical juncture for our nation and our S&E enterprise. We face a global landscape in which other nations are challenging our country's geopolitical influence on a scale that we have not seen since the Cold War. At the same time, once unquestioned U.S. global leadership in science

and technology is in peril, and in some key domains we have already been eclipsed. Preserving our leadership in science and technology is inextricably linked with preserving our national security. Military strength is derived from economic strength, and economic strength is driven by a robust and relentless cycle of discovery and innovation. Thus, science funding – like defense funding – is and ought to be treated as a non-negotiable federal investment.

Let me be very clear. While we continue to debate and dither, the time for concerted action to reinvest in our S&E enterprise grows ever shorter and the stakes grow ever higher. Having watched and learned, other countries have been investing heavily in their own innovation ecosystems, cultivating human talent, expanding their knowledge workforce, and constructing the advanced infrastructure needed to facilitate discovery, economic growth, and defense capabilities. These developments abroad are well documented by the NSB's Congressionally-mandated *Science & Engineering Indicators* report.

The growing challenge to U.S. pre-eminence in S&E reflects the reality that many nations now recognize that a robust S&E enterprise is critical to economic and national security. S&E industries represent a growing share of economic activity worldwide.[1] Officials from Washington to Brussels to Beijing acknowledge that leadership in critical technology fields like semiconductors, biotechnology, clean energy technology, artificial intelligence, and quantum computing and communications is a matter of national security.[2]

China has recently upped the ante. "Strengthening basic research is an urgent requirement for achieving high-level scientific and technological self-reliance [and] is the only way to build a world scientific and technological power," President Xi said earlier this year.[3] This statement came on the heels of China having already doubled spending on basic research in the last five years and having surpassed the United States in STEM degree production.[4] While the United States retains an edge in many areas of basic research, China's message is clear. It intends to go toe-to-toe with the United States by building a soup-to-nuts domestic research and development innovation engine with a large pool of homegrown talent and a sizable, sustained core of world-class basic research that continually provides new fuel for China's economy and its geopolitical ambitions.

Meanwhile, the United States is not producing enough skilled technical workers and STEM bachelor's degree holders in either the numbers or diversity needed to meet the workforce needs of the 21st century knowledge economy. Our pre-K-12 education system is failing far too many students. Too much of our manufacturing capability has been outsourced, making us overly dependent on other countries for critical elements of our economy. Our R&D enterprise is too heavily concentrated in certain geographies, leaving swaths of our country and its residents deprived of associated economic opportunities. Our technology transfer system is too slow, too unwieldy, and too inefficient to compete with an integrated nation state like China.

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[1] https://ncses.nsf.gov/pubs/nsb20226/global-trade-in-knowledge-and-technology-intensive-output

[2] https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/09/16/remarks-by-national-security-advisor-jake-sullivan-at-the-special-competitive-studies-project-global-emerging-technologies-summit/; https://www.politico.com/news/2019/10/28/europe-technology-silicon-valley-059988; https://www.merics.org/en/report/comprehensive-national-security-unleashed-how-xis-approach-shapes-chinas-policies-home-and

[3] https://www.science.org/content/article/china-rolls-out-radical-change-its-research-enterprise

[4] https://www.science.org/content/article/china-rolls-out-radical-change-its-research-enterprise

Fortunately, the *CHIPS & Science Act* recognized that for the United States to retain its S&E leadership, it must strengthen and adapt its S&E enterprise. *The CHIPS and Science Act* includes essential provisions to build the larger and more inclusive STEM workforce at all education levels that we so desperately need, expand the geography of innovative economic activity, and speed the translation of basic research conducted in the United States into products, goods, and services. In addition, through its requirements for an Office of Science and Technology Policy (OSTP)-led Quadrennial Review and greater cross-agency and cross-sector partnerships, the *Act* provides a framework for tighter coordination among government, industry, and educational institutions so that our innovation engine can work faster and more effectively. Acknowledging that new resources are needed to do all of this, *The CHIPS and Science Act* also lays out authorization levels that would provide a significant and much-needed infusion of federal investment across the nation's science agencies.

The Need for a Coherent U.S. S&E Strategy

"Where there is no vision, the people perish." – Proverbs

To compete in this changing global S&E environment, we need a more coherent, strategic plan for U.S. S&E. To be clear, I am not calling for a top-down government plan, with all its attendant bureaucratic burdens, but rather one that lays out the key components our system needs and engenders and incentivizes a cross-sectoral approach that rewards systems thinking and unleashes and empowers American innovation. I hope the upcoming Quadrennial Review moves the nation in this direction. NSB is eager to partner with OSTP on this project.

Our S&E ecosystem is greatly enriched by distributed, independent contributions from industry, academia, and government, but it can also be hampered by choices that benefit specific contexts to the detriment of the overall enterprise. Designing new technologies in the United States and then outsourcing their manufacturing to other countries may reduce labor costs and free companies and investors from onerous capital requirements, but it comes with systemic risks for the U.S. economy and our national security.

One such systemic risk, which stemmed from the offshoring of semiconductor fabrication, materialized during the pandemic. The resulting disruption of the global semiconductor supply chain created shortages that affected a wide range of other industries, including those critical to national defense. Belatedly and at great expense, we are now trying to reshore semiconductor manufacturing. As a nation, we need to be more strategic and systemic in risk assessment and management in other critical technology fields. Put another way, a group of locally effective choices does not always lead to a nationally effective strategy.

The same systemic risks exist for our advanced STEM workforce. Recruiting international STEM talent with better K-12 preparation in mathematics and science – to both academia and industry – is often cheaper and quicker than educating and training domestic talent. The result, long tracked by the NSB, is that we are now critically dependent on attracting and retaining international students, especially those

pursuing or with advanced degrees in critical technology fields.[5] Meanwhile, both the numbers and diversity of our domestic STEM talent base remain far too small.

Make no mistake, we want and need the best and brightest STEM talent from around the world. Only by attracting and retaining such talent can we continue to create an environment in which the United States retains its competitive advantage. After all, the history of intellectual, cultural, and economic contributions by immigrants to the United States is extraordinary; it is one of our country's enduring "superpowers," that we welcome and embrace talent, regardless of country of origin. That said, our current level of dependence on this talent renders us vulnerable. Our continued ability to attract international STEM talent is not a given; other nations are providing increasingly attractive alternatives for globally mobile talent.[6]

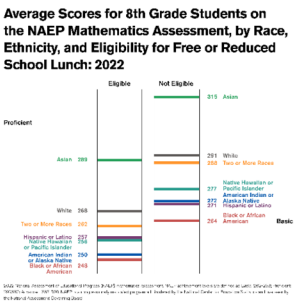
Perhaps it is not surprising, given that I am a computer scientist, that I think about our S&E ecosystem as an operating system. As we have become more complacent as a nation in our approach to S&E, we have resorted to patching "holes" in our operating system code. This is a risky strategy; fixing one piece of code can break another, and a multitude of patches creates a brittle system, making it difficult to add desirable new features.

Simply put, we are running a patched, 20th century innovation ecosystem in a 21st century world. We need to upgrade our entire operating system: expanding and diversifying the STEM talent pipeline, accelerating the delivery of research benefits, upgrading our research infrastructure, and elevating our commitment to basic research. This is why federal funding is so important. Only the federal government can create and nurture these foundational aspects that matter to all sectors.

Operating System Element: Talent Upgrade

"I cannot distinctly remember a time when I did not think that a scientist was the most exciting possible thing to be." – Peter Medawar

For too long, we have failed to build and sustain the domestic STEM talent pipeline needed to feed the 21st century knowledge economy, and we now face a pre-K-12 STEM education crisis. Too many of our primary and secondary school STEM students are being left behind, and the leaky pipeline dwindles further in college and graduate school. As a result, we are failing to develop, attract, and expand the diverse STEM talent base – at all educational levels – necessary for U.S. S&E leadership.



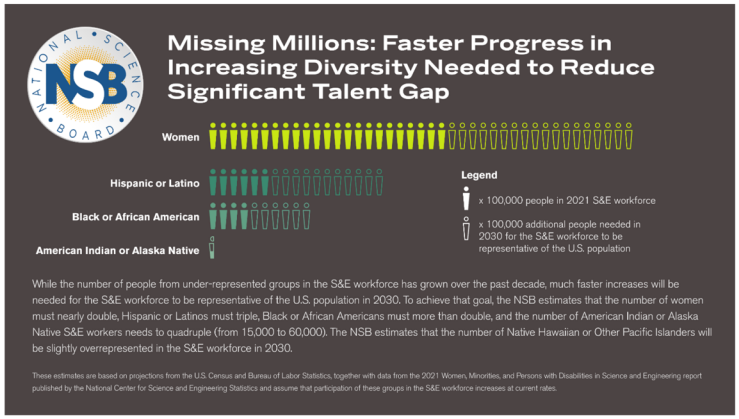
STEM preparation in elementary and secondary school is foundational; the data show that students who do not perform at grade level in mathematics in 8th grade do not go on to study STEM in college. This crippling situation is far more acute for students from lower socioeconomic

[5] https://www.nsf.gov/nsb/sei/one-pagers/NSB-International-STEM-Talent-2022.pdf
[6] https://www.nsf.gov/pubs/2020/nsb20222/nsb20222.pdf

standing or underrepresented backgrounds. On average, U.S. 8th grade students of all ethnicities who are eligible for free or reduced school lunches fail to achieve mathematics proficiency, but the disparity is most pronounced for Black, Hispanic, Native Hawaiian or Pacific Islander, and American Indian or Alaska Native students.[7]

The pandemic compounded these disparities. The most recent National Assessment of Educational Progress showed the largest decline in reading skills since 1990 and the first ever decline in mathematics.[8] Worse, this disruption has exacerbated disparities in math education across the nation. Although all students saw a decline in test scores, the worst performing students saw their test scores drop four times more than the best; Black students' scores decreased more than twice that of white students.[9] STEM post-secondary education is also struggling. The pandemic saw undergraduate enrollment drop by 3.6% in the fall of 2020.[10] Public community colleges, an important pathway for many low socio-economic status and minority students into STEM and for developing the skilled technical workforce, had the sharpest decline (10.1%).[11] Higher proportions of Blacks and Hispanics than of Whites reported that their postsecondary education plans were canceled, whereas higher proportions of Whites than of Blacks or Hispanics reported that they had to take classes in different formats.[12]

These troubling developments come at a time when the nation's demographics are shifting. For our STEM workforce to be representative of the U.S. population in 2030, the number of women must nearly double, Hispanic or Latinos must triple, Black or African Americans must more than double, and the number of American Indian or Alaska Natives must quadruple.



[7] https://ncses.nsf.gov/pubs/nsb20196/student-learning-in-mathematics-and-science#tableCtr1533
[8] https://www.nationsreportcard.gov/highlights/ltt/2022/
[9] https://www.nationsreportcard.gov/highlights/ltt/2022/
[10] https://www.nsf.gov/nsb/news/news_summ.jsp?cntn_id=304497
[11] https://www.nsf.gov/nsb/news/news_summ.jsp?cntn_id=304497
[12] https://ncses.nsf.gov/pubs/nsb20223/u-s-institutions-providing-s-e-higher-education

These "missing millions," as the NSB's *Vision 2030* report highlighted, are an untapped talent base we can ill-afford to lose.[13] We are leaving an extraordinary number of Americans sitting on the sidelines of our S&E enterprise precisely when employers need more domestic STEM talent at all education levels. Failure to cultivate the missing millions – including individuals with fewer socioeconomic resources and individuals in rural communities – is also a failure to enable individual economic opportunity. The NSB has long observed that an increasing fraction of all jobs require critical thinking, technical knowledge, and mathematical reasoning and that STEM jobs are generally both better paid than comparable jobs at the same educational level and more resilient to economic downturns.[14]

We must also address pressing challenges in post-secondary education that limit our ability to develop domestic STEM talent. We need to encourage colleges to continue to reevaluate their educational approaches, making curricula relevant and meeting interested students where they are. We also need to do more to make public higher education more affordable and graduate work in STEM fields more financially viable.

Although I sit before you as Chair of the National Science Board, as a former corporate officer at Microsoft, and as a professor of computational science at the University of Utah, 48 years ago I was a poor, first-generation college student from the Arkansas Ozarks.

I was fortunate to attend university thanks to a combination of academic scholarships, a Basic Educational Opportunity Grant (now Pell) for low-income students, and a small amount of money I saved from working summer jobs. I lived like a pauper, with a social life limited by finances to free lectures and cultural events, and my wallet was empty, save for my student ID card and a driver's license. The latter seemed superfluous because I could not afford a car.

Nevertheless, I completed both undergraduate and graduate degrees in computer science – a field now integral to our scientific enterprise, our economic security, and our national security – without any student debt. While I am extraordinarily grateful for the opportunities, I am also alarmed that it is increasingly clear my educational path is no longer widely available.

Undergraduate tuition at a state university in the 1970s was just a few hundred dollars per year. Today, it exceeds $10,000 a year, with comparable student room and board costs.[15] A four-year college degree at a public university can cost substantially more than $100,000, while the maximum Pell grant is under $7,000 and just recently increased by $500. These economic challenges extend to graduate education as well. Too many of our STEM students in graduate school face years of penury, living at or below the poverty line.

Talent arises everywhere, regardless of culture or family socioeconomic or generational status. Countries that identify, nurture, and cultivate that talent – as the United States did in my case – are the ones that will continue to lead the global race in research and innovation.

The NSF has a critical role to play in addressing our STEM talent crisis. As the nation's STEM talent agency, it is helping underrepresented students find pathways toward STEM careers through targeted

[13] https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf
[14] https://www.nsf.gov/pubs/2015/nsb201510/nsb201510.pdf
[15] https://research.collegeboard.org/media/pdf/trends-in-college-pricing-student-aid-2022.pdf

undergraduate and graduate education programs, including those that aid minority serving institutions. The agency is also developing skilled technical workers through its Advanced Technological Education Program, which supports partnerships among two-year institutions of higher education, colleges and universities, industry, and others to develop technicians in science and engineering. NSF is also forging partnerships with other agencies via programs such as REU-ASSURE, the joint NSF-Department of Defense program that supports undergraduate research in DoD-relevant disciplines, preparing them for the national security workforce.

NSF's FY24 budget request emphasizes efforts to broaden domestic participation in STEM education and turn STEM career dreams into realities. I urge you to fully fund the talent efforts in the Administration's NSF FY24 Budget Request, while acknowledging that the NSF and the nation must do much more to cultivate domestic STEM talent. Based on historical rates of change, current federally-funded programs and approaches across the government will not address either the inadequate numbers nor the missing diversity in the domestic STEM workforce – the *missing millions* – on a timescale consistent with national needs.

We cannot neglect these workforce and education challenges any longer. Educated and empowered talent is the treasure on which any nation's prosperity, health, and security depend. In the late 1950s and early 1960s, in the wake of Sputnik, the United States invested heavily not only in S&E fields but also in developing domestic talent. The National Defense Education Act (NDEA) was transformative; it galvanized higher education to produce more STEM graduates in areas critical to national security.

NSB is laser focused on talent. Inspired by the idea of a NDEA for the 21st century, we look forward to engaging with you in the months ahead on recommendations to meet our urgent domestic talent needs.

Operating System Element: Delivering Benefits from Research

"Genius is one percent inspiration and 99 percent perspiration." – Thomas Edison

For the United States to compete and win in today's S&E environment, we must enhance our ability to rapidly deliver benefits from research. While the U.S.'s decentralized, bottom-up approach to S&E research produces new knowledge in many disciplines, too often nascent discoveries struggle to cross the "valley of death" from the research environment to industry uptake. I have seen this firsthand from both sides, as a Vice President for Research and Economic Development at the University of Iowa and as a Corporate Vice President at Microsoft.

NSF's new Directorate for Technology, Innovation and Partnerships (TIP) is an essential addition to the nation's S&E ecosystem. It will help speed the path from discovery to innovation here in the United States via greater NSF investment in use-inspired research and translation activities, building institutional and regional capacity to engage in innovative activity, and enhancing the partnerships among academia, government, and industry that are needed to do so.

NSB is grateful for the trust the *CHIPS & Science Act* placed in NSF in authorizing this new directorate. However, the promise of TIP cannot be realized without continued and substantial budget growth. In FY23, the agency prioritized allocating new resources to TIP, funding it at the President's FY23 request level. TIP will need additional investment in FY24 and beyond. My NSB colleagues and I remain

concerned that without continued robust budget growth, the TIP directorate will be too small to carry out the mission entrusted to it.

As NSF's first new directorate in over three decades, TIP marks a sizable shift in the agency's culture. The Board is closely monitoring this undertaking and helping shape the directorate's strategy via guidance and oversight. Our messages to NSF have been clear and focused: (1) the new directorate has different objectives than other directorates and will be judged by economic outcome metrics – jobs created and geographic regions strengthened, and (2) the agency must demonstrate synergies between TIP and other NSF directorates. Just as basic research in NSF's other directorates fuel TIP, so too should TIP lead to new basic research questions pursued in the other directorates. Via this feedback loop, NSF can amplify the value of having curiosity-driven, use-inspired, and translational research in its portfolio, fulfilling Vannevar Bush's seminal vision.

In its first year, the TIP directorate launched its signature Regional Innovation Engines (Engines) program. The Engines program develops regional coalitions to conduct use-inspired research and drive those results to market, stimulating job creation and economic growth. NSF saw strong demand for this program from across the entire country. Thanks to the budget increase in FY23, later this year, NSF will be able to make some full-fledged Engine awards of up to $160M each for up to 10 years.

The Engines program is exactly the kind of intentional, systemic effort our innovation ecosystem's operating system needs. It takes a cross-sectoral approach, focuses on building sustainable regional ecosystems (technology and talent), and addresses pressing national needs to speed up the innovation cycle, and expands the geography of innovation to regions of the country that are poised to support S&E industries.

NSF is complementing the Engines program with a suite of related programs, including Enabling Partnerships to Increase Innovation Capacity, Experiential Learning for Emerging and Novel Technologies, Accelerating Research Translation, and the Entrepreneurial Fellowship Program.

Funding TIP at the FY 24 Request Level would permit NSF to continue to scale up the Engines program, regionalize NSF's Convergence Accelerator program, and start a program to support test beds to advance development, operation, integration, deployment and demonstration of innovative technologies.

The NSB's and NSF's commitment to delivering benefits from research goes beyond TIP. In the last decade, the agency has shifted policies to enhance research in the national interest, while increasing accountability and transparency. For over two decades, NSF has also used a broader impacts criterion in its Merit Review process. At the NSB's February 2023 meeting, the NSB authorized the creation of a commission to re-examine NSF's Merit Review criteria. This re-examination, the first in over a decade, is motivated, in part, by a desire to consider how the merit review criteria might be modified to further enhance NSF's emphasis on delivering benefits from research.

Operating System Element: Research Infrastructure

"Nothing tends so much to the advancement of new knowledge as the application of a new instrument."
– Humphry Davy

Research infrastructure — including major research facilities, mid-scale research infrastructure, major research instrumentation, and cyberinfrastructure – enables discovery and innovation. Beamlines permit researchers to explore different materials, cryo-electron microscopy enables probing of biological samples, test beds support new product development in critical technology areas, and computing now underpins so much of science that the very phrase "computational science" is now rhetorically redundant. Our investments in research infrastructure can also lead to unanticipated spillover economic benefits; the technical feat associated with constructing NSF's Laser Interferometer Gravitational Wave Detector (LIGO) pushed the limits of existing technology, spawning breakthroughs that led to spin-off technologies in optics, lasers, and distributed computing.[16]

Just as talent is needed to compete globally in S&E, so too, is research infrastructure. Equally importantly, the two are linked. The world's best STEM talent flows to where the best scientific tools are located. For the U.S. S&E enterprise to remain a global leader, we need to continually invest in the facilities and tools that enable research and development (R&D) and that attract globally mobile talent to the United States.

Now, more than ever, the United States needs a coordinated national strategy for major federally funded research facilities and infrastructure. Major research facilities such as research vessels, telescopes, and gravitational wave detectors represent substantial decades-long financial commitments and need predictable, long-term funding. The cost of designing, constructing, and operating these facilities continues to grow; design and construction alone is now well north of $1 billion for major research facilities in physics and astronomy. Increasingly, this cost threshold exceeds what a single agency or even a single nation can afford alone. Despite rising costs, as a country, we must choose wisely and invest appropriately to ensure continued global leadership.

At the same time, we cannot afford to pursue frontier-class, next generation major research facilities to the exclusion of other types of research infrastructure. Scientific infrastructure at all scales is essential to U.S. competitiveness in S&E. Investments in major research instrumentation, mid-scale research infrastructure, and cyberinfrastructure, which can be more readily distributed across the country to serve as tools for researchers in various regions, are also critical to expanding the geography of innovation and building a more inclusive research enterprise through greater access to such tools.

I hope that the Quadrennial Review can facilitate such a coordinated national approach – one that looks across federal agencies to ensure that the United States' research infrastructure investments are strategic, complementary, and second-to-none. Being second-to-none means investing smartly rather than investing in everything. As part of this process, we must take a hard look at areas where we as a country need – for reasons of economic or national security – to go it alone. We must also identify areas where our dollars would go further by investing in shared facilities in cooperation with like-minded nations.

[16] https://www.ligo.caltech.edu/page/science-impact

NSF's FY24 budget request balances a robust portfolio of facilities and infrastructure at multiple scales with awards to the researchers who depend on the observations and data they produce. The FY24 request for the Major Research Equipment and Facilities Construction (MREFC) account supports several important infrastructure projects, including the construction of the Leadership Class Computing Facility (LCCF) and Track 2 of the Mid-scale Research Infrastructure Program.

The global race of technological leadership, whether in semiconductors or in computing, continues unabated. Europe, Japan, and China are all designing and deploying ever larger advanced computing systems. Moreover, advanced Artificial Intelligence (AI) systems such as GPT-4 depend on large-scale computing platforms for their training and use. Absent access to advanced computing in academia, the "brain drain" of AI researchers from academia to industry will continue, making it harder to train the next generation of talent and realize the collaborative vision of the National AI Research Task Force.

In that spirit, the LCCF will provide unique and powerful computational and data analytics capabilities, as well as critical software and services, for the nation's researchers. In addition to large-scale computational models, the LCCF will also support urgent computing, where immediate access to computing resources and real-time data facilitates emergency response scenarios. Echoing the consistent theme of workforce development, the LCCF will also offer education and outreach activities to nurture our nation's future science and engineering workforce in data and computational science.

As important as big instruments are to innovation and discovery, they are not enough. As the Board stated in its 2018 report, "Bridging the Gap: Building a Sustained Approach to Mid-scale Research Infrastructure and Cyberinfrastructure at NSF," gaps in agency support of mid-scale research infrastructure also put future areas of U.S. science and engineering research at risk. Investing in research instruments and capabilities of more modest financial size can expand the types of research possible, lay the groundwork for building the next generation of major facilities, and build capacity in EPSCOR jurisdictions.

The Board is pleased to see continued strong demand for the second portfolio of Mid-scale Track 2 awards. In the years since its initiation, the Mid-scale Research Infrastructure program has engaged institutions in 30 states and territories, including many EPSCoR states. Such regional investment can catalyze research across a range of institutional types and diversify our science and engineering S&E enterprise.

Operating System Element: Basic Research

> "Basic research is performed without thought of practical ends. It results in general knowledge and understanding of nature and its laws." – Vannevar Bush, *Science the Endless Frontier*

In the 78 years since Bush first crafted that sentence, the federal government has been instrumental to U.S. leadership in basic research – curiosity or use-inspired research undertaken before it had any known application. For the past 73 years, NSF has been privileged to be at the center of this essential effort, investing in basic research across all fields of science and engineering that fuel our innovation ecosystem, strengthening our economic and national security, and paving the way for products, services, and technologies that are now so ubiquitous that we have come to take them for granted. NSF's central mission is to invest across S&E fields, monitor what is emerging, and cultivate the *next,*

next big things in S&E. This often leads to exciting outcomes that could not have been anticipated at the time of initial NSF investment.

Take GPT-4, for example. This artificial intelligence (AI) chatbot has taken the world by storm since its launch a few months ago, and it and other AI tools are changing how we do science and, more broadly, how people approach their work and their leisure. Researchers can now use AI to predict the shape of proteins, readily identify diseases in plants, design parts for spaceships, and summarize academic articles.[17] Companies are already using GPT-4 and other AI tools to accelerate development of new software, translate documents, and assist with a wide variety of business tasks. Today's increasingly sophisticated AI tools are now possible because of decades of government investment, principally through NSF and the Defense Advanced Research Projects Agency (DARPA).

The story of NSF's decades long support for what has become AI illustrates how NSF helps cultivate new fields of research. Initially NSF followed researchers' interests in understanding computer-human interfaces, funding early research grants in machine learning, natural language processing, robotics, and computer vision. As promising areas emerged, NSF cultivated those areas via additional research grants and catalyzed further research by sponsoring meetings that pushed this research forward. As the potential for AI to be the next, next big thing became clear, NSF further scaled its investments by creating AI Research Institutes. These institutes have come to focus on long-term, high-reward AI research and have increasingly brought in partners from across the government and the private sector, paving the way for promising technology to make it to the marketplace. Leveraging these basic research investments and the talent pool they created, U.S. industry invested heavily in the infrastructure and people needed to bring products to market. Because of its longstanding cultivation of this field, NSF is now a leader in AI planning and activities across the federal government.

As this success story illustrates, much basic research – including early research in AI – begins with a driving curiosity about the unknown, then the derivatives of the basic research drive a vital part of our economy, with business R&D leveraging these intellectual insights. Today's R&D-intensive industries exist, in part, because of federal government investments – long before the research had a known application.

Troublingly, although overall funding of R&D in the U.S. continues to rise, the share of basic research that the federal government funds is declining. This matters because while businesses are investing more in basic research, they tend to invest in just a few areas that have a high potential to lead to new or improved technologies in the near-term, such as computing and pharmaceuticals, not in areas where the potential payoff is uncertain and may be years away.

Only the federal government can take the kinds of strategic risks to invest long-term across the sciences and fuel new knowledge with potentially big returns for the country. China's announcement that it is ramping up its investment in basic research, is in fact, a tacit acknowledgement that government investment in basic research is necessary and that the United States has had the right strategy in this regard all along.

Even as the United States and NSF increase their emphasis on directed research related to critical technologies and societal challenges and make new investments to speed the translation of existing basic research, the United States cannot afford to rest on its laurels when it comes to investing in

[17] "35 Ways Real People Are Using A.I. Right Now," *New York Times,* April 14, 2023.

totality of the basic research enterprise. To ensure that the significant share of the scientific breakthroughs and innovations that will shape our global future are "Made in America," we need to translate the blueprint of the *CHIPS and Science Act* into a fully funded, end-to-end action plan that also increases investment in basic research.

Conclusion: Upgrading the OS

"You are either the market leader, a viable number two, or road kill. You don't want to be road kill." – Tom Siebel

In the nine months since the passage of *CHIPS & Science,* NSF has begun implementation of the Act's guidance. In addition to launching several new TIP directorate programs and beginning to implement the semiconductor education and workforce provisions that were funded by CHIPS, NSF has also moved to establish the Office of the Chief of Research Security Strategy and Policy (OCRSSP) and the Research Security Integrity Information Sharing and Analysis Organization, commissioned five required studies, and issued updated solicitations and Dear Colleague Letters that reflect *CHIPS and Science*-mandated changes to cost sharing for Major Research Infrastructure (MRI) awards and Noyce Fellowships. The Board appreciates the trust that you have placed in NSF to lead on so many dimensions of this legislation. The NSB is committed to working with NSF to pursue every possible mechanism — both policy and process — to make existing NSF dollars further the objectives of *CHIPS & Science*. As the FY24 Budget Request attests, the agency has much more planned for FY24.

In an increasingly uncertain world, the U.S. now finds itself facing new challenges; it's not the first time, nor will it be the last. Our continued prosperity and national security depend on the vitality and global leadership of the nation's S&E enterprise. Vannevar Bush recognized this seven decades ago, at the end of World War II. In a global economy driven by scientific discovery and technological innovation, it is even more true today.

As an initial blueprint for a better future, we must fully fund the provisions of the *CHIPS and Science Act*. However, that alone will not be enough. We also need a clear and coherent federal S&E strategy that maximizes our current resources (both intra-agency and inter-agency) while also committing the additional resources needed to secure our continued global leadership. China is moving ahead, and absent further action, it is not a question of *if* but *when* the United States loses its leadership in S&E.

As stewards of the present, the future is in our hands. Let the historians and policy analysts, but most of all – our children and grandchildren – mark this as the time we not only embraced better dreams, but we put aside our differences, embraced our common goal, and acted with compelling vision and unwavering resolution to make those dreams a future and better reality for the country and for the world.

Daniel A. Reed

Biography

Computer Science
B.S., Missouri University of Science and Technology
M.S., Purdue University
Ph.D., Purdue University

Reed chairs the National Science Board, elected by the Board in May 2022 for a two year term. He formerly served as Provost at the University of Utah where he now is Presidential Professor of Computational Science and Professor of Computer Science and Electrical & Computer Engineering. Reed previously was Professor of Computer Science, Electrical and Computer Engineering, and Medicine at the University of Iowa where he served as Vice President for Research and Economic Development. Previously, Reed helped shape Microsoft's long-term vision for technology innovations in cloud computing and the company's policy engagement with governments and institutions worldwide as the company's Corporate Vice President for Technology Policy and Extreme Computing.

Among prior positions, Reed was the Founding Director of the Renaissance Computing Institute at the University of North Carolina at Chapel Hill, Gutgsell Professor and Head of the Department of Computer Science at the University of Illinois at Urbana-Champaign, and a principal investigator and chief architect for the NSF TeraGrid, which became NSF XSEDE.

Reed has served on the U.S. President's Council of Advisors on Science and Technology, the President's Information Technology Advisory Committee, the National Academies of Science (NAS) Board on Global Science and Technology, the International Telecommunications Union CTO Council, and the ICANN Generic Names Supporting Organization Council. He chairs the Department of Energy's Advanced Scientific Computing Advisory Committee and the NAS Panel on Computational Sciences at the Army Research Laboratory. Reed is a Fellow of the Association for Computing Machinery, Institute of Electrical and Electronics Engineers, and American Association for the Advancement of Science.

Reed is a member of the National Science Board's class of 2018-2024.

Chairman LUCAS. Thank you, Doctor.

The Chair now recognizes himself for 5 minutes for questions.

Dr. Panch, as you note, in your testimony, inspiring the Missing Millions and tapping into the talent pool across every geographic region of the country is imperative to securing our Nation's global leadership in science and technology innovation. Could you explain what a whole-of-NSF approach would look like and how this is different from previous efforts to expand geographic diversity?

Dr. PANCHANATHAN. Thank you very much for that question, Mr. Chairman, very appropriate for this moment of intense global competition. We need to bring all possible talent across our Nation energized, inspired, motivated, and brought to life, every part of our Nation, across the geography, across the socioeconomic demographic, and across the rich diversity of our Nation. What we need to do is—and you rightly said this, Mr. Chairman, in your remarks and, Ranking Member, in your remarks, it cannot be limited to only a few institutions. It's got to be all the educational institutions everywhere that are empowered, invested in so that they can bring this talent to life. We cannot leave any talent behind. Talent and ideas are democratized all across our Nation. We cannot leave any talent behind.

So NSF has an approach where all of our directorates are working together, yes, the STEM Education Directorate is one of those important directorates, but all the directorates are working together in unison.

If I were to describe NSF, Mr. Chairman and Ranking Member Lofgren, by one word, it's people. It makes unbelievable people possible. These people are the innovators and discoverers. These people are the translators and leaders in industry. And these people are the entrepreneurs. It's about people. And that's what NSF makes possible. And we need this millions of talent energized.

Chairman LUCAS. Dr. Reed, in your testimony, you discussed the need for a coherent national strategic plan for science and engineering. What role do you see for the Foundation and NSB in the development of the strategy? And along with that, while you're thinking about that, will you commit to partnering with the Office of Science and Technology Policy (OSTP) to serve as a resource?

Dr. REED. Let me address that last part directly. Yes, absolutely. We are already in conversations with OSTP about futures. I also wear other hats in the Department of Energy as Chair of an advisory committee there.

To expand on what Panch said, I believe we not only need a whole-of-foundation, we need a whole-of-government and whole-of-country strategy. And that means we have to work together to think about the differential strengths and capabilities of each of our Federal agencies, how they complement one another and how they can work together not in competition, but as a greater sum than their individual parts. Each has a particular role to play, and it's important that each of them play it well.

Chairman LUCAS. And I would put this question to both of you. Research infrastructure is essential to scientific discovery and innovation. The best tools and facilities can attract the best and brightest minds from around the world. We know this. However, infrastructure projects often require large investments over many years,

and therefore, must be planned out literally years in advance with an intentional consideration for the needs of the future. How does NSF consider this when reviewing and selecting proposals for large infrastructure projects?

Dr. PANCHANATHAN. Thank you very much for the question, Mr. Chairman. You're absolutely right. Infrastructure is one of the things that defines our Nation as a leader. And when you talk about global competition, as a leader, it makes possible unbelievable discoveries all across the spectrum, all across the disciplines.

So for us, we look at the decadal surveys. For example, the most recent Astro2020 is a fantastic analysis. So we take those inputs, we take the inputs from our advisory committees, we work very closely with the National Science Board, with my partner. I'm sure Dr. Reed will have in his comments to say we work very closely with them because that's part of the process. We work with OMB (Office of Management and Budget), we work with all of you because this is a moment we need to scale investments and our infrastructure to make possible all those amazing discoveries that are going to be happening in decades to come, not just only tomorrow, but decades to come. NSF is deeply committed to doing this.

Dr. REED. So I think the answer is it's both a bottom-up, as Panch described, process, community input about where the scientific opportunities drives part of this. But we also need a collaborative strategy where we think thoughtfully about where there are missing points and how we couple pieces. And that's where the Board and the Foundation work together to do that.

In a previous role on the board, I chaired the Awards and Facilities Committee, which is where all large infrastructure comes before it comes to the Board for final approval. One of the processes that we instituted was earlier engagement so we could do more in-depth planning, analysis of competing projects and priorities, and work with the Foundation to develop a collaborative strategic plan that includes not only the community input, but the competing priorities of different disciplines so we have a coherent strategy that we can bring forward for funding.

And the last thing I would say, as the price of instruments, large-scale ones, goes north of $1 billion dollars, it is also important that we have, as I said before, collaborative cross-agency partnerships. The Foundation works closely with other agencies to jointly fund many of these scientific instruments. That's where the collaborative whole-of-government strategy is also critically important.

Chairman LUCAS. I just know that 20-some years ago when I was a Subcommittee Chairman, the '02 *Farm Bill* focused on the agricultural research enterprise, that the talent pool then as now was sufficiently small enough. If we could not provide people with the resources they needed to do their research, they would go. Now we know they go internationally, not just internally in the United States.

With that, I yield back the balance of my time and turn to the Ranking Member to recognize her for 5 minutes of questions.

Ms. LOFGREN. Thank you, Mr. Chairman.

Speaker McCarthy has proposed very steep cuts in the Federal civilian budget that would amount to an anticipated reduction of

over 22 percent to civilian scientific agencies, including NSF. In the meantime, one of our main economic and strategic competitors, China, is continuing to ramp up its research and development budgets.

I want to ask both of the witnesses. If Congress was to cut NSF by 22 percent and lock those cuts in for a decade, as the Speaker has proposed, is there a chance that China could overtake the United States in basic research funding? And if you have any specific answers where we could fall behind, behind our international competitors like China, I would like to hear about that. So if each witness could address that, I would appreciate it.

Dr. REED. I won't sugarcoat it. If we saw those kinds of cuts, we would be ceding the future to our competitors. There's just no question about that. It would affect many things. I'll speak first of all to my own discipline. As I said, I'm a computer scientist. If we look at the AI revolution and how it is poised to reshape our planet, the National Science Foundation funds the overwhelming majority of basic AI research in this country outside what the Department of Defense funds. It would decimate many areas of basic research that are critical to our future, as the Chair mentioned in his opening remarks.

Equally importantly, it would leave the TIP Directorate stillborn just at a time that we're thinking about ramping up and addressing the unequal geography of innovation. As I said, I grew up in one of those parts of the country. I remember it. We need to empower talent across the country because although opportunities aren't equal, talent comes from everywhere, and we have to continue to empower that talent.

And then there are the equally important broad-based effects on all of the programs that would shrink. And I would just note in conclusion that returning to FY '22 budget levels would be an even larger cut because we're in the midst of an area of inflation, and so it is a larger effect than the absolute numbers would suggest. But the short answer is the effect would be devastating.

Ms. LOFGREN. Dr. Panch?

Dr. PANCHANATHAN. Thank you very much, Ranking Member, for the question. Absolutely. I want to second what the Chair said. And as the Chair said, it will have disastrous effects. And I will tell you, I'm not trying to overstate this. I was in Missouri just 2 days ago. I was in Oklahoma, in Stillwater with the Chairman. And I've been traveling all around the country. And I will tell you the unbelievable talent we have everywhere in our Nation is ready to be inspired, ready to play for our Nation. This is not the time that we should slow down anything.

Let me give you a concrete example. Let's take semiconductors. We put the *CHIPS Act* together. Why? Because we ceded our national leadership to other nations. Now it's a Band-Aid that we're putting to secure this back. We cannot let that happen in AI, in quantum, in advanced wireless, in biotech. We cannot let that happen to any of our technologies. Yes, our competitors are investing, hyper-investing in these areas, and we cannot leave any of our talent behind, because we have amazing talent that is not energized to contribute. I mean, what can I say? Shame on us.

So I will give you a concrete example. Just in semiconductor alone, we need 280,000 semiconductor skilled technical workers over the next 5 years. If we were to have this cut, it will remove 10,000 people per year, just NSF alone, from bringing them into this very important time where we need to recapture, advance, and accelerate progress.

Let me give you one other example in the interest of time and I will stop. We will not be able to invest in a national quantum virtual laboratory platform, which is a very important investment for translating the amazing quantum fundamental science discoveries, to the industries in quantum that we need in our country and not leave it for some other country to take those discoveries and build industries there. This would not be acceptable. It will affect our people being able to access the talent to get the jobs, well-paying jobs and being prosperous.

Ms. LOFGREN. I wonder, I've been thinking a lot about the melding of our AI research with quantum that has the potential—really revolutionary potential. Would we fall behind in that critical area?

Dr. PANCHANATHAN. Absolutely, Ranking Member, because, as you rightly said, AI is impacting everything. The Chairman talked about agriculture. We have four AI institutes focused on agriculture, amazing work that's going on in Illinois, in Kansas, in Texas, in Oklahoma, all over our Nation, California, right in your backyard and in Davis. So we cannot let the influence of AI in all areas, particularly in quantum AI and fusion, we cannot let that be ceded to any other nation, absolutely not.

Ms. LOFGREN. Thank you, Mr. Chairman. My time has expired. I would ask unanimous consent to put into the record a statement from Research!America.

Chairman LUCAS. Seeing no objection, so ordered.

Ms. LOFGREN. I yield back.

Chairman LUCAS. And the gentlelady yields back.

The Chair now recognizes the gentleman from Florida, Mr. Posey, for 5 minutes.

Mr. POSEY. Thank you very much, Mr. Chairman. I'd like to ask unanimous consent to include in the record the 2022 Government Accountability Office (GAO) report titled "Federal Research: Information on Funding for U.S.-China Research Collaboration and Other International Activities."

Chairman LUCAS. Seeing no objection, so ordered.

Mr. POSEY. Thank you, Mr. Chairman.

Dr. Panchanathan, did I get that close enough?

Dr. PANCHANATHAN. That's good.

Mr. POSEY. Thank you. How much in Federal research funds did China entities received through subawards from award recipients from 2015 through 2021?

Dr. PANCHANATHAN. Thank you very much [inaudible] for the question. There are two awards, some [inaudible] during this time period from 2015 to 2021. Both awards are expired, and there are no current subawards.

Mr. POSEY. OK. Thank you. Is the National Science Foundation currently conducting or within the past 5 years collaborative research with entities that are connected to the Chinese talent program?

Dr. PANCHANATHAN. So, Mr. Chairman, Representative Posey, I will just tell you that NSF is committed to protecting taxpayer investments, and this is something that is very, very important to me personally and to the agency in research. So I'm so very happy the *CHIPS and Science Act* has very clearly stated that it prohibits researchers from participating in these talent programs if they are to receive any Federal research dollars, and NSF is implementing that very clearly.

So in fact, we released a policy for public comment stating that we will return proposals without review if we determine that there are national security concerns according to a risk matrix that is in development. It's not only that. What they're doing is, it's not that we are relying on people to just disclose their conflicts, we are also having analytical tools to ensure that we are verifying them. So we are taking this very seriously, Representative Posey, because, as you rightly point out, it is exceedingly important that we are competing, particularly with some of our adversaries taking advantage of our investments. We want to make sure that we do everything, everything to protect what needs to be protected.

Mr. POSEY. Thank you. Thank you. The same GAO report that I submitted says that the Department of Defense funded Chinese entities to research alternative technologies to propel drones. Did the NSF provide any assistance in that research?

Dr. PANCHANATHAN. Not to my knowledge, Representative, but I can always check back, and if there is anything different, we will most certainly communicate with your office.

[A response from the National Science Foundation follows:]

A review of NSF proposals confirmed that NSF did not provide any assistance to the DOD collaboration with Chinese entities related to research in alternative technologies to propel drones.

Mr. POSEY. Thank you.

Dr. PANCHANATHAN. Thank you.

Mr. POSEY. Has NSF had any connection to Wuhan virus or Wuhan Institute?

Dr. PANCHANATHAN. No, we did not fund directly the research, but our subawards, when we fund grants here in the United States, a few of the subawards might have, but nothing to do with the COVID-related research.

Mr. POSEY. Yes, what subaward recipients would that have been that is dealing with Wuhan?

Dr. PANCHANATHAN. I mean the award recipients here who might have subaward relationships with the Wuhan Institute. We can again give you the details of the awards, Representative Posey, but nothing—I verified that there is nothing that was related to COVID research.

[A response from the National Science Foundation follows:]

NSF has not made any subawards or direct awards to Wuhan Institute.

Mr. POSEY. OK. Thank you, Mr. Chairman. I yield back.

Chairman LUCAS. The gentleman yields back.

The Chair now recognizes the gentlelady from Oregon, Ms. Bonamici, for 5 minutes.

Ms. BONAMICI. Thank you very much, Chair Lucas and Ranking Member Lofgren and our witnesses.

First, I want to express my condolences and grief about the passing of Jenn Wickre, a member of the staff of this Committee. I know she will be missed.

So, Dr. Panchanathan, good to see you. Oregon State University, as you know, is leading efforts to design and construct the next generation of NSF Regional Class Research Vessels (RCRVs). These are the state-of-the-art ships that will give scientists and educators access to the marine environment that's such an important investment to advance marine transportation, sound fisheries management, aquaculture development, coastal hazard mitigation, national security priorities, so very important development. Construction of the first vessel, which is *Taani*—it's a Siletz word meaning offshore—has reached an important milestone. We're excited about that progress on the on-water stage.

But at the same time, I know NSF is also moving forward with the development of the Antarctic Research Vessel (ARV) Project to replace the *Nathaniel B. Palmer*. Recently, the scientific community has raised concerns about the proposed design and omission of some key features that are crucial to the work of polar scientists. So what is the process and commitment to considering input from the scientific community on designs for research infrastructure like the ARV?

Dr. PANCHANATHAN. So thank you very much, Representative Bonamici. I also am excited by the RCRV *Taani.* It is scheduled to be delivered in January——

Ms. BONAMICI. Exciting.

Dr. PANCHANATHAN [continuing]. Of 2024. And Oregon State University has been doing a great job. I was in fact in one of the Academic Research Fleet ships just close by at the University of Washington very recently.

Ms. BONAMICI. Perfect.

Dr. PANCHANATHAN. So on the ARV input, in any of these things, we always solicit the input from the scientific community and public input to make sure that our investments, taxpayer investments are shepherded in the most responsible way. And of course, we always work with the Board in these kinds of large projects. And I'm sure the Chairman of the Board will also have something to add to that.

Ms. BONAMICI. Terrific. And I do want to move on to another question. But, Dr. Reed, if you want to add briefly to that.

Dr. REED. No, I just quickly echo what Panch said. We welcome input and additional feedback on appropriate features. After all, the only reason we build the infrastructure is to support the community, so——

Ms. BONAMICI. Absolutely.

Dr. REED [continuing]. Input as welcome.

Ms. BONAMICI. Absolutely. So we've had a lot of conversations in this Committee over the years about the importance of diversifying the STEAM (science, technology, engineering, arts, and mathematics)—I use STEAM because I believe in integrating arts for creativity and innovation—field, but—and you were mentioning, Dr. Reed, when I came in that it's so important to get more women and people of color or minorities involved, but it's all so important to keep them in the job when they get there.

So the U.S. Antarctic Program (USAP) has come under fire, including in this Committee, for inadequately protecting scientists and contract employees from sexual harassment and assault. I've worked on this issue with NOAA (National Oceanic and Atmospheric Administration). I've been to McMurdo Station, and I am alarmed. So last year SAHPR ("Sexual Assault/Harassment Prevention and Response") report contains some disturbing accounts of harassment and assault, generally describing a toxic environment that permits such behavior, does not hold perpetrators accountable, is cleared from that report and from Leidos' testimony before this Committee in December, that the prime contractor operating the USAP has been failing those doing important work in Antarctica.

So I understand that the existing Antarctic support contract has been amended with some new reporting requirements. So, Dr. Panch, what are the changes? Will these requirements remain when NSF recompetes the contract? And will the failure of Leidos to keep the participants safe, as well-documented in the SAHPR report, will that be considered when assessing a bid to maintain the contract should they decide to do so?

Dr. PANCHANATHAN. Thank you very much, Representative Bonamici, for asking this question. Sexual harassment has no place, no place in the scientific enterprise. I want to be very clear about this. We will not tolerate that. And I've made sure that the public statements that I've made clearly reflect this to the community, to the agency, and all the folks that are involved in terms of working as subcontractors and other agencies that are involved. So I want to make that very clear. Let me tell you, in that context, we are making sure that there is no light lost between the subcontractors, other agencies that are involved and their subcontractors, that we have a very tight network, which is only one link apart, not many links down, so they are tightly connected. And we established the Sexual Assault/Harassment Prevention office, the SAHPR office, at NSF soon after. We made sure that there should be no lack of coordination of any type that causes any challenges whatsoever. So we took action right away.

I immediately made sure that we had an on-ice advocate so that they are right there, not just a telephone line alone, but on-ice advocate who's able to be a neutral person. Now, people can go to the person and express their concerns as things happen, and they're provided the full support, and our Office of Equity and Civil Rights is a point of contact for people to be able to submit any of the harassment-related complaints.

Ms. BONAMICI. And has enough time passed so that you know that that's making a difference?

Dr. PANCHANATHAN. Yes, it's making a difference. In fact, it's making a difference in terms of number of reporting that we are seeing, which is a positive thing because——

Ms. BONAMICI. Absolutely.

Dr. PANCHANATHAN [continuing]. When people say, oh, there are so many reports, I said, that's good because people are now feeling like they have—actually have a place to go and report those numbers——

Ms. BONAMICI. Right. And I want to get—I know my time has expired, but as I yield back, Mr. Chairman, it's my understanding

that the OIG (Office of Inspector General), the NSF OIG doing important work on this project has had trouble getting Leidos employees to fully cooperate. The agency needed to step in to address the issue. So I'll submit for the record, but I need to know what happened and how NSF will continue to provide the Inspector General with unfettered access to the resources and people——

Dr. PANCHANATHAN. Happy to do that.

Ms. BONAMICI. Thank you very much.

Dr. PANCHANATHAN. We are in tight coordination with——

Ms. BONAMICI. Thank you. I'm sorry I went over, Mr. Chairman. I yield back.

Chairman LUCAS. An important issue. The gentlelady's time has expired.

The Chair now recognizes the gentlelady from Oklahoma for 5 minutes, Congresswoman Bice.

Mrs. BICE. Thank you, Mr. Chairman, and thank you for the witnesses being with us this morning.

Dr. Panch, I want to start by saying I appreciate your willingness to work with me last year on a situation involving an employee or subcontractor that was stationed in Antarctica, unfortunately, had a spouse pass away unexpectedly. And trying to get them back, I learned, is a little bit of a challenge, but you and your organization were incredibly helpful, and I want you to know how much I appreciate your commitment to that situation.

I want to start by asking, you received money in the *CHIPS Act* for NSF. Can you talk a little bit about the money that you received and what the focus would be for that?

Dr. PANCHANATHAN. So basically, we received a total of a $1 billion dollar increase in our budget overall. And from the *CHIPS'* part of that, we received $335 million. There are two components to that. One is our Technology, Innovation, and Partnerships Directorate, and the other component is what we do with the workforce development. So the Technology, Innovation, and Partnerships, if I can get the numbers here, I think received about $210 million, and the rest of it went primarily for workforce development programs authorized in the *CHIPS and Science Act.*

Mrs. BICE. And a significant increase, correct?

Dr. PANCHANATHAN. A significant increase from the *CHIPS* part gave us—just to put this in perspective, we had $52 billion as part of the *CHIPS Act.* NSF got a total of $200 million——

Mrs. BICE. Correct.

Dr. PANCHANATHAN [continuing]. As part of the *CHIPS Act.* I was talking about the budget increase in the component parts, but in the *CHIPS* part we got only $200 million out of the $52 billion. And the $200 million was essentially over a 5-year timeframe. We got $25 million in the first 2 years each. So the $25 million, we are actually leveraging that by working with partners, industry partners like Intel and Micron, in developing the semiconductor skill technical workforce. So as you can see, it is not a very large amount as you were articulating but important, significant amount that we want to create an outsized impact for the investment that we are making.

Mrs. BICE. Taxpayers may disagree that $25 million is a——

Dr. PANCHANATHAN. No, I——

Mrs. BICE [continuing]. A small amount, but I get your point.

Dr. PANCHANATHAN. Relative to the overall budget is what I was saying.

Mrs. BICE. Absolutely. I think that the point is that there has been increases in investment——

Dr. PANCHANATHAN. Yes.

Mrs. BICE [continuing]. In the NSF over the last several years, not just with the *CHIPS Act,* but other increases. And although we certainly want to make sure that we are being able to compete with our adversaries and keep up with quantum and AI and other things, it's not as though the agency has been cut or held flat. I think the point needs to be made there.

I want to follow up with the budget request for discretionary spending for the NSF has—is $11.3 billion. And it recently came to light that the NSF was given grants over the last couple of years for the development of, quote, "course correct," a tool that would allow the government to identify misinformation. Why is it funding the development of this tool?

Dr. PANCHANATHAN. So, Representative Bice, you will appreciate this. As you know, more recently, there has been a lot of deepfakes, deepfake videos and deepfake kind of activities. For example, the conversation that we're having right now, this could be completely construed as something different if they were to reframe this in a deepfake context. So what we are trying to do is we are trying to invest in understanding. We are not trying to do any policymaking. That's the domain of Congress. So we're trying to see how we can invest in understanding some of these things so that our young folks, our elderly folks, they're all protected, we all receive these calls. Recently, I was very disturbed to hear a mom receiving a call from someone pretending to be her daughter. And, you know, these kinds of things we don't want to happen.

And so what we're trying to do with these investments that we're making is understand those situations. And that's the kind of investments that we make.

Mrs. BICE. The concern that I think many have is that you are looking to correct misinformation. And if you think back to the COVID–19 sort of theory of how the pandemic began, you know, even the Department of Energy as recently as last month suggested that it could have been a lab leak, but there was a lot of information sort of suggesting that and a lot of false information on that topic. The point is, who chooses what's the misinformation and what doesn't? And I think that's a concern that I have. And I'm not sure that that NSF funding that is maybe the best use of taxpayer dollars. I understand that the premise behind it, but I do have concerns about that.

Dr. PANCHANATHAN. I just wanted to say this in response. I agree with you. The only thing that I would say is that we do not regulate any content. We do not engage in any censorship. I just want to be very clear that this is about understanding the process of deepfakes and other kinds of activities that we engage on social, behavioral, economic scientist folks. It's not just technologists, social, behavioral, economics, scientist folks, working with the technologists so that we build technologies that can be trusted into the future because we don't want our—you'll appreciate this. We don't

want our adversaries to take advantage of anything that we have not fully understood. And that's what the domain of NSF's work is. I just want to show you that.

Dr. REED. And I'll just add that from a technical perspective, yes, it is about technical understanding. Our adversaries are also using this technology. And how we can detect deception is an important technical question. Part of the practical, technical challenge is that the pace of this technology is advancing so rapidly, and it is so realistic that distinguishing, as the Director said, false information or manufactured human interactions that are in fact not real is increasingly difficult. And there have been studies that say that humans simply can't tell the difference anymore. And so from a security perspective alone, having the technical ways and means to be able to detect this is important. And I can say that from having talked to Department of Defense colleagues, so——

Mrs. BICE. OK.

Dr. REED [continuing]. It's another consideration.

Mrs. BICE. Thank you both for the answers.

And, Mr. Chairman, I yield back.

Chairman LUCAS. The gentlelady's time has expired.

The Chair now turns to the gentlelady from Michigan, Ms. Stevens, for 5 minutes.

Ms. STEVENS. Thank you, Mr. Chair, and thank you to witnesses. And it is a delight to overview the National Science Foundation and reflect on the historic passage of the *CHIPS and Science Act* that really bore out in this Committee over a multitude of years, reauthorizing the NSF but also authorizing the push to double your scientific research efforts. We are an authorizing Committee, we are not an appropriating Committee, but we are absolutely delighted that *CHIPS and Science* both intersected with your very agency.

And, Panch, thank you for the reflection of what it means to have the catching-up investment in chips manufacturing, chips that were innovated here in the very United States of America, but yet we saw the shrinkage of production. And we want to be able to produce those chips here. And we don't, at the same time, want to lose out on investing in AI, quantum, and what we need to do to address deepfakes and the like. And so please know that your words were heard and that we—many of us who care about industrial policy are looking toward *CHIPS* 2.0 here on this Committee and the Committee—the Select Committee on Competitiveness with the CCP.

And you might recall that within the *CHIPS and Science* bill, we did the *CHIPPING IN Act* legislation that I was very proud to author that would tackle some of the workforce component. And what NSF does best, awarding grants, working with stakeholders, working at the university and postsecondary level, we know that there is a refined utilization of the dollar. And just as we are in budget season and we have that debate going on, $52 billion for *CHIPS* begetting 200 billion of industry investment, paying for itself.

But, Panch, could you just shed a little bit of light and provide an update on NSF's CHIPS for America Workforce and Education Fund and how that is going?

Dr. PANCHANATHAN. Thank you very much, Representative Stevens. It's been truly a pleasure to work with all of you, and we are very grateful to Congress. I just want to say even to Representative Bice's question that we are very grateful at NSF. Every dollar that you have invested in us is, if you want to make it work for the Nation, for the amazing talent that is in our country, amazing ideas in our country, and I want to be very clear that nothing is small or big. I just didn't want to give the wrong impression. I just want to correct that, that what I was saying was that——

Ms. STEVENS. [inaudible] my question——

Dr. PANCHANATHAN. I know, I know. I just want to——

Ms. STEVENS. [inaudible].

Dr. PANCHANATHAN. I know, but I just want to make sure that there is never a misunderstanding of whatever I've said.

So the education——

Ms. STEVENS. [inaudible].

Dr. PANCHANATHAN. Yes. So here are the facts to your question. As I said, we received $335 million specifically for *CHIPS and Science* implementation. In terms of our investments, the Education Directorate received $125 million of that. And that was spent essentially on support for STEM education at all levels, pre-K to graduate, $38 million; workforce development across the STEM spectrum, $69 million; cross-cutting efforts to advance diversity, $18 million. And then the TIP Directorate received $210 million out of the $335 million, and that was essentially for the Regional Innovation Engines, which I'm truly excited by because we have innovation all across our Nation being spurred through that process.

Ms. STEVENS. [inaudible].

Dr. PANCHANATHAN. Yes, correct. That's right. So in the $200 million that was appropriated in *CHIPS and Science* as part of the $52 billion, $25 million in FY '23 and $25 million in FY '24 is primarily targeted toward building the skilled technical workforce for semiconductor training so that our industries like Intel, Micron, and all of them are able to benefit with the kind of talent that they need in order for them to be successful. I was very proud to be with Intel co-announcing the $10 million partnership. Part of the investment came from this. And likewise a $10 million Micron partnership, again, part of the investments. In other words, we are not just only using the $25 million that the Federal investments are making, but actually leveraging the Federal investments by working with industry so that we can deliver what they need.

Ms. STEVENS. Phenomenal model. And could you also just shed some light on privacy-enhancing technologies through the investments in the Fiscal Year 2024 budget? This is around digital footprints that obviously grow every day and by the minute and nanosecond. And often on this Committee we're discussing how to strike a healthy balance between privacy without hindering innovation.

Dr. PANCHANATHAN. Yes, so the privacy-enhancing technologies, while they're also focused investments, but we're making this part of many of the major investments that we make. Let me give you an example. On the AI Institutes that they are investing in, each of them $20 million scale, and I'm very proud to say that these AI Institutes are not only in a few places, they are all across our Na-

tion, touching every part of our Nation. And so when you look at the AI Institutes we have privacy, security, safety, ethics. All of that has components of even technologies like AI so that we make sure that we are not building anything in technological terms that is not sensitized to these kinds of things, particularly when it relates to applications where they are very important.

Ms. STEVENS. Well, allow me to say to you and Dr. Reed that we are so enthusiastic for your leadership and what you are doing at the NSF. We salute you, sir. And we recognize Jenn Wickre today and her heroic efforts every day on this Committee.

Thank you, Mr. Chair, and I yield back.

Chairman LUCAS. Thank you. And the gentlelady yields back.

The Chair now turns to the gentlewoman from New York, Ms. Tenney, for 5 minutes.

Ms. TENNEY. Thank you, Chairman Lucas and Ranking Member Lofgren, for holding this hearing. And thank you to the witnesses for appearing today and for your time, your insight on these issues.

The National Science Foundation has a long history of funding nonpartisan basic research that has led to numerous scientific and technological breakthroughs. I'm honored to represent New York's 24th Congressional District, which also has a great history, and home to the Erie Canal, which was once the beginning of the Industrial Revolution and much of our science that has come across our world.

Historically, the National Science Foundation has been a key player in investing in advanced manufacturing jobs that can help revitalize New York's 24th District and others across New York. This work is vital to my region, which has suffered tremendously from the offshoring of well-paying jobs, especially manufacturing jobs, for the past several decades, many decades actually, over 50 years.

However, I would be remiss to not also share my concerns as the National Science Foundation has strayed from its important work, wasting millions of dollars on the implementation of this radical notion of woke, diversity, equity, and inclusion, or the DEI agenda. The Foundation, it seems, has maybe wasted many of its efforts funding projects that are duplicative of private-sector successes. With our Nation with over $31 trillion in debt, I think we need to make an effort in safeguarding some of the taxpayer funds as we have a looming debt crisis facing us this week especially.

I just wanted to just get some—look into this—the latest legislation and look at the history of the National Science Foundation and the non-partisanship and the merit-based system that we once had in dealing with groundbreaking scientific information. I wanted to first ask Dr. Panchanathan. Did I get that right?

Dr. PANCHANATHAN. Panchanathan.

Ms. TENNEY. Yes, thank you so much. Panchanathan, did I get that right? Panchanathan. Perfect. OK. I wanted to ask you about some of the focuses of the National Science Foundation in its FY '24 budget. Can you tell me how many times the word biology appears in the FY '24 budget?

Dr. PANCHANATHAN. Representative Tenney, I would not have, but I will get back to you.

Ms. TENNEY. I'm glad you don't know because you're a scientist. It is 82 times. Can you tell me how many times the word chemistry appears in the National Science Foundation budget?

Dr. PANCHANATHAN. Again, Representative, I would not know that offhand, yes.

Ms. TENNEY. Thirty-eight.

Dr. PANCHANATHAN. OK.

Ms. TENNEY. Can you tell me how many times the word physics appears in the National Science Foundation budget?

Dr. PANCHANATHAN. No, Madam, I cannot.

Ms. TENNEY. Good news, it's 103.

Dr. PANCHANATHAN. OK.

Ms. TENNEY. Finally, can you tell me how many times the word equity appears in the National Science Foundation's 2024 budget?

Dr. PANCHANATHAN. No idea, again, sorry.

Ms. TENNEY. One hundred and thirty-one times, more than—more times than biology, chemistry, and physics, which is the focus of what we're trying to do in this legislation. Why does the word equity appear more often than any of our core sciences such as biology, chemistry, and physics? Can you give us an explanation of that?

Dr. PANCHANATHAN. Representative——

Ms. TENNEY. And please feel free to give us your opinion.

Dr. PANCHANATHAN. Thank you, Representative. Thank you for the opportunity. It's a very good question. First of all, let me tell you, NSF has not strayed away, we'll never stray away—I can assure you this, you have my commitment—from merit-based consideration of all the proposals, period.

Ms. TENNEY. Thank you.

Dr. PANCHANATHAN. There is no swerving away from that because that's the gold standard merit-review process.

Ms. TENNEY. Let me ask you, so while you are saying that, do you think that we should continue to maintain a merit-based system?

Dr. PANCHANATHAN. We are a merit-based system. We will always be a merit-based system.

Ms. TENNEY. Can——

Dr. PANCHANATHAN. When we talk about equity, let me let me clarify that. For me, the equity term is very straightforward. Let me explain that because I came from a small State, Representative Tenney. I have seen firsthand how rural students were left behind, how people with different socioeconomic demographic——

Ms. TENNEY. Well, let me reclaim my time for a minute because I come from a very rural, small community——

Dr. PANCHANATHAN. Yes. Yes.

Ms. TENNEY [continuing]. And my ancestry are people that were immigrants to this country as well. My concern is that equality is what our Constitution talks about——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. Not equity——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. And equity means equality of outcome——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. Not the equality of pursuit and being able to——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. Perform and demand excellence in our—of all the places, it seems to me that the National Science Foundation should be where excellence——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. And equality are—exist, not equity, which does not reward people based on merit. Would you agree with that statement?

Dr. PANCHANATHAN. Representative Tenney, I cannot agree with you more. What we are trying to do is basically this. How do we get all of the talent that is in our country which has not had the same opportunity everywhere? How do you compare? And I am an academic. How do you compare a B plus of a student coming from rural area, having a lot of challenges, working two jobs in order to, you know, take care of the family——

Ms. TENNEY. Well, if I may reclaim my time——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. For a moment——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. I would rather have a brain surgeon, a brilliant——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. Brain surgeon from rural upstate New York——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. As opposed to someone who was given an advantage just because of equity——

Dr. PANCHANATHAN. Yes.

Ms. TENNEY [continuing]. Not because of their excellence.

Dr. PANCHANATHAN. I agree with you on that, too. I'm just trying to——

Ms. TENNEY. Thank you. I think I have to—my time has expired, but thank you, Mr. Chairman.

Dr. PANCHANATHAN. Thank you.

Chairman LUCAS. The gentlelady's time has expired.

The Chair now recognizes the gentleman from New York, Mr. Bowman, for 5 minutes.

Mr. BOWMAN. Thank you so much, Mr. Chairman.

I just want to say for the record, equity just means providing access and opportunity to historically marginalized groups in the STEM fields, so those historically marginalized groups include women and people of color. So equity is about making sure that women and people of color are included in the conversations that we're having around STEM education.

Dr. Panch, would you agree with that statement?

Dr. PANCHANATHAN. Opportunity for all.

Mr. BOWMAN. That's right.

Dr. PANCHANATHAN. Everyone.

Mr. BOWMAN. Absolutely.

Dr. PANCHANATHAN. Rural, urban, across the broad socio-economic spectrum, across the rich diversity. Everyone should have the opportunity to be able to exercise their——

Mr. BOWMAN. That's right.

Dr. PANCHANATHAN [continuing]. God-given talent.

Mr. BOWMAN. Opportunity for everyone. And, Dr. Reed, would you also agree with that statement?

Dr. REED. I absolutely would. Talent is in short supply. We have to cultivate it wherever it comes. In a previous life, I was a corporate officer at Microsoft. I traveled the world telling governments, the societies that cultivate talent wherever it arises—and it's no respecter of socioeconomic or cultural status—are the ones that thrive and win.

Mr. BOWMAN. Absolutely.

Dr. REED. We have a huge shortfall with STEM workers in this country. We can't afford to marginalize anyone. We need to empower everyone to be full participants in the——

Mr. BOWMAN. That's right.

Dr. REED. —21st century economy.

Mr. BOWMAN. And talent is everywhere. You know, prior to coming to Congress, I worked in education for 20 years. I started my career in the South Bronx in one of the poorest ZIP codes in the country. I taught kindergarten mathematics, and the children there were economically poor, but intellectually brilliant and rich. What they lacked was access and opportunity because people had forgotten about them because they were in the South Bronx.

Dr. REED. Exactly.

Mr. BOWMAN. To my first question, Dr. Panch, with the rise of artificial intelligence, researchers are increasingly in need of computing and data resources at scale. Democratizing access to these resources is crucial and can help us address barriers and growing research capacity for emerging institutions, a problem highlighted by your OIG. I am pleased to see the Administration include portions of the National AI Research Resource known as NAIRR, as well as the National Discovery Cloud for Climate in the Fiscal Year 2024 budget proposal. It's critically important that we make this cyberinfrastructure available to make progress on some of the major challenges of our time.

Can you speak to how these initiatives can empower and expand the technical research capacity of our Nation?

Dr. PANCHANATHAN. Thank you so much, Representative Bowman, for asking the question. By the way, we had a very good conversation. I really enjoyed that.

Mr. BOWMAN. Yes.

Dr. PANCHANATHAN. I will tell you that when we talk about opportunity should be made possible for everyone, along with opportunity comes the access to the inspiration that people need to have. And that comes because you have infrastructure that is available in every part of our country so that they are able to access that infrastructure and get inspired for the STEM work. And at the same time, the same infrastructure that is available also makes possible great ideas, which is also democratized, and we want all those ideas to be lifted up.

So the NAIRR that you referenced is, which came out of the *National AI Act,* the *NAIRR* is an excellent example of how investment in computing resources, cloud and other kinds of computing resources, is going to make possible the access to the resource that

is needed for them to be able to bring out the AI talent all across the Nation and energize that.

And so that's not just limited to that. I was referencing the AI Institutes. You know, when we look at all of the work that we're doing in AI, we are keenly aware—as I said earlier, NSF is about people—that all of that investment is about how do we get people the necessary access to the tools, the training, the learning, and the environment that can make them excel?

Mr. BOWMAN. Got it? Let me jump to my second question before time runs out. Also to Dr. Panchanathan, I'm going to ask Dr. Reed to also respond, the new TIP Directorate is unique in its goal to advance emergent technologies to address societal and economic challenges. In the Fiscal Year '24 budget request, there are six key areas highlighted for funding under this directorate, including quantum and semiconductors. Seek, a company in my district, is operating at the intersection of both quantum information and semiconductors by fabricating new chips that more efficiently interface with quantum computers. Can you speak to how the TIP Directorate will support organizations like Seek that are operating under multiple priority areas?

Dr. PANCHANATHAN. In the interest of equal opportunity, I'm going to let this be answered——

Mr. BOWMAN. Yes, thank you.

Dr. PANCHANATHAN [continuing]. By our Chair first.

Dr. REED. So we—the Board has worked closely with NSF to collaboratively develop a portfolio strategy. We recognize that TIP is a continuation of the research enterprise, but we want a portfolio of technical areas. We want to ensure that it touches the geography of innovation, as we've discussed, and that it supports partnerships with both large companies as well as small ones, public, private, and government in some innovative ways.

So the—what we have seen, as Panch said earlier, in terms of responses across the country has been phenomenal. And there's broad-based coverage across areas.

On your previous question, I just want to note quickly that one of the things that's important about talent empowerment with respect to NAIRR is that great sucking sound we hear is talent leaving academia going to the private sector because of the huge AI boom. We need to make sure that we have talent in academia to teach the next generation of students. And one of the things that the NAIRR plan would do was empower education because that, after all, was the seed corn for continuing to drive the revolution forward.

Mr. BOWMAN. Thank you, Mr. Chair. I yield back. Sorry for going over.

Mrs. BICE [presiding]. No problem. Thank you, Representative Bowman.

And at this time, I want to represent—I'm sorry, I want to introduce—recognize Representative Kean for 5 minutes.

Mr. KEAN. Thank you, Madam Chair. Thank you for the witnesses participating in today's hearing. Your valuable insights and perspectives on this matter will certainly help us shape public policies that have significant impact on the future of science and technology in our country.

Now, as you know, New Jersey is a State that thrives on innovation and scientific progress. My district, the 7th Congressional District in New Jersey, is a key location of that research. And funding decisions made by NSF will undoubtedly play a critical role in our State's, my district's ability to maintain and grow its leadership in this field.

Director Panchanathan, the basic type of research that NSF has long funded is unpredictable. It's impossible in many cases to know at the start of the research what will happen down the line. At Princeton, for example, Professor Ted Taylor initially asked what chemicals produced the colors in butterfly wings. Fifty years of additional work led to one of the most extraordinary drugs available for the treatment of a certain kind of lung cancer.

There are countless examples of such discoveries. What is NSF doing to ensure that researchers are encouraged to keep conducting this type of basic research?

Dr. PANCHANATHAN. Thank you so much, Representative Kean, for asking that question. You're absolutely correct. The fundamental core of what NSF is has always been and will always be is this place for investment in discovery and basic research. As you rightly said—and if you look at the investments that we made, for example, in a bacteria in Yellowstone in the 1960's made possible the PCR test for COVID. So there are many, many examples like what you cited. So NSF will always maintain the focus of investing in exploratory discovery research.

What we're also trying to do at the same time is we're synergizing that with all the great discoveries that come. How do we rapidly scale those discoveries in partnership with industry so that our Nation can benefit by those translations? But not just that alone, that those translations then infuse more basic research, not less, but more basic research. And that's why the TIP Directorate is intentionally a cross-cutting directorate, not a separate directorate.

Mr. KEAN. And, Dr. Reed, and also in the interest of equal time——

Dr. REED. Yes.

Mr. KEAN [continuing]. When you think about the new endeavors that NSF is undertaking through the Technology, Innovation, and Partnerships Directorate, how do you define both success and failure?

Dr. REED. So, as I was saying, in response to a previous question, a lot of the focus in the conversation both with the Foundation and the Board has been about outcomes. And outcomes in the context of TIP I think mean several things. One, it means clearly the creation of new jobs, it means empowering areas that have historically not had access to technology and to allow talent to grow and flourish in those areas, so it's about economic impact writ large. That's one.

The other, to connect to what the Director just said, is to close the loop because one of the things that I've learned over the years in my research career is that collaborations with industry and academia expose new questions, questions that academia in isolation might not have thought of. And that feedback loop from the insights from public-private partnerships and TIP will drive those

new basic research curiosity questions, and so we want that loop to be closed. And so I don't view TIP as different than the rest of NSF. It is a mechanism, as the Director said, to translate, but it's also to feed new insights back into the basic research enterprise, though it empowers that enterprise to ask new and better questions.

Mr. KEAN. And how long do you take to get those answers in your determination if you're going down a pathway by either success or failure in years, conversations? What is it that defines success or failure over time?

Dr. REED. Well, I mean, I described the metrics. But if you're asking about timescale, I think, you know, we will know in a handful of years. We're looking to accelerate translation. We won't be asking in 20 years did this work. If we're asking that question in 20 years, we have failed. It will be a much shorter timescale, 5 to 7 years, I would hazard.

Mr. KEAN. That's fair. Thank you both, and I yield back my time.

Dr. PANCHANATHAN. Thank you very much.

Mrs. BICE. Representative Kean yields back.

I now recognize Representative Salinas for 5 minutes.

Ms. SALINAS. Thank you, Madam Chair. And thank you again to the—Chair Lucas and the Ranking Member for this hearing.

Dr. Panchanathan, in your testimony you highlight NSF's role in supporting workforce training to meet the aspirations of the *CHIPS* legislation. And institutions in Oregon have taken advantage of some of the NSF programs that promote STEAM pipelines and diversity in my district. Chemeketa Community College (CCC) is a Hispanic-serving institution that has received funding from NSF to improve student success in STEAM. And by implementing new student support strategies and faculty training, CCC is really helping underrepresented students, including our rural communities, gain the skills that they need to join the workforce or continue their education.

And building on these efforts, the University of Oregon is an emerging Hispanic-serving institution that has also won several awards to promote the transition of STEAM talent from community colleges, including those in rural areas like mine, to completing a 4-year degree.

It's also my understanding that OSU, the Oregon State University, is leading a proposal to the new Regional Innovation Engines Program with U of O and other Pacific Northwest partners like Lam Research, also in my district, which manufactures the fabrication equipment essential to advanced semiconductor manufacturing. So ultimately, I would expect that successful proposals will create new efficiencies in the talent pipeline by bringing educators, students, and industry closer together.

So my question, how does NSF plan to take advantage of the on-the-ground student-centered expertise of diverse local institutions like our community colleges and technical institutions to build those partnerships through innovation engines and other NSF programs and ultimately, that will leverage your resources to ensure that we train enough skilled and technical workers to meet our economy's needs? Because truly, right now, that is all my employers are asking for is workforce, workforce, workforce.

Dr. PANCHANATHAN. No, Representative Salinas, this is an excellent question. And knowing something about Oregon and Intel having a huge presence there, as you know, I can answer it very directly. With Intel, we have strong partnerships in terms of delivering not only the technical workforce that is at the Ph.D., doctoral level, graduate students, master's, and undergraduate students, but also skilled technical workforce, working with specifically community colleges and minority-serving institutions, Hispanic-serving institutions, HBCUs, and others.

So NSF invests in multiple ways in all of these activities. One, digital innovation engines that you referenced is essentially a sort of convergence of how do you get the innovation platforms that are in place, in Oregon specifically in the area of microelectronics and semiconductor manufacturing? How do you take that innovation in place ideas, bring the community together—by partnering with not only academic institutions, industry, but also the economic development ecosystems in those places—so that we can bring all of them together so that we can deliver all of the talent that is necessary and create an environment that the new ideas can emerge. Therefore, the industries of not only today are empowered, but the industries of tomorrow are readied, and the industries of tomorrow are created and birthed in those locations. That's the singular purpose of how you take the RIEs as incubation of those. And then with the next scale, scale them.

But I will tell you, we are also closely partnering with the Department of Commerce. We are great partners because the Regional Technology Hubs of the Department of Commerce and the Regional Innovation Engines of the NSF are working hand-in-hand so that we can scale them because, at the end of the day, you want these innovation engines to scale and deliver for those regions. And all of the workforce development programs at NSF, I won't have time to answer all of that—include all of that, but we are happy to answer your question in written form. All of that contributes to this, so it's a complete ecosystem of programs.

[A response from the National Science Foundation follows:]

NSF strongly supports STEM workforce development. It does so, in part, through its research grants, on which graduate student research assistantships may be included. These research grants have a small workforce development component, thus providing valuable education and training to the future professional science and engineering workforce. NSF also supports STEM workforce development through its programs. Development of a diverse professional science and engineering workforce is supported through programs such as the Alliances for Graduate Education and the Professoriate program, the Graduate Research Fellowship program, and the NSF Research Traineeship program.

More than 50 programs across NSF support the STEM workforce, as indicated by the inclusion of the term "STEM workforce" in their solicitations. For example. The Advanced Technological Education program supports development of the STEM skilled technical workforce. CyberCorps: Scholarship for Service supports the development of the federal cyber workforce. Programs aimed at minority-serving institutions, such as the Tribal Colleges and Universities Program, help to diversify the STEM workforce. The Robert Noyce Teacher Scholarship program supports development of the K-12 STEM teacher workforce, as do the Research Experiences for Teachers in Engineering and Computer Science program and the Computer Science for All program. The NSF Innovation Corps aims to develop the nation's entrepreneurs. In addition to programs such as these, many others support STEM learning at various levels of education, which contribute to a well-educated and well-prepared diverse STEM workforce.

Ms. SALINAS. Thank you.

Dr. REED. I'll just add one quick thing. You put your finger on a critical issue that I think we don't talk about enough in this country and that's the skilled technical workforce. There are actually more STEM jobs available in the skilled technical workforce area than there are for bachelor's and above. And there's a critical shortage of those workers. It's a rapid entry point, lower-cost entry point for many people. And to echo what the Director said, this is an example of where the Regional Innovation Engines, by creating experiential education opportunities for students, can transform the workforce opportunities and grow that base.

Ms. SALINAS. Thank you. And I yield back.

Mrs. BICE. Thank you, Representative Salinas.

And at this time, I yield 5 minutes to the gentleman from Ohio, Mr. Miller.

Mr. MILLER. Thank you, and I appreciate my colleague's comments on the other side about STEM workforce and technical education.

I just want to say thank you to the Chairman, and thank you, Stephanie, and thank you to the—Ranking Member Lofgren for hosting today's hearing. And thank you to our witnesses for joining us to discuss the National Science Foundation's budget proposal for Fiscal Year '24.

Director Panchanathan and Dr. Reed, as you know, the NSF plays an important role in workforce development and STEM education. A couple of important programs in these spaces are the Advanced Technical Education, ATE program, and the Experiential Learning for Emerging and Novel Technologies, known as the ExLENT program.

Let's start with the Advanced Technological Education program. Director, what role will this program play in meeting the Nation's need for skilled technical workforce? Thank you.

Dr. PANCHANATHAN. Thank you very much for asking this, Representative Miller. As you know, in Ohio—I talked about Intel in Oregon. I was there celebrating the groundbreaking of the Intel, working closely with Ohio State University and all of the community colleges and other institutes—institutions in the State of Ohio. We're all working together on this with Intel. And that's specifically focused on the skilled technical workforce that the Chairman talked about rightly that is very, very important to bring all of the skilled technical workforce that we need for our industries to be successful.

So the ATE program does this, and it has been doing this for a while, but we are now in fact doubling down, tripling down if you may to make sure that you're developing the curriculum in these emerging areas, like whether it is quantum, whether it is AI, whether it is semiconductor workforce. How do you invest in the curriculum development? How do you also then make sure the curriculum then is then deployed and, you know, trains generations of skilled technical workers? So ATE does both of that at the same time.

Mr. MILLER. Yes, I think it's absolutely phenomenal. And there's not enough emphasis on technical education throughout our entire country amongst all fields, and we've seen a lot of the—that field, unfortunately, have a lot of unemployment as of recently, and we'd

love to see that back on its way. And thank you for all your hard work.

Dr. PANCHANATHAN. Thank you.

Mr. MILLER. Recently, we've seen that rapid advances in emerging technologies like artificial intelligence that you just acknowledged and the Experiential Learning Center for Emerging and Novel Technologies program is key to supporting experiential learning opportunities within these new technologies. Director, how will the Experiential Learning for Emerging and Novel Technologies, known as ExLENT, program help to develop and maintain a diverse workforce as the required skills and training evolve?

Dr. PANCHANATHAN. Again, an excellent question. This was part of the Technology, Innovation, and Partnerships Directorate that we launched. We felt that we need the inspiration of experiential learning so that people can get their STEM spark excited even more and committed to wanting to learn the skills and therefore contribute to the—become the workforce of the future.

So we have multiple pathways in the ExLENT program. One of that is how do we get people who are not in STEM at all to be excited by STEM and therefore wanting to train themselves? How do we get people who are in STEM but now want that experience so they can then further enhance their skill sets in STEM? So there is a combination of subcomponents of the ExLENT program that's precisely delivering for the emerging and, you know, the future technologies. The workforce, the skilled technical workforce, and the workforce are at all levels, by partnering with our industry partners.

Mr. MILLER. Yes. And what I would love to see in the near future is, you know, bringing this education into our schools——

Dr. PANCHANATHAN. Yes.

Mr. MILLER [continuing]. At a middle school level and even that young and really showing other individuals a different career pathway, that yes, you can achieve an advanced degree within our country, and that's phenomenal.

Dr. PANCHANATHAN. Yes.

Mr. MILLER. We have many individuals who need those and how important that that truly is to the functioning of the United States of America. But more emphasis when it comes to the middle school level and maybe a little bit underneath, that educational aspect of you can do this. And how—and the best part is——

Dr. PANCHANATHAN. Yes.

Mr. MILLER [continuing]. How exciting it actually is.

Dr. PANCHANATHAN. Yes.

Mr. MILLER. When you bring children into these rooms and you give them the opportunity to see what lies in front of them, they are excited because the technology is amazing. And they get a skill and a trade that they can take with them to set up in a beautiful life. And to me——

Dr. PANCHANATHAN. Yes.

Mr. MILLER [continuing]. That's the American dream——

Dr. PANCHANATHAN. Yes.

Mr. MILLER [continuing]. Right there——

Dr. PANCHANATHAN. Yes.

Mr. MILLER [continuing]. Which I believe has been a little bit distorted. But thank you.

Lastly, I just would appreciate the opportunity to hear about the NSF's work to prepare the workforce of tomorrow for upcoming challenges. Dr. Reed, what activities does the Board believe the NSF should engage in to inspire and recruit future generations to the skilled technical workforce?

Dr. REED. Well, we've—you just asked rightly, and the Director answered a couple of those things. I do believe, as I said in response to an earlier question, this is a place where the geography of innovation activities that the regional innovations will do will put those experiential education opportunities. I completely agree with what you just said about it is important to expose students early to these opportunities, that they can see the excitement that is there. And we have to deal with the reality that talent, as I said before, is everywhere. And unfortunately, too often, what we have is people leaving regions to seek opportunities elsewhere because there simply aren't opportunities where they grew up. I'm a living example of this. I left rural Arkansas because there were no opportunities there to pursue my dreams.

We have to engage students, so the Board has been looking aggressively at the skilled technical workforce. The skilled technical workforce report we put out a couple of years ago highlighted both the need and the opportunities, the shortfall of skilled workers, and the need to change our educational mission. I think we have to look at the whole ecosystem. Some of this speaks to how we change K–12 education. Science is exciting. We all too often have made it boring. It's not boring. It is incredibly exciting. And every child is born a scientist. We tend to stamp curiosity out of them, I fear, often in our educational system. We've got to show them those opportunities.

And the Board has been really working with—directly with K–12 teachers. We have a working group that has been engaging with K–12 teachers to ask on-the-ground questions, not the sort of abstracted report version of this is what we should do, but what do you see on the ground that are limitations to us being able to address these challenge in workforce. And then the plan is then to take those ideas, partner with the Education Directorate, Edu Directorate at NSF, work with our college in other—colleagues in other agencies and push those ideas out into tangible practice.

Mr. MILLER. Thank you. That's absolutely phenomenal. I yield back.

Chairman LUCAS. The gentleman's time has expired.

The Chair now recognizes the gentlelady from Ohio, Mrs. Sykes, for 5 minutes.

Mrs. SYKES. Thank you, Mr. Chair. And thank you to you and the Ranking Member for bringing forward this really incredible and exciting conversation about the possibilities for innovation in science in this country.

And we've talked about Intel in Ohio, Intel in Oregon, and all of the jobs and innovations that your agency and your organization can bring forth. But I do want to bring us back to reality because you did mention, Dr. Panch, about the 280,000 technical semiconductor jobs that could be lost with the new H.R. 2811, *Defaulting*

on America Act, that we are perhaps going to see on the floor today. And we can talk about all the exciting opportunities and technologies, but with the significant cuts coming to your budget, we won't see any of those technologies. Is that correct? Is that what I heard you say earlier?

Dr. PANCHANATHAN. I had indicated the impact that it will have in terms of moving the ideas that are important for our national security, economic security, and workforce development, absolutely.

Mrs. SYKES. So—thank you for that. So I do want to again not be the Debbie Downer in the room but just be seated in reality because, before us today, we have a bill that will significantly impact our ability to protect our national security, to be competitive with China, to allow for our workforce to truly develop so we can find the Missing Million and create economic engines through Intel in the *CHIPS Act* in Ohio and in northeast Ohio where I represent the 13th Congressional District.

Dr. Reed, you didn't talk much about the impact of what this significant cut would do and how defaulting on America would impact the economy, our national security, our competitiveness with the Communist Party of China and so on.

Dr. REED. Well, I will echo what the Director said, that the effect of large cuts would be devastating for some very pragmatic reasons. We're behind at the current level. If you look at the level of investment that China is making and what China leadership has announced in terms of its doubling down on the future, as I mentioned in my opening remarks, we're losing now. If we step back even further, then the rate of loss will simply increase.

There are deep issues here. As I said at the outset, national security in the end flows from economic security. Economic security flows from innovation. Innovation cycle is relentless and ever-accelerating. That's why we have to double down on the future because that's what will secure the future of our country and of our citizens.

And so, yes, I'm very worried that we're not willing to step up to the plate and do what I believe needs to be done to invest in the future, to cultivate talent, expand that base of innovation across the country, and empower the workforce that we need to compete because I do believe that our innovation system is the best in the world, but we can't starve it.

Mrs. SYKES. Thank you so much for your response. And I know that's just one Of the many pieces in which this *Defaulting on America Act* is going to impact our national security, our competitiveness, our economy, our future altogether.

But I do want to stick with you, Dr. Reed, because you did mention—and I wrote this down—opportunities are—aren't equal, but talent comes from everywhere, and I thought that was such a great line. And thinking in Ohio's 13th Congressional District, you know, we don't have the big flagship university in Ohio's 13th, but we have plenty of talent. And when I think about the people who have left our communities, I was one of them for a part of time, and then I moved back home to take—as another famous Akron said—bring my talents back home at one point. What are some of the things that you can do to invest in these smaller hubs of the country where there is a lot of rural, a lot of suburban areas and not the

large flagship universities to create pipelines that are easily accessible, that are less intimidating, and ensure that we're getting talent from all over, rather than just our large flagship universities and larger cities across the country?

Dr. REED. Well, you put your finger on one of the key issues that I think drove our thinking broadly about the Regional Innovation Engines. And we've said multiple times and I'll say again here in front of the Committee, it's not about empowering the already empowered, although we need to do that, too, because those are historically the powerhouses that have driven innovation. We have to empower the unempowered as well. And there is talent everywhere. That means, as we look at the portfolio of opportunities, every area of the country has some unique or unusual intellectual strengths. The opportunity is how we bring those assets together, whether it be small- or medium-sized businesses, how we engage our other educational institutions, whether it be our MSIs or our HBCUs or our traditional teaching universities. Those are actually the backbone of our educational system. That's where most of our students get trained.

There are real opportunities to build ecosystems there. They don't necessarily end at State boundaries. They span natural economic regions that do cross State boundaries, but they are tightknit, and they can drive real economic effects that will create the opportunities for people to stay where they were born and grew up. And that's what we really have looked at and worked with NSF to shape the criteria for evaluation for these proposals.

And I'll just quickly end by saying, as the Director noted, we have been thrilled with the number, the richness, and the diversity of those proposals. They have come not just from the places you would think of, but they have come from all over the country, and that's really the exciting opportunity.

Mrs. SYKES. Thank you, Mr. Chair. I yield back.

Chairman LUCAS. The gentlelady yields back.

The Chair now recognizes the gentleman from Indiana, Dr. Baird, for 5 minutes.

Mr. BAIRD. Thank you, Mr. Chairman and Ranking Member. I really appreciate you holding this hearing. I also appreciate our witnesses for being here and expert technology that you present to us.

Before I start, though, I really want to recognize Dr. Reed and his exceptional decision to attend Purdue University for both his master's and his Ph.D. Purdue is in my—is my alma mater, and it's in my district, so I think you made a wise choice. But, you know——

Dr. REED. Thank you, sir.

Mr. BAIRD. You bet. But my first question really goes to Dr. Panchanathan dealing with why do you think it's important to codify interagency partnerships like the MOUs (memorandums of understanding) between NSF and DOE? And so, in your opinion, how does this benefit the continuity of research from one Administration to the next?

Dr. PANCHANATHAN. So, excellent question. Again, Representative Baird, really glad to be here talking to you.

When I came into the agency, I felt that—the Chair talked about this. That's all-of-government approach to advancing science, technology, innovation in our Nation. And the workforce is something that NSF has a unique role to play in terms of the STEM talent for our Nation.

So when you're talking about any topical area, the mission agencies like Department of Energy, NASA (National Aeronautics and Space Administration), and others, NOAA and others, working seamlessly with NSF is going to make possible that investments the taxpayers are making are utilized fully without any duplication or minimal, if at all, any duplication, but highly synergistic, and leveraging each other so that we can deliver for our Nation in a way that not only is basic research conducted to the highest quality and outcomes, but also translated rapidly the economic, national security benefit, and societal benefits. So we are deeply committed at NSF to partner with Department of Energy and all the Federal agencies to see how we can deliver for our citizens.

Dr. REED. I just add that truth is on the ground, and one of the things that is the real collaborative element are people, right? Paper is one thing, but it's people that actually drive real action. And many members of the Science Board and NSF have deep personal connections to members of other agencies. I actually Chair a Department of Energy Advisory Board, in addition to being Chair of the Science Board, so I work personally to facilitate those collaborations. And many members of senior NSF staff and the Science Board do as well.

Mr. BAIRD. Thank you. I—you know, I really appreciate not creating silos and ending up working together through government-as-a-whole kind of approach, so I thank you for that.

My other question deals with in the past few years, NSF and USDA (United States Department of Agriculture), the NIFA (National Institute of Food and Agriculture)——

Dr. PANCHANATHAN. Yes.

Mr. BAIRD [continuing]. Have partnered to establish two AI Institutes focused on advancing AI-driven innovation in agriculture and in the food systems. So why is this collaboration important, and what opportunity does the partnership create that neither agency would have on its own?

Dr. PANCHANATHAN. Congressman Baird, I think—I would like to double the number. We have four AI Institutes in partnership with USDA. This is an extremely important partnership because you will all agree that, you know, the future of agriculture is how do you ensure the technology empowered agriculture, that farmers are empowered with technology so that we can have better yields, much more precise agriculture, and a whole host of things that you can do to ensure that we are, you know, in the vanguard of innovation in the agricultural space.

And therefore, our partnership with USDA is centered on that because USDA is interested to make sure that they are delivering to our farmers all of the things that they need in their hands. And I was very happy to be in Illinois, for example, working—looking at John Deere and talking to them and seeing how the partnership is so seamless. And that's the kind of thing that we need to do more of. So NSF is deeply committed to that in terms of working

with agencies like USDA. In fact, that has motivated us also to think about our own centers.

In addition to AI Institutes in partnership with USDA, right at Purdue University we have an engineering research center called the Internet of Things for Precision Agriculture. So we're very excited about that. The lead institution is Purdue University. It's a $14 million engineering research center focused on increasing crop production, while minimizing the use of energy and water resources. We all want that. And so we can be leaders in this area. And Purdue is a leading institution in this arena, working with NSF investments, so thank you so much.

Mr. BAIRD. Thank you for your response.

Dr. Reed, we have got 14 seconds if you can—if you want to make a comment.

Dr. REED. No, just echo what he said. Agriculture is much more scientific-intensive than most people who haven't spent times on farms realize. Technology is driving the future for efficiency and conservation. We have to double down on that.

Mr. BAIRD. Thank both of you. And I yield back.

Chairman LUCAS. The gentleman's time has expired.

The Chair now recognizes gentlelady from Colorado, Ms. Caraveo, for 5 minutes.

Ms. CARAVEO. Thank you, Mr. Chair, and thank you to you and Ranking Member Lofgren for putting together this very interesting hearing today, and to our witnesses for taking the time today to speak to us, and for everything that you do to advance science and innovation in our country.

The National Science Foundation is the backbone of America's fundamental research enterprise and the only Federal agency that supports all sciences. NSF-funded advancements touch every corner of our lives and economy, which is exactly why we need to ensure that the agency is adequately funded. In Colorado, $372 million in NSF awards statewide supported fundamental science, Advanced Technical Education, entrepreneurial training, STEM teacher training, small business development, and more last year.

My home is—my district is home to a K through 8 school called STEM Launch, so I really appreciate Mr. Miller's comments earlier on the importance of K through 8 education. This school is in Thornton, and it uses inquiry and problem-based learning to inspire students to solve real-world problems with science and engineering. It's important not only that we inspire our younger students to pursue STEM fields, but we also ensure that every child, regardless of their demographics or background, has the chance to pursue these opportunities, so I really appreciate your comments earlier in the hearing.

Now in Fiscal Year 2022 NSF supported over 40,000 K through 12 teachers and nearly 140,000 K through 12 students. So, Dr. Reed, what is the importance more specifically of experiential and problem-based learning in inspiring students to pursue a career in STEM?

Dr. REED. Well, it exposes them to how science is actually done. And so much of the dry recitation we often talk about in the scientific method misses the excitement, the passion, the joy that comes from understanding something. That's what experiential

education gives. And anyone who's ever taught students realizes that the joy that when you see enlightenment on a child's face when they truly understand something, this is why we do this stuff. It's about empowering lives and understanding the fact that you can do this thing because most of what we need to do to empower people is creating in them not only the opportunity for them to do things, but the belief that they can. And that comes from that hands-on experience to see that, yes, it's not just these people in white coats that don't look like me some other place, but they're people just like me doing this, and they're having the times of their lives and they're having rewarding careers. I can do this thing. That's what experiential education—it creates the fire early on in a child. And as one Greek philosopher said, "A mind is not a vessel to be filled, it's a fire to be lit." That's what experiential education does.

Ms. CARAVEO. Absolutely. I cannot agree with your comments more. And I had so many teachers along the way who inspired that love of science for me and led me to going into medicine.

So, Dr. Panchanathan, can you describe some of the NSF activities that support our teachers in K through 12, especially those that are trying to close the achievement gap and create a diverse and inclusive workforce?

Dr. PANCHANATHAN. Thank you so much for asking this question, Representative Caraveo. I tell you that all of us can go back and identify ourselves being excited by STEM with the STEM spark. For me, the STEM spark for an 8-year-old kid was seeing the Moon rocks which were sent all across the globe by the United States. They did an amazing thing, and I was a small kid in India who went and saw this, and I was—it just blew me away. So we need to make sure—your point and the Chair's point, everybody has that opportunity to get excited by that.

To the teachers question that you asked, our Robert Noyce program is about teacher training and investment in teacher scholarships. We need a lot of STEM teachers, not only what we do in terms of the teachers of the future that are getting trained today in the Departments of Education, in various colleges, but the teachers who are already in the workforce. How do we get them to work such that they can get excited by STEM, who in turn can then excite the students in STEM? So we're working on a number of programs within the agency to see how we can get that excitement even more ignited, as you said, not just filled, but ignite that spark. And so we're working on a number of programs.

In Digital Innovation Engines itself, we are making sure that also K–12 components can be connected. That's another mechanism. We have a number of programs in our STEM Education Directorate which is focused on ensuring that we are able to build the K–12 capacity for teachers, STEM teachers, and so we are working on all those fronts. And Robert Noyce is an example in that regard.

Ms. CARAVEO. Sounds like an incredible program. I thank you for the focus on children as a pediatrician, and seeing that ignition of joy and excitement when you talk to them about science, and especially when they put their hands into something is something that I very much appreciate as a scientist and somebody who focuses on children, and so thank you for your work there.

Dr. PANCHANATHAN. Thank you very much.

Chairman LUCAS. The gentlelady yields back.

The Chair now recognizes the gentleman from Tennessee, Mr. Fleischmann, for 5 minutes.

Mr. FLEISCHMANN. Thank you, Mr. Chairman.

Gentlemen, good to see you again today. I apologize. We've had hearings going on. As you know, I chair the Energy and Water Subcommittee of Appropriations, and I'm also on two others, but so good to see you again, and I appreciate all that both of you all do.

I know both of you share Congress' interest in ensuring that innovation and discovery happens across a wide range of institutions and researchers from all parts of the country. To that end, the *CHIPS and Science Act* made some changes to the EPSCoR programs at different agencies, including the NSF. Tennessee graduated out of the NSF EPSCoR program in 2014. I'm concerned that the increased focus on supporting institutions in EPSCoR States will result in less support for smaller or minority-serving institutions in States that are not in EPSCoR programs such as those in Tennessee.

According to NSF data from fiscal 2021, most institutions in Tennessee that conduct federally funded research would be classified as emerging research institutions. I'm very proud of the few Tennessee institutions that have large portfolios of federally funded research, including UT (University of Tennessee) Knoxville, my alma mater, and Vanderbilt. But I'm also concerned about these smaller research institutions such as my constituent, the University of Tennessee at Chattanooga, that could be left behind. I understand that there is always a potential for partnerships, but I'm concerned that could relegate smaller research institutions to always being the partner and never the lead.

My question is, is what is NSF doing to ensure that smaller research institutions in non-EPSCoR States are held harmless as a result of this policy change?

Dr. PANCHANATHAN. Thank you so much for the question, Representative Fleischmann. First of all, it was truly a pleasure talking to you——

Mr. FLEISCHMANN. Yes.

Dr. PANCHANATHAN [continuing]. So thank you so much for that opportunity.

So let me address this. When we talk about ideas and talent being democratized and everywhere, what we're trying to do at NSF is how do you invest in a way that institutions of all types have the potential to be able to transcend the gold standard merit-review process of NSF and get invested in their ideas that they have in all institutions. You rightly point out the emerging research institutions in both EPSCoR and non-EPSCoR States, all of them deserve their ideas to be lifted up so they can transcend the gold standard merit-review process of NSF and get invested in because the talent also goes to those institutions. In fact, I would say a diverse talent base goes to those institutions that needs to be energized and empowered.

So what are we doing in this regard? We are launching a new program called GRANTED. GRANTED is an acronym, Growing Research Access through Nationally Transformative Equity and Di-

versity. This GRANTED program is simply a virtual research office that is available to any institution that does not have such an office. If you look at most of the established research institutions that you referenced, great institutions like University of Tennessee and Vanderbilt, they have excellent research offices that essentially serve the faculty and the researchers to be able to ensure that their ideas are connected and provided support so that they can be lifted up in terms of proposals that succeed in the gold standard merit-review process. So this GRANTED virtual research office is going to be available for every institution virtually, and NSF is investing heavily in this as part of the *CHIPS and Science Act.* So that emerging research institution in States like Tennessee have the chance to be able to get a larger share of the representation of their ideas being funded by NSF. So I want to make sure that I talk about this very clearly so it is not just limited only to EPSCoR States, it's also about non-EPSCoR States.

Having said that, we know that a number of those ideas in the EPSCoR [inaudible] before and they have been lifted up, so we want all EPSCoR States to be lifted up. And so we are making sure that this GRANTED program is giving the opportunity for all those research 1, research 2, community colleges, and other institutions to have the chance to excel and do well in the gold standard merit-review process.

The only request I have is please invest in NSF in large measure so that everybody wins and that all talent gets energized.

Mr. FLEISCHMANN. Very well stated, Doctor, and I thank you. My time is waning, so again, I'm going to thank you, gentlemen. And I also especially want to thank our distinguished Chairman. I began my congressional career 13 years ago on the Science Committee, and he's been gracious enough to invite me back. And it's a privilege, Mr. Chairman, to be with you again.

Chairman LUCAS. You look good sitting at this dais. With that, the gentleman yields back.

The Chair now recognizes the gentlelady from Pennsylvania, Congresswoman Lee, for 5 minutes.

Ms. LEE. Thank you, Mr. Chairman.

NSF funding in my district supports research, training, and STEM education that improve our quality of life. For example, in western Pennsylvania, NSF funding has supported University of Pittsburgh in neuro-engineering, nanotechnology, and renewable energy, while CMU (Carnegie Mellon University) has received funding for projects in areas such as artificial intelligence, robotics, and cybersecurity. The NSF funds researchers and institutions that make the U.S. an innovation leader.

Historic investments in NSF like those in the *CHIPS and Science Act of 2022* are under threat if funding is reduced to the Fiscal Year 2022 levels that Speaker McCarthy is pushing for. For my colleagues who demand for American independence and leadership, let's fund it then.

Dr. Reed, the NSF declines over 80 percent of proposals for AI research due to limited funding. Why is AI research and development important to fields like healthcare and environmental sustainability?

Dr. REED. Well, first of all, my wife is a proud Pitt graduate, so I have deep connections to Pennsylvania.

Look, AI is transforming almost everything we do. In healthcare, it begins with predictive and analytics, whether it be looking at healthcare records and understanding issues that might not be observable by individuals, but one could identify themes. It goes to issues around drug design. One of the great breakthroughs in AI recently was the ability to predict how proteins fold. That was something that had been an unsolved problem the community had been working on for over 20 years. AI made that possible.

So across a range of things, it's changing how we think about problems. In my domain of computing and computer-based modeling, whether it be about modeling the spread of disease or spreading air pollution or other dynamics, AI is making those computations more compact. It means we can do broader parameter studies, better predictive analytics. All of those things are a consequence of new technology.

And you put your finger on it when you said that NSF funds most of basic AI research in this country, and the overwhelming majority of proposals are funded.

I'll just add when I had hair, which I did at one point, believe it or not, and was a young researcher, the success rate at NSF for research proposals was much higher. We're leaving lots of great ideas on the table because the number of great proposals we receive that we can't fund, it does mean the ones it funded are phenomenal. But there are a large number of phenomenal ones we simply don't have the resources to fund. That speaks to how we empower that broad geography of innovation because we're leaving people unable to capitalize on great ideas because they lack the research infrastructure, as the Chair mentioned at the outset, or the support for the students that will be that next generation of talent. But AI cuts across all of those things. It is one of those transformational technologies that may be a once-in-a-generation opportunity that will reshape our world and reshape our economy and reshape our national security.

Ms. LEE. Thank you. You just answered my second, so I'll go straight to another. The United States lags behind other nations in producing STEM degree graduates. How crucial is improving diversity in the scientific community to economic and national security?

Dr. REED. Well, I'll let the Director answer——

Ms. LEE. Please, either.

Dr. REED [continuing]. This one, but I'll jump in as well. It's critical. Look, we need a workforce that's representative of the population. And I'll tell you a story from when I used to work at Microsoft. I was a corporate VP (Vice President). I told my teams, we need a diverse and inclusive team because we will build better products. We'll build products that are more representative of what the population needs because we have perspective that reflects the real population. It's critical.

Dr. PANCHANATHAN. So I will simply put it this way. Without diversity, we will not be innovative. Diversity of ideas, diversity of context, diversity of experiences, diversity of backgrounds, all of this is what makes innovation so rich. So therefore, it's exceedingly important that we embrace diversity of all types so that we can

make sure that we are in the vanguard of innovation because of the diversity. It's not just it's a good thing to do but it's the right and smart thing to do.

Ms. LEE. I couldn't have said it better myself. Staying with you, Dr. Panchanathan, how much will—how will underinvestment in the NSF hinder the development of reliable U.S.-made supply chain of microelectronics and semiconductors?

Dr. PANCHANATHAN. A lot. So in the interest of time, I will tell you that we have really faced—I addressed this earlier. We have really faced the challenges of what happened because of supply chain disruptions with all of the offshoring of some of the activities that we should have had, rightly here in the United States with the jobs right here. So what's happened is we are facing the consequences of that. Particularly in the COVID moment, we faced it even more. So we are bringing them and onshoring them back, and it is exceedingly important that we continue to invest in all areas, including supply chain, understanding the importance of the critical supply chain, and therefore, the emerging technologies of national importance is something that we don't cede leadership or make sure that they are not where we are reliant on nations, particularly adversarial nations who are not going to necessarily partner with us. So it's very important that NSF is invested in turn, which invests in these important areas.

Ms. LEE. I thank you both for the most enthusiastic exchange that I've had yet in my short time here.

That is my time. I yield back, Mr. Chairman.

Chairman LUCAS. The gentlelady's time has expired.

The Chair now recognizes the gentleman from Georgia, Mr. McCormick, for 5 minutes.

Mr. MCCORMICK. Thank you, Mr. Chair.

I want to start by echoing the sentiments and then sharing with the sympathies for Jenn Wickre. Her family, friends, entire Science and Technology Committee staff in her recent passing, just really, our heart goes out to her, and I just want to recognize her. I'll keep them in my prayers for sure.

Mr. Director, the *CHIPS and Science Act* rightfully recognizes a key strength for the United States' innovation in the range of institutions and research from all parts of the country. The law contains numerous provisions that seek to broaden participation in research enterprise and bolster research capacity in institutions that haven't previously received significant research funding. I think we—ad nauseam, we've discussed EPSCoR today and how we want to diversify how we do research. What are we missing though as far as recommendations for the next thing that we aren't investing in? We know where we've invested already, but there's always blind spots out there. What do you think—we're thinking outside the box. We're trying to be visionary rather than reactionary because a lot of times we in Congress, just like everybody else, tend to be reacting to a market pressure at this time and we're not thinking about the next big thing. What's on the horizon that we're not investing in right now?

Dr. PANCHANATHAN. So it's an excellent question, Representative McCormick. Let me tell you that we are already investing in the technologies, I will say, of tomorrow, right? But these technologies

of tomorrow have been made possible because of not just investments of today, but investments for several decades, of NSF investing in those ideas that have emerged as technologies of tomorrow, quantum being an example, AI being an example. AI today is more than five to six decades of sustained investments by NSF and other agencies that we are with AI today.

So to your point, therefore, there are two things. Already, the investments of NSF and basic discovery is setting the stage for the discoveries, then translating it into technologies of not tomorrow, but the future. That's the first point I want to make.

The second point—as a physician, you will appreciate this. The second point that I want to make is the fusion of disciplines is where the future innovations lie. Having built the Biomedical Informatics Department in my previous role where the fusion of medicine, biology, informatics, and computing and engineering is how the physicians of the future are going to deliver the quality care at the lowest possible price, right? And so these are the kinds of fused sort of disciplines where this innovation lies.

So what NSF is doing right now is preparing for that already. All our directorates are now working together and not only advancing innovations in individual disciplines, but also at the intersection of disciplines. If NSF configures it that way, then the domains that we invest in, namely, universities, are also going to configure themselves that way.

So a person who is trained to become a physician is not only going to be a physician, they are going to be an expert in computing, they're going to be an expert in engineering principles, they're going to be an expert, or at least knowledge of in social behavioral principles because all of that is required to deliver the best possible and effective care. And you will appreciate that. So those are the kinds of emerging areas that we are investing in also.

Mr. MCCORMICK. You know, I really appreciate that because I do see a lot of crossover between different—as a guy who started off as a pilot and then went into——

Dr. PANCHANATHAN. Yes.

Mr. MCCORMICK [continuing]. Medicine and——

Dr. PANCHANATHAN. Yes.

Mr. MCCORMICK [continuing]. Just transitioning your brain in different—and you can see the crossover in technologies. And I appreciate your comprehensive approach to that. I also appreciate your definition of diversity. I think it's really important to think about it's not—we're just—we're not just defined by what we look like, but our experiences where we grow up, our regional experiences, and that we respect that in all matters.

One of the things I'm going to kind of—I'll skip over my EPSCoR because that's been just talked about a lot. One of the things I have concerns about when we're sharing information, just like with anything in government or in schools, there is a danger to that also. We know we're in direct competition to China. When I was at Georgia Tech doing my pre-med and instructing Associate Professor, we had a case there where we actually had some espionage and we had some people arrested for sharing information that was critical to the future technology. And we know we have a big problem in protecting our technologies into the future. And with all the cor-

porate and government investments in technologies, especially in our universities, what are we doing to protect that, especially since there's been some recent investigations that have actually resulted in convictions of both professors and students? How do we avoid that into the future? Because this is going to continue to be a problem where we make these heavy investments, and then somebody just takes it from us.

Dr. PANCHANATHAN. No, thank you so much. I'm going to let the Chair answer this, and then I will follow up with some data that would make you——

Mr. MCCORMICK. Sure.

Dr. REED. So this is a real issue because our educational and research system depends on openness and broad-based collaborations. And so we have to always be mindful that there is creative tension between the desire to welcome ideas and perspectives, and we depend on continuing to attract global talent. That has been one of the geniuses, superpowers of this country in its history is that we've been a magnet for global talent. We don't want a level playing field. We want disproportionate tilted in our favor, and that means we want to continue to welcome people.

But we have to be realistic that, as you rightly said, there are real issues. A lot of this goes to better education in our research institutions, better information-sharing about what the risks are because I will tell you, as a former VP for research in a university, there's a lot of naivete still out there about what's going on. And so it's education, it's diligence, it's communication.

The Foundation has worked hard to ensure that its research integrity and research security office can be mindful of those issues and they can put in place policies and mechanisms with the universities collaboratively to be able to manage those things.

And I'll let the Director expand a little bit more on that. But it is a creative tension that necessarily is, given the nature of our society.

Dr. PANCHANATHAN. We have a Chief Officer for Security Strategy and Policy, and we have a team, which works very closely with the intelligence agencies, Defense Department, other agencies, Administration and Congress, and more importantly, as the Chair said, with the universities to make sure whatever needs to be protected, is protected and safe, that people disclose their conflicts of interest and conflicts of commitment. And we make sure that we not only are relying on their disclosures, but we're using analytical tools to ensure that they're verifying. So we're doing everything, Representative McCormick. I mean, the world has changed and so has NSF and other agencies. We are taking this head on and making sure that the taxpayers' investments are benefiting our Nation.

Mr. MCCORMICK. Thank you. I yield.

Chairman LUCAS. The gentleman's time has expired.

The Chair now recognizes the gentlelady from Virginia, Mrs. McClellan, for 5 minutes.

Mrs. MCCLELLAN. Thank you, Mr. Chair and Ranking Member Lofgren, and I want to thank Dr. Panchanathan and Dr. Reed for being two of the most enthusiastic witnesses I've seen since I've been in Congress.

Dr. Panchanathan, I was glad you had the opportunity to visit the 4th District of Virginia and see some of the groundbreaking work that we are doing and was very pleased that Virginia State University in my district has received funding through the Historically Black Colleges and Universities—Excellence in Research program. They're doing great things with that.

I want to ask—I also represent Virginia Commonwealth University where the Medicines for All Institute has received NSF funding to integrate multiple disciplines, including chemistry, engineering, and pharmaceutical sciences, to address the drug product development and manufacturing needs. And I wonder, you know, Dr. Panchanathan, could you speak to how the NSF budget supports onshoring the full pharmaceutical supply chain for the benefit of our national security, public health preparedness, and environment?

Dr. PANCHANATHAN. Thank you so much, Representative McClellan. It is truly a delight to be here with my friend, partner, and a colleague working together. That's why you see the excitement. We work together very well.

So to your questions—before we go to your question, it was truly a delight visiting Virginia Commonwealth University. You know what the highlight of my trip was? Franklin Military Academy.

Mrs. MCCLELLAN. Oh, great.

Dr. PANCHANATHAN. And I saw these unbelievable students in high school doing these amazing projects. And I talked about STEM inspiration earlier. They are all inspired, and that's the kind of inspiration we want spread everywhere across our Nation. We are thrilled to invest in Virginia State University, as well as VCU.

And to your personal onshoring, biotechnology is a significant focus area for us because we believe that emerging technology, we need to make sure that we are seizing the opportunity to be in the vanguard of innovation. So in fact, they're investing in biofoundries through the TIP Directorate so that it is all across our Nation. Biomanufacturing is something that we need to make sure that it is in place and in places where, you know, we have the convergence of the ideas, the buildup of the technology, and how we can scale the technology, all of them coexisting together in these regions. And RIEs is focused—our Regional Innovation Engines are focused on that kind of an approach.

Mrs. MCCLELLAN. Great. We know graduate students are often full-time researchers with additional responsibilities but are paid very little. And many are—many of those graduate students are from lower-income families. Can you talk about what NSF is doing to address the financial instability faced by so many of our graduate students?

Dr. PANCHANATHAN. Yes. It's a very, very good question. So, as you know, NSF does two kinds of investments, many kinds of investments, and these two on the graduate front broadly categorized. One is what NSF invests directly called the Graduate Research Fellowship Program (GRFP), which is a very prestigious fellowship program. Now, we invest about 2,000 to 2,500. In the 2024 budget, we have asked for an increase in the number because there are so many applicants well-deserved in terms of getting those investments.

What we have—since I became Director, we have increased the stipend investments from what used to be $34,000 to $37,000 now. And the tuition remission that we provide, which was $12,000, is now $16,000. So they're keeping pace with what is happening in terms of inflation, as well as other kinds of things that we need to make sure that they are paying at least living wages to be able to want to pursue this because they do pursue this out of the real interest in wanting to contribute to science and technology and engineering and others, and so we are mindful of that.

The second path, which is we fund our grants and the grants then go to the institutions which then fund the graduate students. So which means that we're encouraging institutions to submit whatever is the true cost for a graduate student, and if that that means that the grant size has to increase, we should make that happen. Whatever is the size of the grant, we should be paying the graduate students because we cannot risk losing good graduate students because they found that the paid—they're already take a huge pay cut to do the graduate program. We don't want them to sacrifice where they can't even have a living wage. And so we are taking that very seriously and working on both fronts. And the Board is extremely supportive of this, and in fact, has brought this to our attention how important this is, and that is because of Chair Reed. And I will let him speak to that.

Dr. REED. Yes, I mean, this has been an all-hands-on-deck conversation among the Board. Workforce writ large is our No. 1 issue. But you put your finger on the issue. We're asking the best and brightest in our country to take a vow of poverty to pursue STEM careers. This is not a sustainable operation. We've got to be honest about those true costs. It's a reckoning that has to take place across the country if we want talent to continue.

And you also rightly said those costs fall disproportionately on first-generation and underrepresented students because they typically start graduate school with higher amounts of debt. They've taken on deferred income, in addition to low wages. We have to continue to raise those stipends.

It's got to be a national conversation. I have begun some of those conversations with my colleagues across the country wearing my hat as Chair of the Board, and I know OSTP and PCAST (President's Council of Advisors on Science and Technology) have also talked about these issues. It's got to be addressed.

Mrs. MCCLELLAN. Thank you, Mr. Chair. I yield back.

Mr. MILLER [presiding]. The gentlewoman's time has expired.

The Chair recognizes Hon. Dr. Babin from Texas.

Mr. BABIN. Thank you, Doctor. I appreciate it.

Director Panchanathan, Director Panch I guess, I am concerned by the recent NSF announcement that the agency intends to wind down operations to the *JOIDES (Joint Oceanographic Institutions for Deep Earth Sampling) Resolution* or *JR* as part of the International Ocean Discovery Program (IODP) in FY '24, thereby leaving the researchers with no U.S.-led scientific ocean drilling capabilities. How does this plan address the ocean science community stakeholder priorities carefully laid out in the 2050 science framework document?

Dr. PANCHANATHAN. Thank you so much for asking——

Mr. BABIN. Briefly.

Dr. PANCHANATHAN [continuing]. The question——

Mr. BABIN. Yes, sir.

Dr. PANCHANATHAN [continuing]. Representative Babin.

Mr. BABIN. OK.

Dr. PANCHANATHAN. I just want to underscore this right up front. This does not signify the end of the U.S. program. I just want to be very clear.

Mr. BABIN. Good.

Dr. PANCHANATHAN. Why do I say that? The vessel is nearing its retirement. The EIS (Environmental Impact Statement) expires in 2028. It is 45 years old. And the current operational model requires significant contributions from our international partners to also move this forward, and that is becoming increasingly not viable because the changing priorities of our international partners.

Having said that, NSF is committed and will do everything to support the operation of the core repositories, as well as the research on the archive cores, and we have a lot of them already that are there. And we are going to make sure that the research continues on those and the use of alternate or mission-specific drilling platforms and other efforts. So that's to make sure that we are not ceding any leadership position here.

Mr. BABIN. Yes, sir.

Dr. PANCHANATHAN. At the same time, we are also going to engage with the young researchers in the scientific ocean drilling community, early career researchers to sit with them to see how we can plan for future scientific ocean drilling and promote those opportunities. So we're working on both fronts is what we might do today——

Mr. BABIN. OK.

Dr. PANCHANATHAN [continuing]. To continue this and what we might do preparing for the future.

Mr. BABIN. OK. Thank you. And then my next question for you, in Fiscal Year '24, NSF budget justification document, NSF proposes an annual budget of $52.77 million for the IODP for the next 6 years. After detailing the great successes of the *JOIDES Resolution,* the budget proposal states that NSF has decided not to renew the IODP operation and maintenance or *JR* operations in Fiscal Year '24. And given that the operations of the *JR* constituted the bulk of the IODP funding, what does NSF plan to do with the $52.77 million?

Dr. PANCHANATHAN. So, as you can appreciate, Representative, when we take the taxpayers' investments, we want to make sure that we are investing in places where the maximum impact is realized. So it is not that we are walking away from anything. You know, we are good at starting things. I know all of us can attest to this. We are good at starting things. We are also good at sometimes sustaining things. But it's very hard to say that something is done and we need to move on to the next thing where we need to close. And in the interest of making sure that we are delivering for our taxpayer investments, we have to take a critical look at every project and see what are the things that have been achieved, what needs to continue to be achieved and be invested in IODP, *JOIDES,* and so on for many, many years. And now we're saying

what can we continue to do in terms of the research rigor, but not necessarily using those as only continuing investments but investing in things like, for example, how do we get the talent trained for the future? How do we get our industries having the workforce that they need today so that we can be competitive globally, that we take care of our economic and national security concerns very seriously?

Mr. BABIN. OK. OK. Thank you. And then third, NSF's announcement that it is ending operations of the U.S. scientific drillship 4 years before its expected operational life leaves the United States without a U.S. vessel precisely at the same time that China is putting their drillship into operation. I am concerned by the loss of scientific leadership for the United States as a result of this announcement. What resources do you need to establish long-term U.S. leadership in ocean sciences while extending *JR* operations

Dr. PANCHANATHAN. So, Representative Babin, I will tell you, as I said earlier, because again, the first is *JOIDES Resolution.* We want to make sure that we are investing in those things that continues the research progress, but we're also at the same time preparing for the future. And we want to make sure that we prioritize—and the Chairman spoke about this. We have a number of infrastructure projects that we have in line, and we're trying to prioritize those infrastructure projects related to the strategic vision of where we want our science, technology, and engineering to go into the future, what gives us the maximum advantage, and investing in those. And therefore, in this case, we are going to assemble the group of scientists who are involved in ocean drilling to make sure that we are planning for the future.

Having said that, we do a lot of other investments to continue ocean scientists' ocean research, and I won't have the time to dig into all of them, happy to send you the information.

[A response from the National Science Foundation follows:]

The NSF Division of Ocean Sciences (OCE) supports cutting-edge research, education, and infrastructure that advances the Nation's scientific knowledge of the oceans to support the U.S. economy over the long term, provides vital information regarding national security matters such as sea-level rise, and advances U.S. leadership in ocean science and technological innovation. In Fiscal Year 2023 OCE will provide over $400 million in support for ocean research and associated infrastructure. OCE research programs delve into the physical, chemical, biological, and geological aspects of the oceans. This research provides essential information regarding ocean circulation and the heat, nutrients, and contaminants transported throughout the global ocean. Each year around 400 awards support a vibrant U.S. ocean research enterprise. Key infrastructure investments include:

- U.S. Academic Research Fleet, which consists of 17 oceanographic research vessels operating in the World's oceans and the U.S. Great Lakes
- National Deep Submergence Facility, which provides submersible assets that enable targeted sampling of the deep ocean and other extreme underwater environments
- Ocean Observatories Initiative hosts technologically advanced sensors that measure the properties of the ocean, revealing details of the ocean's chemistry, physics, biology, and geology

While NSF is not renewing operation of the Joides Resolution after FY 2024, NSF recognizes the valuable knowledge provided by scientific ocean drilling. NSF will continue to support meritorious research proposals from the U.S. scientific ocean drilling community and is committed to supporting cutting-edge science along with the tools and workforce that make it possible.

Mr. BABIN. OK.

Dr. PANCHANATHAN. We are not backing off, we are not slowing down, but we are being very precise and strategic about our investments.

Mr. BABIN. I want to ask one real quick question if you'll indulge me, Mr. Chair.

Dr. Reed, what is NSF's plan for filling the gap in ocean science drilling beyond accessing current core samples stored at the repositories or relying on foreign entities?

Dr. REED. Well, as the Director said, this draws on community perspective. One of the things that I've always been impressed about from NSF in my 40 years of engagement with it is that it is community-driven. It takes ideas and priorities from the community and it convolves those with budget realities to make appropriate choices. All of these things across all of the STEM disciplines draw on community input. They surface ideas, they make cases via national initiatives, via National Academy studies, and the Foundation takes those as really the driving impetus for its priorities. So it will come from the community.

Mr. BABIN. Thank you very much. I'm out of time. I yield back. Thank you.

Dr. PANCHANATHAN. Thank you so much.

Mr. MILLER. The gentleman's time is expired.

Next up, we have Hon. Mr. Mullin from California, please.

Mr. MULLIN. Thank you, Mr. Chair.

Thank you, Doctors, for your testimony.

My question is around artificial intelligence and the implications for our democracy. DARPA (Defense Advanced Research Projects Agency), I believe, just last week demonstrated its impressive work on creating tools for detecting deepfakes, so-called deepfakes, and the use of artificial intelligence in political communications. I'm concerned that much of the research around this area of AI has been in the defense and intelligence realms, important to be sure, but not enough is being done specifically as it relates to protecting our democracy going forward, including at the State and local level, so the use of AI in political content.

So my question is around the role of NSF, what might be done by NSF to take a more active role in researching and planning for how we better protect our democracy against nefarious uses of AI? And beyond basic research, how might NSF play a role in better preparing the American people for the misuse of AI in elections and political communications?

Dr. REED. Well, I will say this is an issue that's top of mind. In fact, I'll illustrate it with a concrete example. At the upcoming National Science Board meeting, we will have members of the Defense Department coming to talk to the collective leadership about exactly this issue, the challenges around deepfakes and the way that AI is being used by global actors to influence our political process and why it's critical that we have an understanding of how that technology works, how we can detect those actions and respond appropriately.

As the Director said a few moments ago, AI—basic research in AI goes back for decades. The expansion of that investment via the AI Institutes is about collaborative partnerships across different domains and that notion of how basic research intersects with na-

tional security. If you had told me 20 years ago that I would be inviting the National Security Advisor to come speak to the National Science Board about joint issues, it speaks to how much the world has changed and how much the basic research ideas drive this future. So it is a critical issue. We are very much committed to basic research explorations of the technology and the interactions between the government, the academic community, and where so much of this technology is taking place, in the private sector.

Dr. PANCHANATHAN. Thank you so much, Representative Mullin, for asking the question. NSF has made investments in research to ensure that we understand how technologies that allow for things like deepfakes that you talked about work and how people interact with them. So we are finding solutions, developing toolkits to be able to assist people.

Having said that, you talked about AI in general. We are very committed to ensuring that, as we are building the AI research portfolios into the future and investing in them, we are making sure that safety, security, privacy, trustworthiness, reliability, accuracy, all of that is being invested in at the same time because it takes all of the above in order for people to be able to trust the technology, deploy the technology, use the technology to its fullest ability and capacity.

The way we are doing that is we are also bringing a multidisciplinary perspective. The Chair talked about working with the Department of Defense and other agencies. But also within our own agency, we have got a crown jewel called the Social, Behavioral, Economic Sciences Research Directorate. We need to bring these things a priori, these ideas of what does it mean when you develop a technology and deploy them? And not after the fact trying to put fixes and Band-Aids, but before the fact so that we develop these technologies with responsibility, ethical use. All of this is part of our thinking.

So in our AI investments therefore, we are ensuring that explainability, understandability, ethics are all part of the threads of how we are making sure that our investments address those concerns and emerging concerns to ensure that we're providing safety, security, privacy, and trustworthiness as how we move forward into the future.

Mr. MULLIN. I appreciate the answers very much, look forward to further discussion on the matter, and I yield back.

Dr. PANCHANATHAN. Thank you, Representative Mullin.

Mr. MILLER. The gentleman yields.

With that, the Chair recognizes Mr. Frost from Florida.

Mr. FROST. Thank you, Mr. Chairman.

Dr. Reed, you included a proverb in your written testimony, "Where there's no vision, the people perish." And for my home State of Florida, that's a reality and very real. You know, my constituents, my family, my friends now face deadly storms year after year, and their lives could depend on Congress having the vision to fund the National Science Foundation's wide-ranging, comprehensive climate and resilience research.

Dr. Panchanathan, did I say that right?

Dr. PANCHANATHAN. Yes.

Mr. FROST. There we go, Panchanathan. In your March letter to the Appropriations Committee, you said that a 22 percent cut in funding would lead to the loss of 4,600 grant awards and the lost knowledge of 66,000 people pursuing STEM.

Dr. PANCHANATHAN. Yes.

Mr. FROST. In the area of resiliency research, what could come—or what could that loss of funding mean?

Dr. PANCHANATHAN. So in all areas of research, the loss of funding will have a detrimental impact in terms of being able to fund those great ideas that our researchers are proposing, our students are proposing, and losing them. We are essentially ceding our leadership by de facto. That means our international competitors can leap forward and take advantage of this moment that when we are underinvesting or not investing to the extent that our ideas and talent need to be energized.

So this is a very—I said this in the very beginning of this testimony. It's an important moment for our Nation, we really have to double down, triple down our investments to ensure that all talent and ideas are energized right here and that they contribute to solutions and they contribute to industries of the future and they contribute to the jobs of today and tomorrow right here in our country. That's a national security issue. And therefore, resiliency is part of that portfolio. You know, we have a resilient plan as one of the focus teams that we have at NSF, and that cannot be invested in at the level that we need it. We see the effects of what's happening. And in Florida, in your home State of Florida, you see that in action. And so we need to make sure that we're building resilient futures in every possible way, whether it's natural hazards, weather-related, or whether it is pandemic-related.

Mr. FROST. Yes.

Dr. PANCHANATHAN. We need to be more resilient.

Mr. FROST. Thank you. You know, in 2017, a category 5 hurricane and a cat 4 hurricane both hit Puerto Rico and Florida just 10 days apart, devastating the island and forcing many to leave their homes for good. Florida now sees multiple hurricanes hit our coastal cities each year. I actually just went to Orlovista, a community in my district where people are living in the sheds behind their homes because of the storm surge that completely took over their house, and they're still not able to move into their home.

In response, researchers at the University of Central Florida—go Knights—are using an NSF grant to study the effects of multiple landfalls on our buildings and our natural environments. We don't know where that research will lead exactly, but the results will almost certainly save lives.

Dr. Reed, would it be fair to say that a loss of funding now means that—it could mean a domino effect with the loss of life-saving knowledge in the future?

Dr. REED. It would, and I—this is a topic near and dear to my heart. Because I lived in North Carolina, I experienced the coastal effects. I actually worked on storm surge modeling as a research topic. Our ability to understand the interactions of air and water flow together with the geography and the unique characteristics of microclimates are really critical for both urban planning and for being able to manage disaster response. That's an area that, given

what we're seeing in terms of frequency of severe storms and hurricanes, is increasingly clearly critical. As you know, we run the increased risk of flooding in those areas, and rising water levels will have profound effects.

As the Director said, this is one point, example. We sometimes tend to generalize science as we invest in the exploration of the great unknown, and that's true. But the practical translation of those ideas comes down to how does it affect people's lives? How does it affect jobs? How does it affect how they live? And how do we ensure the quality of life? That's why we do science. That's why the investment is so important.

Mr. FROST. No, 100 percent. And you know, at the end of the day, when we talk about this type of work, the people who—we benefit from it as a country and as a humanity, but the people who really need this information are folks who don't have the means to leave quickly, especially during these storms.

Back to that proverb, "Where there's no vision, the people perish," you know, I think part of my job when I think about is how do we see the world through the eyes of the most vulnerable? And I truly believe that science and the work that y'all are doing and—we should continue to adequately fund and fund it even more, so that way, the most vulnerable actually have a fighting chance, especially as it relates to resiliency and the storms in the State of Florida.

And here's the thing, these storms don't care if you're Democrat or Republican, and so for me, this should not be a political issue but one about saving lives and thinking about our most vulnerable populations no matter where they're at.

So thank you for your work, and I yield back.

Mr. MILLER. The gentleman yields.

With that, the Chair recognizes Mr. Tonko for New York.

Mr. TONKO. Thank you, Mr. Chair. And thank you to our Chair Lucas and Ranking Member Lofgren for this important hearing today. And a special thanks to Dr. Panchanathan and Dr. Reed for the work that both of you are doing to ensure the success of the U.S. scientific enterprise.

It's an incredible accomplishment that the NSF has been around for over 70 years, leading our Nation as the primary source of Federal funding for fundamental research and, of course, STEM education programs. I'm deeply proud of what we accomplished in the House last year to support this work and sharpen our competitive edge on the global stage through the *CHIPS and Science Act.* To see this through, we need to ensure that America has a rich demographic, socioeconomic and geographic diversity, is well represented across our STEM workforce.

So I want to focus on the provisions in *CHIPS and Science* intended to foster diversity, equity, and inclusion in our growing STEM workforce, including new requirements, the collection of demographic data about all grant applicants. Can either of you speak, please, to the implementation of these data collection requirements and any progress that has been struck to date?

Dr. REED. Well, you've put your finger on a core issue. We can't fix something we don't know—have the data on, and so it is important that we do that. The Foundation, under the Director's leader-

ship, has invested in upgrading IT (information technology) systems to be able to improve the capture and analysis of data. And as I said a moment ago, broadly, workforce issues are top of mind for the Science Board and its partnership with the Foundation and its oversight role, how we look at these issues that span the entire spectrum of K–12 and the leaky pipeline there, to community college and those skilled technical workforce we discussed a moment earlier, through university and postgraduate education and how we look at those demographics and ensure that we have a broad and inclusive workforce.

There are actions going on at every one of those levels, both operational, for example, in terms of data analysis, but also programmatic as we look at what's working and what's not working because I think the core for data is to identify what is working and then you double down on that. There are other programs that may be less scalable or less effective. You scale those back. You shift the resources to the places you see it's making a difference. That's why the data matters.

Dr. PANCHANATHAN. Representative Tonko, an excellent question. You're addressing two computer scientists, it turns out, who believe in this concept of data-driven everything, particularly decisionmaking. So when I came to the agency, what I did was I said let's take all of the information infrastructure of the agency and make sure we empower them. And this COVID moment has taught us a lot of good lessons in terms of what it takes to build an infrastructure that makes possible harvesting data, utilizing data, and therefore allowing data base decisionmaking even more at a higher level of intensity.

Second, it's important as we are all investing and talking about investment, that those investments are clearly reaping the benefits and the rewards. We clearly know it is. It is qualitatively in many cases—we know there are many stories to be told, but we also want to establish even stronger the quantitative evidence. And the Board has been a tremendous partner in this in terms of motivating us to do that even more, as the Chair just talked about.

So let me give you a concrete example. It is not just about the talk, it's about action. So at the agency now we have launched a new Office of Business Information Technology to elevate the whole information technology infrastructure and the importance of data, the importance of analytics to the level of the Office of the Director, not just only in our sort of in-the-weeds, as important as it is, but it's got to all be managed strategically, both bottom up and top down working together so that we gather appropriate data, we have the infrastructure to process and gather the data, and we are able to visualize the data, we are able to transact with the data, we are able to make decisions based on the data, and that everything is captured and that we are working with our partner. This cannot be done by NSF alone. We have to work with our university partners that we invest in to make sure they're presenting the data. All the places where we invested, we are gathering the data so that we can measure progress and keep ourselves accountable.

Mr. TONKO. Well, I appreciate the enthusiasm from each of you.

Dr. Panchanathan, in your written testimony, you note that in Fiscal Year '24, NSF intends to prioritize both advancing research

equity and supporting the next generation of researchers. One of the principal programs in the budget under the Create Opportunities Everywhere theme is the NSF Graduate Research Fellowship Program. Many graduate students are paid at or only slightly above poverty levels. So how does the NSF work to ensure that programs aimed at creating opportunity, including the GRFP, don't further perpetuate systemic inequity in research and science?

Dr. PANCHANATHAN. Representative Tonko, an excellent question. I answered this a little while earlier. I'll expand this. When I came to the agency, I said we cannot have our Graduate Research Fellowship investments at a level where it is a disincentive. Forget about incentive, disincentive for a student to want to pursue a graduate program. So we came in, we immediately lifted our graduate stipends. We also increased the tuition remission rates. We increased the number of graduate GRFPs also. It's a very strategic, important investment, and I plead for the support of the Committee and Congress in more resources to be able to get all our ideas and talent that are—2 days ago, I was in Missouri. I had a student poster competition I was looking at—he is going to strike the gavel—looking at the students, and I'm saying if we have these kinds of students everywhere, we are done because we will outcompete any Nation, but we need the investment.

Mr. TONKO. Thank you very much. I have other questions that I'll get to the Committee, but thank you very much. And again, I appreciate the enthusiasm. I yield back.

Mr. MILLER. Thank you. The gentleman's time has expired.

With that, the Chair recognizes Hon. Mr. Issa from California.

Mr. ISSA. Thank you, Mr. Chairman. I apologize, but we had a markup in Foreign Affairs, so I'm getting a two-for, three-for type of a day.

Dr. PANCHANATHAN. No problem. We understand that.

Mr. ISSA. But I was briefed on some of the questions that were asked earlier. And, Dr. Panchanathan——

Dr. PANCHANATHAN. Yes.

Mr. ISSA [continuing]. You previously said you don't suppress information or provide disinformation or support it in any way. Is that true?

Dr. PANCHANATHAN. What I said was that we are engaging in projects that essentially bring out an understanding of what is happening with our technological investments that we are making and the technology infrastructure that is being deployed——

Mr. ISSA. OK.

Dr. PANCHANATHAN [continuing]. That we are not engaged in any censorship.

Mr. ISSA. Well, I appreciate your saying that and believing it. And by the way, I love how we say data, data, data.

Dr. PANCHANATHAN. Yes.

Mr. ISSA. Now I go—and you're both computer scientists. I studied with—when NC—National Cash Register 500's——

Dr. PANCHANATHAN. Yes.

Mr. ISSA [continuing]. Were in vogue and I ran a deck facility for the military——

Dr. PANCHANATHAN. Yes.

Mr. ISSA [continuing]. Back when Digital Corporation was a corporation.

Dr. PANCHANATHAN. A corporation, yes.

Mr. ISSA. So, as I've seen the advancement in computer science, one thing I've noted is that the old expression "garbage in, garbage out" hasn't changed. And so you're only as good as the data you have. And contrary opinions are only as good as the ability to present them with some level of equality. A data search that suppresses anyone or steers anyone in a direction, by definition, denies equal relevance to data that you agree with and disagree with. I see your heads shaking.

And for that reason, I do have to ask, for example—and I don't want to harp on it, but I brought it up in a previous hearing, the $130,000 that went to a university in China, one that the Chinese Ministry of Defense uses. It is clearly a CCP operation. Why should we believe that any money given to the Chinese Communist regime, directly or through the university structure, doesn't—and particularly when it is in support of what one might call disinformation, why should we believe that that isn't a misuse of funds, albeit a relatively small amount, but it still is one that I question? Should we go through the data and pull that kind of funding away since you have such limited funding?

Dr. PANCHANATHAN. No, Representative Issa, it is a very, very important question. As you know, in the geopolitical context that we are in today and our adversarial competitors are using asymmetric means. We have to do everything that does not allow them to take advantage of any of that.

Before we go, Representative Issa, I mentioned that the two subawards that was referenced, they don't exist anymore. We are very clear about investments, particularly in terms of our adversarial competitors and taking advantage of the investments that we make here because it has to work for the objectives of what we want in the Nation.

Mr. ISSA. Yes, and I only ask retrospectively——

Dr. PANCHANATHAN. Yes.

Mr. ISSA [continuing]. To ask have you gone through the system to make sure that, prospectively, we're not going to be back here again?

Dr. PANCHANATHAN. That's exactly what we are talking about, is to make sure that our investments are carefully reviewed, to make sure that we're putting research security strategy, policy protocols in place, and we have a number of them, Representative. We can outline that for you and return a response if that's helpful. We are making sure that we are taking every precaution. We are working very closely with the intelligence agencies, with the Defense Department, other agencies to make sure that we are not investing in those things that give advantages to our competitors or adversaries.

[A response from the National Science Foundation follows:]

NSF funds foreign entities only in exceptional circumstances and there are no current awards or subawards to Chinese entities. The NSF Office of the Chief of Research Security Strategy and Policy (OCRSSP) focuses on a data-driven approach to detect potential research and national-security related risks. OCRSSP has developed a sophisticated analytics program, using big data to identify research security issues. NSF has formed close partnerships with the intelligence and law enforce-

ment community through the National Counter-Intelligence Task Force and direct bilateral relationships to share information and to consult with the intelligence community and law enforcement on potential security risks.

Furthermore, NSF has just made policy in the 2024 Proposals and Awards Policies and Procedures Guide in which an NSF proposal can fail to be accepted or returned without review by NSF if it ″has the potential to negatively impact research security and integrity due to credible information of a national security concern.″ Note, this decision-making process will be informed by OCRSSP's aforementioned data analytics process, as well as a forthcoming risk rubric.

Mr. ISSA. OK. And maybe one additional example that I'd like to have you come in on, it's an NSF video with Professor Michael Wagner, Wagner or Wagner, of the University of Wisconsin, Madison. They've received millions of dollars. This is not a small grant. And one of the quotes was that—they say it's not censorship, but he says in the in the video, "Course Correct is trying to nudge us in a direction of understanding and agreeing upon verifiable truth." Now that sounds pretty benign, but realistically, he wants to course correct to his truth. Is that good implementation of science, or is that exactly what you must guard against? We fund programs to people who have opinions, but a course correct that essentially denies or moves people toward just one, is that inconsistent with the NSF role?

Dr. PANCHANATHAN. NSF invests in those things that—you use the word understanding. Understanding is what we invest in and not a specific philosophy or a specific kind of—what you're offering to us, any biases that might be there. That's not what NSF invests in. NSF invests in—to the point that you make—to understand and, therefore, the real issues can be therefore brought up, and policymakers will make the determination in terms of what guardrails we may have to put in place, et cetera. But our objective in terms of investments is to get the understanding.

Mr. ISSA. And last question, if I could, Mr. Chairman, very briefly, your graduate program that you just increased the funding for and would like more for, does it include Chinese nationals here in any way? Is it exclusively to those who would, by definition, be able to remain here in the United States afterwards to the benefit of our country?

Dr. PANCHANATHAN. The Graduate Research Fellowship Program invests in U.S. citizens——

Mr. ISSA. I wanted to make that clear——

Dr. PANCHANATHAN [continuing]. People who are here.

Mr. ISSA [continuing]. And I want to thank you——

Dr. PANCHANATHAN. Yes.

Mr. ISSA [continuing]. Because I think it's so important that we look at the retention of our investments.

Dr. PANCHANATHAN. Yes, exactly.

Mr. ISSA. Mr. Chairman, thank you for your indulgence, and I yield back.

Mr. MILLER. The gentleman's time is expired.

I thank the witnesses for their valuable testimony and the Members for their questions. The record will remain open for 10 days for additional comments and written questions from the Members.

This hearing is adjourned. Thank you.

[Whereupon, at 12:32 p.m., the Committee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Sethuraman Panchanathan

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
FULL COMMITTEE
Hearing on
An Overview of the Budget Proposal for the National Science Foundation for Fiscal Year 2024

April 26, 2023

Dr. Sethuraman Panchanathan, Director

Questions for the Record Submitted by Rep. Frank D. Lucas

MICROELECTRONICS WORKFORCE DEVELOPMENT

Question: The CHIPS and Science Act provides NSF with $200 million in appropriated funding over five years for microelectronics workforce development activities. How does NSF plan to spend this money for workforce development?

Answer: As part of Creating Helpful Incentives to Produce Semiconductors and Science Act (CHIPS) (P.L. 117-167), Congress provided NSF $200.0 million over five years to establish a fund "for microelectronics workforce development activities." NSF previously transmitted FY 2023 plans for the first year provided by CHIPS (FY 2023), accounting for $25.0 million of the total $200.0 million appropriation. Specifically, it described specific investments in workforce development, including scalable partnerships with the private sector to enhance the skilled semiconductor manufacturing workforce. These plans are summarized in the table below.

Select Programs Addressing Microelectronics and Semiconductors Workforce Development	**NSF CHIPS Funding in FY 2023 (Dollars in millions)**
NSF-Intel and NSF-Micron Workforce Development Programs – invests in (i) enhancing industry-relevant, rigorous, engaging curriculum; (ii) providing teacher professional development to help prepare teachers to teach to this new curriculum; and (iii) enabling experiential learning opportunities, including internships and apprenticeships, to complement classroom instruction with practical experiences. This investment includes a particular focus on community colleges and minority-serving institutions.	$10.0 (To be leveraged by an additional $10.0 from Intel and Micron)
Future of Semiconductors (FuSe) – invests in graduate students focused on the frontiers of semiconductor design and manufacturing broadly.	$6.0
Computer and Information Science and Engineering Graduate Fellowships (CSGrad4US), NSF Research Traineeships (NRT), and Centers for Research Excellence in Science and Technology (CREST) – invests in graduate students and postdoctoral fellows in specific fields at the foundation for semiconductor design and manufacturing.	$9.0
TOTAL	**$25.0**

As NSF looks to the future, it considers the investments in FY 2023 and FY 2024 as part of a long-term strategy to leverage the CHIPS for America Workforce and Education Fund to train upwards of 100,000 new semiconductor researchers, practitioners, technicians, and educators, fulfilling a key need of the semiconductor industry through FY 2027 and beyond.

NSF anticipates pursuing a strategic investment that brings together academia, industry, and government, with a particular focus on community colleges as well as Historically Black Colleges and

Universities (HBCUs) and other Minority-Serving Institutions (MSIs). Through intentional cross-sector engagement and partnerships, such an investment would aim to grow capacity to "meet people where they are," in turn reducing workforce barriers and improving workforce outcomes in microelectronics. The investment will:

- Offer a proving ground for practicable, evidence-based, industry-aware curricula leading to new certificates, credentials, and degree programs spanning secondary schools, two-year colleges, and MSIs across all 50 states, the District of Columbia, and U.S. territories.
- Enhance industry and career awareness, develop professional and technical skills, and provide work-based, experiential learning experiences that inspire prospective students to enroll in industry-related programs at community colleges and four-year universities.
- Present comprehensive, mapped educational pathways related to the current and future needs of employers, including by expanding on-the-job training opportunities via apprenticeships and internships.
- Develop specialized pathways, workforce, and R&D opportunities, focusing on historically underrepresented groups (e.g., low-income, people of color, women, veterans).
- Develop the necessary teacher and faculty professional development on the latest technology trends and curricular offerings.
- Catalogue and leverage existing recruiting and retention programs in STEM and beyond.

With $25.0 million proposed in the FY 2024 President's Budget, NSF would initiate the above investment, working toward a national network for semiconductor workforce development that unites institutions of higher education, including community colleges and MSIs as well as secondary schools at a national scale. Future investments in FY 2025-FY 2027 would leverage and expand upon these efforts.

RESEARCH SECURITY

Question: Since 1996, Chinese researchers have been building relationships with Chilean universities and gaining access to research time at NSF-led facilities in Chile. Given concerns surrounding threats to research security, how is NSF considering national security and research integrity when it comes to international facilities like the Vera C. Rubin Observatory and the proposed U.S. Extremely Large Telescope Program?

Answer: NSF is aware of and has been monitoring the growth of Chinese investments in Chilean universities and associated relationships. We have been in touch with the U.S. Embassy in Chile to share information over the past 2-3 years, and our awardees closely monitor Chinese access to research time through Chilean channels. Most access is through delivered astronomical data, not physical or virtual access to the sites or equipment. Any access to the site is closely managed following International Traffic in Arms (ITAR) regulations.

NSF is coordinating with the Department of Energy (DOE) and other U.S. government agencies regarding the national security and research integrity aspects of the Vera C. Rubin Observatory operations, which are scheduled to begin in 2025. Appropriate physical and data security measures are being agreed upon through multi-agency discussions. Similar discussions will take place as planning for NSF participation in the U.S. Extremely Large Telescopes advances.

Questions for the Record Submitted by
Rep. Zoe Lofgren

FUSION ENERGY TECHNOLOGIES

As you may know, I have a strong interest in accelerating the development of fusion energy technologies, and I was very happy to see a substantial boost for fusion proposed in the President's budget request for the Department of Energy. I do not expect NSF to match DOE's support for research in this area, but there is a gap when it comes to science education and workforce development that I believe the Foundation could be especially helpful in addressing. In particular, I do not believe there is any specific program within DOE that would support fusion curriculum development at community colleges or even universities.

Question: Is this an area that NSF would be willing and able to work with DOE to ensure that this emerging clean energy industry will have the workforce it needs in the years to come?

Answer: Multiple areas across NSF support the development and understanding of the basic science and engineering principles underlying fusion energy technologies. These cover a broad range of disciplines including plasma physics, nuclear physics, materials research, optics, electrical engineering, etc. The research supported through these various programs serves as the primary platform for training the next generation advanced workforce in this area through the inclusion of undergraduate students, graduate students, and postdocs within the award packages. Graduates of these programs have gone on to fill multiple positions in industry, academia, and the national laboratories. As opportunities in the fusion energy area grow with increased investment, it is expected that these programs will continue to serve as a key source of needed talent.

NSF and DOE have a long history of working together in the fields of plasma physics and nuclear physics. For over two decades the Directorates for Mathematical and Physical Sciences (MPS), Geosciences (GEO), and Engineering (ENG), together with the DOE Office of Fusion Energy Sciences, have sponsored the NSF/DOE Partnership in Basic Plasma Science and Engineering. This program has coordinated support for plasma physics in the US and heightened its visibility in academia. NSF and DOE efforts in Nuclear Physics are coordinated through regular meetings and through a collective response to the recommendations of the joint Nuclear Science Advisory Committee (NSAC). Both these platforms can serve as a starting point for efforts that can be expanded to include both the Directorates for STEM Education (EDU) and Translation, Innovation, and Partnerships (TIP) as needs are identified.

Question: I understand that NSF currently stewards several programs that could be relevant to this effort - including the Advanced Technology Education program, the Experiential Learning for Emerging and Novel Technologies program, and the Industry-University Cooperative Research Centers program. Would you be supportive of extending the scope of these programs to better support the development of a vibrant fusion energy workforce?

Answer: The programs noted above welcome proposals from all key technology and challenge areas called out in Section 10387 of the CHIPS and Science Act. One of these areas is, "Advanced energy and industrial efficiency technologies, such as batteries and advanced nuclear technologies, including but not limited to for the purposes of electric generation (consistent with section 15 of the National Science Foundation Act of 1950 (42 U.S.C. 1874)." We therefore welcome proposals from the community along these lines, and they would be reviewed consistent with NSF's merit review policies and practices.

CONSTRUCTION OF LARGE FACILITIES

In the last decade, NSF has come a long way in strengthening budgeting, management, and oversight for construction of its large facilities. It was a priority oversight topic for this committee several years ago, and we enacted several new requirements in the American Innovation and Competitiveness Act of 2017. However, other challenges remain. In particular, NSF still falls short on lifecycle planning for facilities even as operations costs continue to increase with increasingly

sophisticated facilities. Some believe the Astronomy division is near a breaking point because of the pressure the operations budget puts on the research budget. Different solutions have been proposed, having a budget line in the MREFC account for operations. Different approaches have different pros and cons.

Question: What steps are you taking to find solutions to this challenge, and how are you learning from how other agencies like NASA approach lifecycle planning and budgeting?

Answer: NSF continues to responsibly manage the operations and maintenance (O&M) costs of its large facilities through careful oversight and thoughtful consideration of the interplay between support for research infrastructure and support for scientific studies using that infrastructure. O&M budgets are reviewed annually to ensure that efforts are aligned with the highest priority goals for each facility. NSF is also implementing new requirements for the facilities, such as regular, formal facility condition assessments, that aid in budgeting for maintenance costs. In response to a recent audit by NSF's OIG ("Audit of NSF's Divestment of Major Facilities", OIG 22-2-006, issued September 2, 2022), NSF is developing methodology for determining credible life-cycle cost estimates. NSF consults with other agencies, such as NASA and DOE, on many research infrastructure topics through formal channels, such as the NSTC Research and Development Infrastructure subcommittee, and through informal networks.

Questions for the Record Submitted by
Rep. Brian Babin

INTERNATIONAL OCEAN DISCOVERY PROGRAM

Question: I want to follow up on the IODP annual budget question in hopes of getting a fuller answer to the question. The FY24 NSF budget justification document proposes an annual budget of $52.77 million for the International Ocean Discovery Program (IODP) over the next 6 years. Given that operational costs for a drilling ship, Joides Resolution (JR), constitutes the bulk of IODP funding, and your budget justification document proposes to end JR operations in FY24, what does NSF intend to do with that $52.77 million in years FY25-FY29?

Answer: While NSF is ending support for operation of the JOIDES Resolution (JR) in support of the International Ocean Discovery Program (IODP), research activities are expected to continue as will out-year costs to provide critical infrastructure to enable those research activities. The out-years estimate assumes costs remain steady at the FY 2024 President's Budget level of $52.77 million.

As the JR is demobilized, there will be costs associated with the decommissioning of the JR, closing out the current award, and the transfer and recommissioning of instrumentation currently onboard the vessel. In the post-JR IODP, drilling-based research will continue, using other international assets and through NSF's provision of alternate mission-specific drilling platforms. Ending the current cooperative agreement that provides access to the JR marks a transition in IODP support, but not the end of the program.

Question: Following up on questions raised during our hearing about the International Ocean Discovery Program (IODP), it appears that NSF has no plan for the future of this program and thus will be deliberating on next steps. Given that the operational life of the Joides Resolution (JR) is still four years out, wouldn't it make sense to extend operations of this vessel to minimize the gap in U.S. ocean drilling capabilities? What level of funding is required from Congress to extend the JR an additional four years, with the full contingent of missions previously planned, so that the U.S. doesn't fall behind China and other nations in this research?

Answer: NSF will continue to support meritorious research proposals from the U.S. scientific ocean drilling community and is committed to supporting cutting-edge science along with the tools and workforce that make it possible. NSF is taking this time to work with the community to envision what the future of scientific ocean drilling might look like. In the post-JR IODP, drilling-based research will continue using other international assets as available and through NSF's provision of alternate mission-specific drilling platforms. Ending the current cooperative agreement that provides access to the JR marks a transition in IODP support, but not the end of scientific ocean drilling.

The shift in priorities of international partners impacts both the operation of the JR and the scientific support necessary for utilization of the vessel. Any future operation of the drill ship would also have to be accompanied by planning efforts for a future program, given the expiration of the Environmental Impact Statement of the JR in 2028. The FY 2024 Request includes $52.77 million for JR operations, but the total operating budget of the vessel is $72.0 million including international contributions. Scientific support from NSF totals $20.60 million in 2024 with an additional $41.20 million from international partners. A U.S. program comparable to the existing IODP would cost approximately $136 million for FY 2025 not including potential international contributions; roughly $72 million in direct operations, $62 million in science support to fully utilize the ship, and $2-3 million for planning the future post-JR program.

Question: What is the shortfall dollar amount that the U.S. would need to "fill" due to an anticipated decline in foreign contributions for the IODP program? How has China's departure from the IODP program, to pursue their own ocean drilling program, complicated matters from a national security perspective?

Answer: The shift in priorities of international partners impacts both the operation of the JR and the scientific support necessary for successful utilization of the vessel. Any future operation of the drill ship

must also be accompanied by planning efforts for a future program, given the expiration of the Environmental Impact Statement of the JR in 2028. If foreign contributions were eliminated, a U.S. program comparable to the existing IODP, would cost approximately $136 million per year.

Nearly all the international partners in IODP have indicated a shift in priorities away from support for the JR; as such, China's departure is not unique. Current understanding of the capabilities of the anticipated Chinese drill ship, which appears to have been built for industry and research purposes, indicate limitations in dynamic positioning, a critical component for a globally ranging vessel.

Unlike virtually all large commercial drilling vessels built in the last 50+ years, which use an automatic station-keeping system, the Chinese ship uses anchor wire to maintain position through a system of 4 mooring winches and 8 anchor wires. The rationale for using this anchored system is unclear as it requires tender vessels to assist in setting and retrieving anchors and anchor wire, and thus significantly inhibits vessel mobility from drilling site to drilling site.

Also, the Chinese drill ship does not carry its 5000-foot marine riser. The riser is a complex that enables a closed system from the borehole to the drill ship during drilling, thus providing significant control over borehole conditions and enabling safety control during oil and gas drilling. In contrast, a modern drill ship carries its own drill string and riser system. Instead, the new Chinese vessel requires tender ships to carry its riser, severely limiting vessel ability.

Finally, it is unclear how much opportunity there will be for use of the drill ship by Chinese scientists or the international science community. From questioning of representatives from the China IODP Office, it is likely that the ship would not be available every year and would likely be limited in duration. Similar questioning has indicated that a major design objective of the ship is to prospect for gas hydrate deposits in the South China Sea region and nearby seas. The design concepts limiting vessel mobility, as identified above, further indicate that this vessel is not designed to be a drilling vessel with global reach but, instead, designed to work primarily in the South China Sea area, as this limited mobility prevents practical use much beyond this area.

Question: During the hearing, it was stated several times that NSF needs to "engage early career scientists" and "hear from the community" on the future of the IOPD program. I would like to draw your attention to two attached documents. The first is a letter signed by 2,213 international scientists and stakeholders -- including 855 U.S. signatures across 50 states and the District of Columbia -- underscoring the importance of scientific ocean drilling and the future direction outlined in the 2050 Science Framework. The scientific community calls for a "bridging program" over FY24-FY28 by extending the Joides Resolution combined with the lease or acquisition of new U.S. drilling vessel. The second document is a letter signed by 208 early career scientists calling for that exact same plan, in an effort to bridge the current program with a new scientific ocean drilling program. What additional issues/limitations does NSF need to address in order to proceed with such recommendation from those two sources, representing a community of career scientists. What resources do you need from Congress to carry out this direction?

Answer: NSF is grateful for the input and is engaging with the community on a variety of fronts to take full advantage of existing research samples and to envision the future of scientific ocean drilling.

The shift in priorities of international partners impacts both the operation of the JR and the scientific support necessary for successful utilization of the vessel. Any future operation of the drill ship must also be accompanied by supported planning efforts, given the expiration of the Environmental Impact Statement of the JR in 2028.

Rather than continuing to dedicate limited resources to a few additional years of JR operations, NSF has judged that, in the long run, those resources are better spent on planning for the future of scientific ocean drilling, leveraging a diversity of tools through alternative drilling platforms and technologies, and

capitalizing on the wealth of information stored in the already-retrieved cores accessible through the instrumented core repositories in Texas, Japan, and Germany. NSF issued a Dear Colleague Letter in March (NSF 23-070) encouraging the community to submit proposals utilizing the cores in the three core repositories supported by NSF and international partners. These cores and their existing data repositories represent decades of effort and can continue to yield impactful scientific results.

Additionally, NSF has asked the National Academies of Science, Engineering, and Medicine to conduct the 2025-2035 Decadal Survey of Ocean Sciences for the National Science Foundation, with an interim report that will specifically address high priority research questions requiring scientific ocean drilling. We also anticipate supporting workshops to engage researchers, including early career scientists, to explore future scientific ocean drilling objectives, new approaches in methodology and platforms, and international engagement.

NSF will continue to support research of the US scientific ocean drilling community and is committed to supporting cutting-edge science along with the tools and workforce that make it possible. The JR has been the mainstay of the international scientific ocean drilling program for decades, so it's understandable that there are concerns with the non-renewal. However, with evolving technologies, we have the opportunity to think more broadly about how to address those scientific questions that can only be explored through scientific ocean drilling.

Questions for the Record Submitted by
Rep. Rick Crawford

RESEARCH SECURITY

Question: Congress authorized a number of research security activities in the CHIPS and Science Act. What actions has the NSF taken to begin implementing these new authorizations for research security activities? What additional action can and should U.S. government agencies funding research and development programs at U.S. universities do to protect taxpayer dollars and investments from ending up in the hands of competitor nations?

Answer: The Office of the Chief of Research Security Strategy and Policy (OCRSSP) has begun implementing multiple research security-related activities as required under the CHIPS and Science Act, including:

- Working to establish the Research Security and Integrity Information Sharing and Analysis Organization (RSI-ISAO) as required in Sec. 10338 of the CHIPS and Science Act, including scoping the RSI-ISAO remit; conducting stakeholder engagement, publishing a dear colleague letter (NSF 23-098), and conducting webinars to ensure the services provided by the RSI-ISAO are aligned with the needs of the research community; drafting the solicitation; and notional planning for the development of the USG steering committee which will interact and steer policy for the RSI-ISAO; among other activities.
- Planning for the foreign financial reporting requirements as required in Sec. 10339B of the CHIPS and Science Act, including coordinating with the U.S. Department of Education on their foreign financial support requirement under Section 117 of the Higher Education Act of 1965; working to develop the IT system that the research community will submit this information to NSF on an annual basis; and coordinating with other USG agencies to begin strategizing on how OCRSSP will utilize this information.
- Included the malign foreign talent program prohibition in the new Proposal and Award Policies and Procedures Guide (PAPPG) that is currently out for public comment.
- Developing research security training that will be required for researchers. Training modules will be complete by December 2023.

OCRSSP focuses on a data-driven approach to research security. OCRSSP has developed a sophisticated analytics program, using big data to identify research security issues. Furthermore, NSF has formed close partnerships with the intelligence and law enforcement community to streamline information sharing and capitalize on tools to identify research security risks. NSF is demonstrating its research security analytics tools to other U.S. Government agencies. NSF believes that coordinated interagency use of analytics tools and increased information-sharing on risks that are identified could greatly assist the research community in addressing research security risks.

Question: Has the NSF implemented the ban on funding going to any institutions that host Confucius Institutes on their campus, as directed in the CHIPS and Science Act?

Answer: The CHIPs and Science Act states that NSF shall implement this prohibition "the first fiscal year that begins after the date that is two years after the date of the enactment of this Act." Given the importance of this issue, NSF is exploring the possibility of implementing the prohibition earlier than this time. NSF would be pleased to provide updates as the process is developed.

Question: What kind of processes has NSF stood up, through their Research Security Office, to identify, track, and address concerning activity? Have you seen a dramatic increase in incidents over the past 4 years and do you feel the Academic Research Community is beginning to take this threat more seriously?

Answer: The Office of the Chief of Research Security Strategy and Policy (OCRSSP) has stood up a Data Analytics Program, which identifies potential foreign interference utilizing academic literature from multiple sources as well as international patent databases to determine the extent of interactions between

NSF-funded researchers and researchers located abroad. OCRSSP shares the resulting information with NSF staff and disseminates it to the interagency community in a limited capacity as appropriate.

OCRSSP cannot attest to whether there has been a dramatic increase in incidents over the past four years, since OCRSSP is in the process of scaling up its analytics capabilities; however, the Academic Research Community is beginning to take this threat more seriously. OCRSSP has been diligently focusing on building relationships with the research community to partner with them to understand, address, and mitigate research security risks. As a result, many universities have proactively come to NSF to work together to address research security issues they have identified, including pursuing corrective action plans and removing and replacing principal investigators (PIs), among other activities.

Questions for the Record Submitted by
Rep. Valerie Foushee

EPSCOR PROGRAM

Question: Dr. Panchanathan, NSF has long standing programs to support specific geographies in the U.S., particularly the EPSCoR program. CHIPS & Science enacted provisions that will notably grow EPSCoR, potentially at the detriment of emerging research institutions in different geographies. To negate that impact, the law says that NSF should ensure that ERIs not in those specific jurisdictions are also supported. What is NSF doing to carry out that provision?

Answer: 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. In FY 2024, NSF's proposed Create Opportunities Everywhere (COE) investments would take a comprehensive, whole-of-NSF approach for attracting, supporting, and advancing groups underrepresented in STEM as well as providing opportunities to all individuals regardless of their location, institution, or organization type. The CHIPS and Science Act, while directing increases of the share of NSF's funding to EPSCoR jurisdictions reinforces NSF's multi-pronged COE strategy to (1) address research equity, (2) build capacity, (3) foster collaborations and partnerships, and (4) support the next generation of researchers. COE would expand access and inclusion in STEM along individual, institutional, and geographic lines.

NSF continues to explore activities to implement the CHIPS and Science Act, particularly in fostering research capacity-building at emerging research institutions (as defined in the CHIPS and Science Act. With that being said, as part of planned activities and complementary to CHIPS and Science Act provisions, in FY 2023, NSF launched the Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED) initiative. GRANTED supports emerging research institutions (ERIs), including minority-serving institutions, and aims to mitigate the barriers to competitiveness within the Nation's research enterprise at underserved institutions. In FY 2024, GRANTED activities will support the enhancement of research administration and post-award management, the implementation of effective practices for competitive proposal development, partnership development, and broad sharing of new and existing effective practices to providing support for a variety of research areas within the research enterprise. GRANTED mechanisms will focus on delivering knowledge and services to train investigators at all levels, including early career investigators (assistant professors, postdocs, graduate students, undergraduates), in research and program idea development, grant writing and proposal development, grant/award management, research team development and cultivation, and collaboration and partnership development.

Activities supported by GRANTED may include,

- Improving the Nation's research support and service capacity at emerging and underserved research institutions.
- Partnering with national and regional professional societies to grow the Nation's research capacity within underserved communities and institutions.
- Facilitating the development of leadership in research administration as well as enhancing institutional research administrative and research support infrastructure.
- Addressing a systemic barrier to participation: the lack of professional resources to assist faculty with proposal development, submission, and award management.

Questions for the Record Submitted by
Rep. Suzanne Bonamici

U.S. ANTARCTIC PROGRAM

The U.S. Antarctic Program has come under fire – including in this Committee – for inadequately protecting scientists and contract employees from sexual harassment and assault. I've worked on this issue with NOAA. I've been to McMurdo Station. And I'm very alarmed. Last year's SAHPR [SAPPER] report contains disturbing accounts of harassment and assault and generally describes a toxic environment that permits such behavior and does not hold perpetrators accountable. It is clear from that report – and from Leidos's testimony before this Committee in December – that the prime contractor operating the USAP has been failing those doing important work in Antarctica. It's my understanding that the NSF OIG – who is doing important work on this topic – has had trouble getting Leidos employees to fully cooperate, and that the Agency needed to step in to address this issue.

Question: Please tell us what happened and how NSF will continue to provide the OIG with unfettered access to the resources and people it needs to complete its work.

Answer: NSF received some reports about unclear guidance from the Antarctic Support Contractor (ASC) regarding the participation of their staff in office hours when representatives of NSF's Office of the Inspector General (OIG) visited Antarctica or other ASC locations. NSF verbally reminded ASC of its legal obligation (under Federal Acquisition Regulations) to cooperate with OIG, and also proactively communicated with ASC employees to encourage them to participate in OIG office hours. NSF employees continue to work directly with OIG to support OIG's suite of SAHPR-related activities.

Questions for the Record Submitted by
Rep. Eric Sorensen

ASTRO2020 RECOMMENDATION TO IMPROVE COORDINATION AMONG U.S. DATA ARCHIVE CENTERS

Statement: I want to thank Chairman Lucas and Ranking Member Lofgren for convening this hearing and our witnesses for their willingness to appear before us today. I have spent my whole career in the STEM field. Much of what I have accomplished would not have been possible without interagency collaboration at the federal level. 1. As a general rule, federally-funded astronomical telescopes are primarily funded either by NSF, if they are ground-based observatories, or by NASA, if they are space-based. The most recent decadal survey for astronomy and astrophysics, or Astro2020, recommended that NSF and NASA should explore mechanisms to improve coordination among U.S. data archive centers hosting ground- and space-based data to "create a centralized nexus for interacting with the international archive communities."

Question: Has NSF begun working with NASA to implement this recommendation? How would improving the coordination and collaboration across ground- and space-based data sources improve the scientific return on our investments in these facilities? What are the biggest challenges in working across ground- and space-based astronomical data?

Answer: Yes, NSF and NASA have reinvigorated their ongoing discussions and coordination of data management, access, and utilization. There have been ongoing discussions about coordination between the Vera C. Rubin Observatory data and tools and those of the planned Nancy Grace Roman Space Telescope at NASA. More recently, NSF and NASA organized a joint workshop in February 2023, in collaboration with the Simons foundation, to explore ways that the community can work together (https://aas.org/posts/news/2022/12/future-astrophysical-data-infrastructure-workshop).

Both NSF and NASA have several stakeholders involved in this effort: telescopes, data centers, universities, and individual developers and contributors. Also, regarding time domain astronomy, the conversation between NSF and NASA is building on two recent workshops related to this field: NSF's 2018 workshop "Multi-messenger Astrophysics: Harnessing the Data Revolution" (https://arxiv.org/pdf/1807.04780.pdf) and NASA's 2022 workshop "The Dynamic Universe: realizing the science potential of Time Domain and Multi-Messenger Astrophysics" (https://pcos.gsfc.nasa.gov/TDAMM/docs/TDAMM_Report.pdf). Finally, NSF and NASA are organizing a joint workshop, to be held in October 2023, to coordinate the development of technology and astronomical instrumentation.

Overall, a closer collaboration between NSF and NASA would increase the scientific productivity in many ways, by offering unprecedented opportunities to observe elusive astronomical phenomena from space and from the ground with a suite of complementary instruments and at different wavelengths, by reducing duplication of effort and producing higher quality data analysis tools, and by supporting technological innovation.

In most cases, a major obstacle to effective collaboration is related to the funding models, which are largely based on individual projects. Single mission funding creates silos, sometimes making it difficult to collaborate with other missions. Another obstacle is related to the fluctuating nature of funding: it is difficult to establish long-term collaborations based on yearly budget cycles. Finally, the structural differences between the two agencies in relation to processes and policies can make aligning activities challenging.

PROMOTING INCLUSION OF UNDERREPRESENTED POPULATIONS

Question: Before coming to Congress, I served my community as the local weatherman for over two decades. As you know, LGBTQ+ and women's involvement in STEM, while improving, is not at proportional parity with their straight male counterparts. We know that representation is critical

to show future generations they can be anything they want to be. One of NSF's stated priorities is to bring underrepresented groups into the STEM community. What is the NSF doing to promote inclusion of these underrepresented populations?

Answer: 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. In FY 2024, NSF's proposed Create Opportunities Everywhere (COE) investments would take a comprehensive, whole-of-NSF approach for attracting, supporting, and advancing groups underrepresented in STEM as well as providing opportunities to all individuals regardless of their location, institution, or organization type. NSF's strategy for COE will (1) address research equity, (2) build capacity, (3) foster collaborations and partnerships, and (4) support the next generation of researchers. COE will expand access and inclusion in STEM along individual, institutional, and geographic lines.

The COE strategy leverages NSF's Equity Ecosystem, which is organized into four separate, but interrelated, streams: (1) Broadening participation (BP) activities that seek to increase diversity and participation in the STEM enterprise overall;[1] (2) the Missing Millions, closing representation and resource gaps; (3) Equity in program delivery, ensuring that NSF incorporates DEIA principles into the work that it does in this community;[2] and (4) Internal DEIA for employees and employment applicants[3].

Through NSF's proposed COE investments in FY 2024, NSF would take a multi-level, systemic approach to improve the representation of women, underrepresented racial and ethnic minorities, and persons with disabilities in research, STEM learning, and the STEM workforce. This approach has been informed by numerous stakeholders including the National Science Board (NSB) and the congressionally mandated advisory committee, Committee on Equal Opportunities in Science and Engineering (CEOSE)[4].

- For example, NSF is implementing two resolutions of the NSB to help address the issue of Missing Millions: (1) training to improve peer-reviewing in the merit review process and (2) Broader Impacts experts to serve on Committees of Visitors. Additionally, NSF is developing goals and metrics related to inspiring the Missing Millions; for example, populations identified as missing are included in performance target for the current Agency Priority Goal.

NSF is committed to expanding equal opportunity in STEM through safe and inclusive research environments. To that end, NSF has developed an award term and condition addressing sexual assault, and sexual and other forms of harassment, as well as anti-harassment proposal requirements for NSF funded conferences, travel, research experiences for undergraduates and remote research sites. NSF also conducts pre- and post-award compliance reviews to ensure recipients of NSF research funds comply with civil rights laws and regulations.

ELECTROMAGNETIC SPECTRUM MANAGEMENT

NSF's electromagnetic spectrum management activities help ensure the continued access of the scientific community to portions of the radio spectrum that are needed for research, especially for radio astronomy and passive and active Earth remote sensing for climate and weather research.

Question: How does NSF work with other federal agencies, like NASA and NOAA, with shared equities for scientific uses of spectrum? What are the biggest challenges for the interagency processes in keeping the portions of the radio spectrum protected for scientific purposes free from harmful interference?

Answer: NSF participates in both national and international formal spectrum management processes and venues with NASA, NOAA and other federal agencies. Additionally, NSF works directly with its sister scientific agencies toward shared goals and solutions for similar and common spectrum needs. Formal

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[1] NSF Broadening Participation Portfolio: https://beta.nsf.gov/funding/initiatives/broadening-participation
[2] NSF Equity Action Plan https://nsf.gov/equity/index.jsp
[3] NSF DEIA Strategic Plan www.nsf.gov/od/oecr/reports/DEIA_Strategic_Plan_2022.pdf
[4] new.nsf.gov/od/oia/ceose

interactions include the National Telecommunications and Information Administration's Interdepartmental Radio Advisory Committee (IRAC) and preparations for the International Telecommunication Union (ITU) World Radio Conference (WRC), including regional Inter-American Telecommunication Commission (CITEL) meetings. NSF participates in the ITU Study Groups, especially Study Group 7 (Science Services). NSF serves as the U.S. Head of Delegation for ITU Working Party 7D (radio astronomy), while NASA serves in this role for Working Party 7C (Earth sensing). NSF works closely in these forums with NASA and NOAA, especially regarding technical preparations. NSF and NASA co-sponsor the National Academies of Sciences, Engineering, and Medicine Committee on Radio Frequencies (CORF).

NTIA works closely with NSF to represent scientific interests. A challenge for scientific services in the interagency processes is the increasing demand for spectrum, the sheer volume and cadence of proposals for new spectrum entrants, and the lack of specificity in many cases. To determine appropriate spectrum protection for each new proposed usage, generalized models are not enough: careful technical analysis must be conducted specific to the application, its location, local terrain, and weather conditions, followed by in-the-field testing and verification. Adequate analysis and tests take significant time and resources. Scientific services are generally many orders of magnitude more sensitive than typical telecommunication devices, making them more vulnerable to out-of-band and aggregate emissions. Finally, the benefits of scientific usage of the spectrum to society are often harder to quantify and are thus not adequately represented.

Question: How does the FY2024 budget request support NSF's work in advancing concepts and technologies for dynamic spectrum sharing?

Answer: The FY2024 budget request proposes investment in concepts and technologies for dynamic spectrum sharing in multiple categories. Foundational programs in the Directorate for Computer Information Science and Engineering (CISE) and the Directorate for Engineering (ENG) support fundamental advanced wireless research that helps future communications systems operate more effectively in shared spectrum and to operate across multiple spectrum bands. The NSF Platforms for Advanced Wireless Research (PAWR) program supports testbeds that enable researchers to experiment over-the-air with innovative spectrum dependent systems. In FY 2024 proposed experiments at PAWR sites include early proofs of concept of dynamic spectrum sharing. Finally, the multi-disciplinary, NSF-wide Spectrum Innovation Initiative (SII) includes four thrusts relevant for dynamic spectrum sharing:

- The National Radio Dynamic Zones program (SII-NRDZ) supports development of concepts and infrastructure for innovative methods of sharing spectrum between activities inside a defined zone such as a federal facility or wireless testbed and activities outside the zone. In FY 2024, proposed SII-NRDZ investments continue study of sharing mechanisms among heterogeneous services (passive science, active sensors such as radars, and communications) and initiate engineering work and planning for the first program field trial scheduled for FY 2025.
- Continued investment in the National Center for Wireless Spectrum Research (SII-Center) supports multiple collaborative research projects in spectrum sharing.
- Investment in SII Integration Activities support integration of spectrum science including dynamic spectrum sharing into NSF programs across the directorates, such as the coexistence between satellites and terrestrial systems (SWIFT-SAT).
- SII Education and Workforce Development investments include graduate research fellowships on topics related to dynamic spectrum sharing.

Climate Communication

Question: As the first meteorologist in Congress in nearly 50 years, I pride myself on being a climate communicator. I have been talking about climate for decades. The NSF contributes significantly to climate science research. How can Congress assist the NSF in bolstering their communication efforts to the public about the environmental impacts and research they fund?

Answer: As you know, communicating science plays a critical role in conveying scientific discoveries and innovations to non-scientists in terms they can understand and which connect them to the world around

them. NSF believes that innovation can happen anywhere, and innovators are everywhere. It is important to bring all sectors of society into this discussion in order to help them realize the economic benefits that come from funding science and technology and the role they can play. The NSF Director has been traveling around the country with Congressional Members from both the House and Senate to do just this; communicate the benefits of NSF funding in their districts and states and to create excitement around discovery science. NSF plans to continue this effort and would be happy to work with you in this regard. For example, the NSF-funded AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES) recently had major press coverage regarding the aviation industry's use of its weather models. (www.ai2es.org/ai2es-on-cbs-news/).

The work of Congress is vital in providing the sustained policies and funding that continue to keep the United States a global leader in science and technology, and this sustained support will help NSF and Congress continue to communicate the benefits of research to a wide audience.

Question a: Relatedly, I have been talking about climate for decades in a way that Americans of all walks of life can relate to. How can Congress and I help NSF relay their research results to Americans of all backgrounds?

Answer: See response above.

Questions for the Record Submitted by
Rep. Jennifer McClellan

Graduate Research Fellowship Program

As defined by the National Science Foundation, the purpose of the Graduate Research Fellowship Program (GRFP) is to "ensure the quality, vitality, and diversity of the scientific and engineering workforce of the United States." Although this program is highly respected in its ability to support students pursuing graduate degrees in STEM, there are many consistent, troubling problems in the distribution of its fellowship awards. For one thing, the fellowship tends to only be awarded to certain types of students, generally those coming from well- resourced or renowned institutions., A 2019 analysis revealed that the 10 schools with the most grad student awardees amassed 31% of all the grants, with many going to schools such as the University of California, Berkeley, the Massachusetts Institute of Technology, and Stanford University.

Question: Concerns That Awards are Biased to Privileged Institutions. GRFP fellowships can be awarded in a student's first year of their graduate program or before the student has matriculated to any graduate program, ultimately making fellows more competitive for graduate school applications. Although this can explain the bias of GRFP fellows belonging to well-resourced graduate programs, it does not explain the bias of well- resourced undergraduate institutions among the fellows. Given that the mission of the program is to diversify the scientific and engineering workforce, can you describe what tools NSF uses or can use to diversify the institutional representation and demographics among its awardees without limiting the ability of awarded fellows to choose their own program?

Answer: GRFP is NSF's oldest program, established in 1950 as part of the NSF organic act. The goal of the program is to recruit and support outstanding students with high potential in STEM very early in their graduate training. A touchstone of the GRFP is to provide sustained support from the fellowship to allow students to pursue research in their area of interest and at the institution of their choice. Choice is a hallmark of the program, and fellows choose their institutions and research areas without fear of losing funding.

Using this model, NSF has awarded more than 70,000 Fellowships, and many recipients have gone on to make important discoveries, win Nobel Prizes, train many generations of American scientists and engineers and create inventions that improve our lives. GRFP is open *only* to: US citizens, permanent residents, and nationals pursuing research-based master's and doctoral degrees in eligible fields of study. Every year, NSF receives ~13,000 applications, and makes ~2,000 Fellowship awards. Applicants come from 600+ academic institutions including undergraduate-only institutions. Fellows are supported at 270+ institutions in every state and territory except American Samoa (which has only a community college).

The primary tool that NSF uses to diversify the demographics and institutional representation of its fellowship awardees is outreach. As GRFP nears its 75th anniversary in 2025, NSF is accelerating its efforts to recruit talented individuals who demonstrate potential to make outstanding contributions to STEM. The program's staff significantly increased outreach efforts to ensure no communities were overlooked in seeking promising talent. The program especially prioritized virtual information sessions, offering presentations to institutions large and small, and to meetings held across the country. This emphasis on virtual outreach came in handy when the pandemic erupted as students could join from anywhere, get information about the program, and ask questions. NSF successfully tapped a broader swath of students, and its efforts are reflected in the competition outcomes.

Another approach to diversify representation that GRFP uses is holistic review, in which the applicant is reviewed as an individual, including all the experiences and competencies that they may bring to STEM. Each year, there are numerous applicants whose academic training was not in STEM. With this in mind, a holistic review allows the assessment of their creativity and innovation in other fields that they may bring to STEM.

In FY 2024, GRFP plans to partner with programs across NSF to conduct outreach in EPSCoR jurisdictions, rural areas, and to institutions with student groups who are underrepresented in NSF programs. NSF has made it an agency-wide priority goal to increase the percentage of underrepresented principal investigators by 10 percent over the 2020 baseline. At this point, GRFP has exceeded this goal, increasing the number of underrepresented fellowship awardees by nearly 18 percent since 2020.

GRFP has also made impressive gains in the area of accessibility. In 2021, NSF introduced language in the GRFP description to highlight accessibility accommodations available to individuals identifying as having disabilities. That year, the competition yielded a near-doubling of Fellowship offers to persons with disabilities, from 74 (3.6 percent) the previous year to 145 (6.5 percent). In FY 2023, this number increased to 201 (7.9 percent)

The FY 2023 Appropriation provided sufficient funding to NSF to award 2500 Fellowships in 2023. The focus on recruiting high-potential individuals allowed NSF to offer 1,023 Fellowships to those who had not yet started graduate school, a record for the program.

Moving forward, NSF will continue to support individuals with demonstrated potential to make outstanding contributions to STEM.

Question: Concerns About Quality of Review and Selection Criteria. It has been reported that some reviewers of GRFP may be making improper and even biased comments about applicants, and that at least in some cases, those comments are being shared with the applicants.1 It has also been reported that there is not consistency more generally in the criteria for evaluation of GRFP applications.2 What are you doing to ensure that all applications are subject to the same clear review criteria, that reviewers are well informed about those criteria and their responsibilities as reviewers, and that their reviews are screened for any improper commentary before being shared with the applicants?

Answer: NSF receives around 13,000 GRFP applications each year. Typically, three external reviewers are assigned to review every eligible application, resulting in ~37,000 reviews. All GRFP applications are reviewed by volunteers with expertise in the areas of research according to the fields of study indicated in the applications, using a comprehensive, holistic approach that takes into consideration all components of the application.

Prior to reviewing applications, GRFP reviewers are required to participate in a 1.5-hour mandatory training webinar that includes guidance on using holistic review. They are also provided extensive training resources including:

- A 17-page “Reviewer Guide: Application and Rating” (2023 GRFP Reviewer Guide),
- A 10-page “How to Use the Review Site” (2023 Review Site Technical Guide),
- A 45-page version of the “NSF GRFP Reviewer Orientation Supplemental Guide”
- 2023 NSF GRFP Reviewers Training Video Supplement,
- An “Unconscious Bias Peer Review Checklist”, and
- Several videos including “GRFP Avoiding Unintended Bias” and “The Art and Science of Reviewing proposals”.

Once the reviews are submitted, NSF utilizes automated searching mechanisms to screen the comments prior to release. In FY 2023, NSF staff read ~1,000 instances of potentially biased comments. Unfortunately, in rare cases, such comments are released to an applicant. Thus, it is worth noting that these comments do not impact NSF’s final decision on selecting an applicant, because all decisions are based on a holistic evaluation of the entire application package and all the reviews are provided by people who are experts in their fields. NSF makes decisions using the merit review process, to ensure that applications submitted are reviewed in a fair, competitive and in-depth manner.

Question: Concerns About Data and Process Transparency. As previously cited, many researchers, students, and news outlets have repeatedly brought up these issues over the past five years but have been hindered by little-to-no data on the composition of reviewers, applicants,

and awardees. In accordance with the CHIPS and Science Act, the GRFP was updated to support more fellows annually and to recruit a more diverse pool of applicants. Could you provide data on the demographic and institutional diversity of the applicants, awardees, and honorable mentions?

Answer: NSF does not release information on applicants by program. The table below provides demographic information for awardees and honorable mentions for the 2019 to 2023 Fellowship years. Honorable mention is not a status that is captured by any NSF data systems, however, the list of award offers and honorable mentions for each year is available at: NSF FastLane : GRFP (research.gov)

Offered Awards

Fellowship Year	Number of Applications	Number of Offered Awards	Female	Under-represented Minorities	Persons with Disabilities	Veterans	Undergrad/ Bachelor's Degrees	Honorable Mentions*
2019	13,308	2,052	1,172	426	87	31	749	1582
2020	13,835	2,076	1,223	462	105	20	877	1827
2021	13,802	2,074	1,203	550	145	25	846	1830
2022	12,626	2,193	1,236	523	143	22	891	1413
2023	12,664	2,555	1,431	666	201	14	1,023	825

*Note that some recipients elect to not have their information displayed in NSF FastLane.

Questions for the Record Submitted by
Rep. Paul Tonko

POLAR PROGRAM

Question: NSF is conducting critical scientific research in harsh polar environments. What are the long- term needs of NSF related to the transportation of personnel and materials in the Antarctic, Arctic, and Greenland?

Answer: NSF requires access to Antarctic gateway cites to assemble passengers and cargo for all activities on the continent. Christchurch, New Zealand and Punta Arenas, Chile both have ample port, airport, and hotel resources to support a robust U.S. Antarctic Program. In Greenland, access to Kangerlussuaq and Pituffik Space Base provide the same critical logistics resources.

NSF requires access to unique DoD transportation assets and U.S. Coast Guard (USCG) ice breakers to continue world-leading science in both theaters. The current use of C-17 and LC-130 aircraft and the USCG POLAR STAR icebreaker enable the U.S. to have the largest and most prestigious science programs in the Antarctic. The aviation assets also support NSF activities in Greenland and are key to continued research, site development, and recapitalization.

Military Sealift Command contracted cargo ships and tanker ships are key to economical resupply and continued presence in the Antarctic.

The USCG is currently engaged in their program to construct several new Polar Security Cutters, which would replace the USCG POLAR STAR and assure continued access for cargo and fuel deliveries to McMurdo Station in Antarctica. However, currently there is no planned replacement for the LC-130H skied aircraft, which is a critical need for the U.S. Antarctic Program.

Question: How does NSF rely upon Department of Defense capabilities for transportation of personnel and equipment?

Answer: NSF requires access to unique DoD transportation assets and other services to continue world-leading science in both theaters. The current use of C-17 and LC-130 aircraft enables the U.S. to have the largest and most prestigious science programs in the Antarctic. The aviation assets also support NSF activities in Greenland and are key to continued research, site development, and recapitalization.

Military Sealift Command contracted cargo ships and tanker ships are key to economical resupply and continued presence in the Antarctic.

The Defense Logistics Agency provides access to bulk aviation fuel that is specially formulated to allow for extreme low temperature operations of the LC-130H aircraft. Other aircraft, station power plants, and some vehicles use the same fuel, allowing a better economic order quantity.

The U.S. Space Force provides satellite communications services for field operations and the transfer of scientific data.

Question: I understand that the aging fleet of 10 LC-130H aircraft, operated by the Air National Guard, has been an important component of the NSF's ability to function in Antarctica, the Arctic, and Greenland. How critical are these aircraft to NSF's ability to conduct research in the polar regions?

Answer: The ski-equipped LC-130s present a unique capability to the U.S. and are key to the construction and sustainment of the premier U.S. science stations in both the Arctic and Antarctic. Its large cargo bay, heavy lift capability, and long range enable the U.S. to do activities nearly everywhere in the Antarctic and Greenland.

During the warmest periods of the Antarctic summer, these ski-equipped aircraft provide the only international link to McMurdo Station, Antarctica, because ice runways soften and cannot support wheeled aircraft. During this 45-day period, the LC-130 fleet provides critical resupply, medical evacuation, and personnel transport for the NSF and U.S. allies in the region near McMurdo Station.

In addition, the ski-equipped LC-130 fleet provides the only means to move large amounts of cargo and people to the South Pole Station and to some of the deep-field sites on the Antarctic continent, which are not capable of accepting large, wheeled aircraft. Without an LC-130-like resource, the NSF would need to reduce the U.S. presence in Antarctica, stop developing the South Pole Station astrophysics activities, and operate without medical evacuation capabilities during periods of runway softening.

In Greenland, the NSF operates the world's premier high altitude Arctic station, Summit Camp. The leading-edge research at this station and its continued existence is solely dependent on NSF access to LC-130 type aircraft that provide resupply and site development/construction.

Question: What would be the impact on U.S. polar research if LC-130 aircraft were no longer available to NSF?

Answer: The ski-equipped LC-130 fleet provides the only means to move large amounts of cargo and people to the South Pole Station and larger deep-field sites on the Antarctic continent and to Summit Camp in Greenland. Most remote field sites on the Antarctic or Greenland ice caps are not capable of accepting large, wheeled aircraft.

During the warmest periods of the Antarctic summer, these ski-equipped aircraft provide the only international link to McMurdo Station, Antarctica, because ice runways soften and cannot support wheeled aircraft. During this 45-day period, the LC-130 fleet provides critical resupply, medical evacuation, and personnel transport for the NSF and U.S. allies in the region near McMurdo Station.

Without an LC-130-like resource, the NSF would need to reduce the US presence in Antarctica, stop developing the South Pole Station astrophysics activities, and operate without medical evacuation capabilities during periods of runway softening. The Summit Station's continued existence is solely dependent on NSF access to LC-130 type aircraft that provide resupply and site development/ construction.

Question: Are you concerned that increasing competition by foreign nations in the polar regions may limit NSF's ability to conduct unconstrained scientific research in the future?

Answer: NSF is aware of the activities of foreign nations in the polar regions and is highly aware of the impacts – positive and negative – those may have on NSF's ability to support research there.

Strategic partnerships with Greenland, Chile, and New Zealand particularly important for staging and deploying to the polar regions through their gateway cities.

Responses by Dr. Dan Reed

May 2023 HSST QFRs for Daniel Reed, NSB Chair

Questions submitted by Chairman Frank Lucas

1. How should NSF consider the needs of industry in the development of a skilled technical workforce for semiconductor manufacturing?

There is a continuum of semiconductor workforce needs. For example, skilled technical workers – those who do not hold a bachelor's degree and work in highly technical fields – are needed to meet the foundry worker shortage while advanced manufacturing and chip design requires highly trained engineers and scientists.

Industry inputs about its semiconductor workforce needs at all educational levels are key. Industry provides subject matter expertise, including assistance with curriculum development, instructional materials, and the integration of industry standards into education and training, offers students experiential learning opportunities, and provides co-funding to NSF programs to help accelerate workforce development.

For all these reasons, NSF, even before the passage of the *CHIPS and Science Act*, began to forge partnerships with major semiconductor companies. NSF used its $25 million from the FY23 *CHIPS Act* appropriation to accelerate those partnership efforts; it now has partnerships with Intel, Micron, Samsung, and Ericsson.

Among the NSF programs that support developing the semiconductor manufacturing skilled technical workforce are Advanced Technological Education (ATE), NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM), and the Experiential Learning in Emerging and Novel Technologies (ExLENT) program. ExLENT, specifically, focuses on reskilling workers for critical technology fields.

In January, NSF also announced the Future of Semiconductors (FuSe) program that supports transdisciplinary, co-design approaches to create the next generation of semiconductor technologies and has a strong workforce component. In FY24, NSF plans to continue to work hand in glove with industry and leverage these collaborations to focus on programs at community colleges and minority serving institutions. Going forward, it will be helpful for industry to share granular data across industry sectors on specific workforce needs.

2. In your testimony, you suggest that it is often cheaper and quicker to recruit foreign talent than educate and train domestic talent. How will federal investment in the development of a domestic STEM workforce help to mitigate the risks associated with a dependence on foreign STEM talent?

There are two kinds of risks associated with our current dependence on recruiting and retaining foreign STEM talent: (a) shifting geopolitics, immigration policy, and economic (job) opportunities that threaten to reduce the flow of international talent upon which we heavily depend to meet our workforce needs and (b) an urgent need for more domestic workers, both to reduce our overdependence on foreign talent and to fill defense/security jobs that require US citizenship.

Additional federal investment in developing domestic STEM talent is needed to mitigate these risks. NSF plays a vital role in domestic STEM talent development; as America's STEM talent agency NSF invests in STEM education and workforce development at all education levels.

Redoubling our efforts to develop domestic STEM talent is also a matter of national security; NSB regularly hears from the military and national security sectors that there is shortfall of domestic STEM talent who can obtain security clearances. Developing domestic STEM talent is also critical to our economic strength. If we are to expand the geography of innovation nationwide, we need federal investment in domestic STEM education and workforce development to seed and support R&D in emerging science and engineering (S&E) hubs. Investments in STEM talent also matter at the individual level. STEM jobs offer economic opportunity; data show that STEM jobs pay better than non-STEM jobs at the same educational level and that STEM jobs are more resilient in the face of economic downturns.

At the advanced degree-levels and in fields that underpin critical technology areas, the U.S. is extremely reliant on foreign-born talent; nearly 60% of the PhD holders working in the U.S. in engineering, computer science, and mathematics are foreign-born. This degree of reliance, coupled with the fact that the preponderance of those students come from two countries (China and India) leaves us exposed to policy shifts that may reduce or limit flow of those students. While we must continue to welcome the very best talent from around the globe (the U.S. has and continues to benefit from this talent), we must also reduce this risk by investing in domestic talent to make STEM careers more accessible and attractive.

Domestic STEM students face significant financial challenges that impact their choices. Many already have high undergraduate student debt and graduate stipends are low. Our country is asking highly talented students – who can earn substantially more in industry right out of college – to work at or near poverty wages as they pursue an advanced degree in STEM. If we want more domestic STEM talent, we have to make that option more financially attractive.

Equally worrisome, the preparation of our K-12 students in math and science continues to lag far behind our nation's key competitors, creating a significant barrier to expanding our domestic base of STEM workers. While this challenge is far-reaching, extending beyond the federal government, NSF-funded research is part of the solution, and programs to translate and scale effective innovations are growing under TIP and the new authorizations in the *CHIPS + Science* legislation. The National STEM Teacher Corps could be particularly helpful in this regard.

Questions submitted by Ranking Member Zoe Lofgren

1. In the last decade, NSF has come a long way in strengthening budgeting, management, and oversight for construction of its large facilities. It was a priority oversight topic for this committee several years ago, and we enacted several new requirements in the American Innovation and Competitiveness Act of 2017. However, other challenges remain. In particular, NSF still falls short on lifecycle planning for facilities even as operations costs continue to increase with increasingly sophisticated facilities. Some believe the Astronomy division is near a breaking point because of the pressure the operations budget puts on the research budget. Different solutions have been proposed, having a budget line in the MREFC account for operations. Different approaches have different pros and cons.

a. How does the NSB weigh major facility projects from different scientific disciplines in its recommendations? How is the NSB overseeing NSF's lifecycle planning for major research facilities?

The National Science Board provides full lifecycle oversight on NSF's major research facilities, through the Committee on Awards and Facilities (A&F). A&F reviews the sufficiency and integrity of NSF's merit review process, engages on strategic matters including the appropriateness of the project for NSF, and considers NSF's plans for award oversight to ensure strong performance by the awardee and delivering good science, and to manage and mitigate risk, including political support when facilities are closed. A&F has begun instituting a process that would allow for earlier engagement in the process to understand the project's importance and viability. The Board looks forward to continued conversations with NSF both to strengthen lifecycle processes and enhance the Board's engagement across the full facility lifecycle.

The National Science Board and NSF Director, with input from a report by the National Academies of Science, developed an approach to prioritize major facility projects across different scientific disciplines (NSB-05-77). Under this approach, the Board and Director consider several criteria, including the potential to maintain U.S. leadership in key science and engineering fields, impact on current national priorities and needs, level of community support, and projects with the greatest degree of community support. More recently, in response to Congress, the NSB also produced the 2018 report, *Study of Operations and Maintenance Costs for NSF Facilities* that examined the extent to which O&M costs potentially may upset the balance between funding for research facilities, research grants, and cross-cutting initiatives.

Recent A&F strategic work has included monitoring the share of division/directorate budgets that are devoted to research infrastructure and to understand challenges to and or gaps within existing programs. Based on this, the Board offered several recommendations that triggered NSF responses. In particular, collaboration between A&F and NSF leadership has resulted in the Mid-scale Research Infrastructure program and new budgetary approaches to managing the transition from facility construction to operations. A&F has asked NSF to develop strategic

priorities for current and future infrastructure projects, working in collaboration with the Office of Management and Budget and Congress.

Questions submitted by Rep. Brian Babin

1. **During the hearing, it was stated several times that NSF needs to "engage early career scientists" and "hear from the community" on the future of the IOPD program. I would like to draw your attention to two attached documents. The first is a letter signed by 2,213 international scientists and stakeholders -- including 855 U.S. signatures across 50 states and the District of Columbia -- underscoring the importance of scientific ocean drilling and the future direction outlined in the 2050 Science Framework. The scientific community calls for a "bridging program" over FY24-FY28 by extending the Joides Resolution combined with the lease or acquisition of new U.S. drilling vessel. The second document is a letter signed by 208 early career scientists calling for that exact same plan, in an effort to bridge the current program with a new scientific ocean drilling program. What additional issues/limitations does NSF need to address in order to proceed with such recommendation from those two sources, representing a community of career scientists. What resources do you need from Congress to carry out this direction?**

No decision to close a research facility is taken without careful due diligence and evaluation of community input. Considering the loss of international support for the program, NSF has judged that the taxpayer dollars are best spent on planning for the future of scientific ocean drilling, leveraging a diversity of tools through alternative drilling platforms and technologies, and capitalizing on the wealth of information stored in the already-retrieved cores accessible through the instrumented core repositories in Texas, Japan, and Germany. NSF will continue to support the research of the US scientific ocean drilling community through the International Ocean Discovery Program and is committed to supporting cutting-edge science along with the tools and workforce that make it possible.

Questions submitted by Rep. Rick Crawford

1. Congress authorized a number of research security activities in the CHIPS and Science Act. What actions has the NSF taken to begin implementing these new authorizations for research security activities? What additional action can and should U.S. government agencies funding research and development programs at U.S. universities do to protect taxpayer dollars and investments from ending up in the hands of competitor nations?

The Board is deeply invested in the success of NSF's new Office of the Chief of Research Security Strategy and Policy and has asked NSF for regular updates on research security efforts to ensure NSF is addressing this critical issue.

NSF actions:

- Established the Office of the Chief of Research Security Strategy and Policy (OCRSSP). The office has begun implementing many of the research security-related activities required under the *CHIPS and Science Act*.
- Establishing the Research Security and Integrity Information Sharing Analysis Organization (RSI-ISAO), Sec. 10338.
    - Actions to date include scoping the RSI-ISAO remit; conducting stakeholder engagement to ensure the services provided by the RSI-ISAO are aligned with the needs of the research community. Examples of outreach include: publishing a Dear Colleague letter (NSF 23-098) and conducting webinars; drafting the solicitation; and notional planning for the development of the USG steering committee which will interact and steer policy for the RSI-ISAO; among other activities.
- Planning for foreign financial disclosure reporting, Sec. 10339B. OCRSSP is working to develop and implement a new reporting system to manage an annual financial disclosure reporting requirement from institutions of higher education receiving $50,000 or more from foreign sources associated with a foreign country of concern.
    - OCRSSP is coordinating with the U.S. Department of Education on their foreign financial support requirement under Section 117 of the Higher Education Act of 1965; working to develop the IT system that the research community will submit this information to NSF on an annual basis; and coordinating with other USG agencies to begin strategizing on how OCRSSP will utilize this information.
- Included malign foreign talent program prohibition in the new PAPPG that is currently out for public comment.
- Developing research security training that will be required for researchers. Training modules will be complete by December 2023.
- Constructed a SCIF that, once technologically fitted and cleared, will give NSF a space to evaluate classified data to inform decisions

Additional potential actions for US government agencies:

- Continue/expand engagement with research community, including on communicating security threats and risks
- Evaluate effectiveness of training materials to ensure uptake and adherence to research security policies
- Continue to develop a coordinated, interagency approach, especially for information-sharing and development and use of research security analytics tools

2. Has the NSF implemented the ban on funding going to any institutions that host Confucius Institutes on their campus, as directed in the CHIPS and Science Act?

The *CHIPs and Science Act* states that NSF shall implement this prohibition "the first fiscal year that begins after the date that is two years after the date of the enactment of this Act." Given the importance of this issue, NSF is exploring the possibility of implementing the prohibition earlier than this time. NSF would be pleased to provide updates as the process is developed.

3. What kind of processes has NSF stood up, through their Research Security Office, to identify, track, and address concerning activity? Have you seen a dramatic increase in incidents over the past 4 years and do you feel the Academic Research Community is beginning to take this threat more seriously?

Process:

- NSF collaborates with the Office of Inspector General (OIG) to refer concerns of waste, fraud and abuse to the OIG; take administrative action when recommended by the OIG; and work with organizational awardees on principal investigator reassignments and other actions, if needed.
- The OCRSSP has also stood up a Data Analytics Program, which identifies potential foreign interference utilizing academic literature from multiple sources as well as international patent databases to determine the extent of interactions between NSF-funded researchers and researchers located abroad. OCRSSP shares the resulting information with NSF staff and disseminates it to the interagency community in a limited capacity as appropriate.

Incident rate:

- As of February 2023, among other actions, 50 awards have been suspended and 20 have been terminated; 15 government-wide suspensions have been issued for 9 researchers and 4 entities; 5 researchers and 2 entities have been debarred; and 17 researchers have been barred from serving as reviewers (https://nsf-gov-resources.nsf.gov/2023-03/ResearchSecurity_Feb2023.pdf?VersionId=mhC5j7Cn1EC.MY_vZ63ixcRITJYQ18t.)
- Specific trend analysis from the past four years is not available since OCRSSP is in the process of scaling up analytics capabilities.

Academic community:

- The academic community is increasingly aware of research security concerns and actively putting plans and processes in place to train faculty and staff and protect the research enterprise. In the same way that universities ramped up laboratory safety compliance after the UCLA chemistry incident, this will require additional staffing, verification, and education.
- Many universities have proactively come forward to NSF with research security issues they have identified so that the Foundation can work together with the university to address the issues, including pursuing corrective action plans, removing and replacing principal investigators (PIs), among other activities.

- Challenges remain, particularly in financing the staff and infrastructure needed to comply with new regulations; continuing to encourage international collaboration generally; and avoiding the perception of or actual discrimination against Asian-American researchers.
- Other challenges are related to the rapid turnover of awardees and consistent influx of new researchers into the US R&D enterprise. This requires ongoing education on the issues and their importance.
- In coordination with NSF, Board members are engaging with their respective academic communities to help raise awareness of the seriousness of security threats and to help drive cultural change at higher education institutions.

Questions submitted by Rep. Suzanne Bonamici

1. Following the publication of the Sexual Assault/Harassment Prevention and Response (SAHPR) report, the National Science Board (NSB) put out a strong statement that described the hostile environment in the U.S. Antarctic Program and the sexual harassment, assault, and stalking that occurs at the ends of the earth. There is also insufficient accountability for the perpetrators and for Leidos, the prime contractor. The NSB statement said, in no uncertain terms, that the Board does not tolerate these actions.

a. In the months since the publication of the SAHPR report, how has NSB held the Agency accountable to change the status quo in the U.S. Antarctic Program?

The safety of *all* personnel – from researchers to contractors and subcontractors – not just on the ice, but across locations where NSF-funded research is being conducted – will continue to be a Board priority for which we will hold ourselves and the agency accountable.

Since the August public release of the SAHPR report and NSB's statement, the Board met with Director Panchanathan, NSF COO Karen Marongelle, Rhonda Davis – the head of NSF's Office of Equity and Civil Rights – and NSF staff from the Office of Polar Programs to discuss this matter during each of our NSB meetings. These discussions were lengthy and detailed – for example, the February discussion lasted two hours, and the May meeting also had in-depth open and closed discussion. The discussions were frank and detailed, with everyone committed to the safety of all personnel.

Together with NSF, we held two virtual townhall meetings on the ice – one at McMurdo station and one at the South Pole – and used those opportunities to encourage NSF to incorporate researcher and contractor concerns into their response. Reflecting the commitment of the Board and the importance of confidential exchange, these townhalls included private time

where only Board members were present to hear from personnel at both McMurdo station and the South Pole.

We worked closely with Director Panchanathan to ensure that personnel were safer in the 2022-2023 season, including (among others) enhancing physical security measures and implementing on-ice support services. We have repeatedly exhorted NSF to expand and accelerate the agency response and are encouraged by its work, including establishing single communication points, increased vetting of personnel deployed to the ice, increased bystander training, and the launch of a 24hour/7 days a week crisis hotline, among other procedural changes.

In addition, NSB's Committee on Oversight and NSB's Committee on Awards and Facilities have provided additional touchpoints. We anticipate continued and similar interaction with NSF throughout the next season on the ice and beyond.

Specifically, NSB has urged the Director's teams to use all contractual flexibilities to bring about needed changes and has pushed for and will continue to ask for evidence of specific actions and their impacts. Additionally, NSB members have been pointed in seeking consequences for offenders and have pushed for clearer organizational lines of reporting and NSF presence on the bases.

NSB continues to work closely with the Director and his team to address this matter with alacrity and clarity. Board members are eager to go to the ice to assess progress and listen to people.

b. Does the Board consider NSF's current efforts to be adequate? In your assessment, are the Agency and Leidos prepared to meaningfully address this toxic culture in the 2023-2024 season?

The Board is encouraged by NSF's response since August's public release of the SAHPR report, especially as that response has gained momentum. However, there is more to be done. We have worked closely with Director Panchanathan and his staff to make immediate changes on the ice (as detailed above). We have also worked to ensure that all agency changes are long-lasting and amenable to frequent assessments of efficacy in decreasing sexual assault and all forms of harassment, as well as improving culture.

In addition to agency-specific action, ensuring that other partners – especially LEIDOS – are held to the same standards and accountability measures is paramount. Although LEIDOS leadership is in communication with NSF, their slow and uncertain response to the SAHPR report still concerns us greatly. The Board will continue to demand attention until we are satisfied that

LEIDOS (and all contractors, subcontractors, and other entities) meet new guidelines NSF is developing.

For example, the NSB in its listening sessions heard repeated comments from contractors that they feared retaliation if they reported incidents. This is unacceptable and must be addressed immediately and directly by LEIDOS and any future contract awardee.

While NSF and Leidos appear to be on a path to make meaningful improvements for next season, significant work remains over the next several months.

Questions submitted by Rep. Eric Sorensen

Statement
I want to thank Chairman Lucas and Ranking Member Lofgren for convening this hearing and our witnesses for their willingness to appear before us today.
I have spent my whole career in the STEM field. Much of what I have accomplished would not have been possible without interagency collaboration at the federal level.

1. Before coming to Congress, I served my community as the local weatherman for over two decades. As you know, LGBTQ+ and women's involvement in STEM, while improving, is not at proportional parity with their straight male counterparts. We know that representation is critical to show future generations they can be anything they want to be. One of NSF's stated priorities is to bring underrepresented groups into the STEM community. What is the NSF doing to promote inclusion of these underrepresented populations?

NSF is taking a multi-level, systemic approach to improve the representation of women, underrepresented racial and ethnic minorities, and persons with disabilities in research, STEM learning, and the STEM workforce. For example, NSF is implementing two NSB resolutions to help address the issue of Missing Millions: (1) training to improve peer-reviewing in the merit review process and (2) Broader Impacts experts to serve on Committees of Visitors.

In FY24, NSF's Create Opportunities Everywhere (COE) investments will address research equity, build capacity, foster collaborations and partnerships, and support the next generation of researchers. COE will expand access and inclusion in STEM along individual, institutional, and geographic lines.

NSF also has an award term and condition addressing sexual assault, and sexual and other forms of harassment, as well as anti-harassment proposal requirements for NSF funded conferences, travel, research experiences for undergraduates and remote research sites. In addition, the agency conducts pre- and post-award compliance reviews to ensure the NSF grantees comply with civil rights laws and regulations.

2. As the first meteorologist in Congress in nearly 50 years, I pride myself on being a climate communicator. I have been talking about climate for decades. The NSF contributes significantly to climate science research. How can Congress assist the NSF in bolstering their communication efforts to the public about the environmental impacts and research they fund?

Congress can continue to appropriate robust funding for science and technology research across the federal government to maintain our nation's scientific edge. Congressional support is crucial to advancing climate research. NSF-funded researchers are not only studying the mechanisms and rate of warming but are also studying climate impacts and mitigation techniques.

The NSB welcomes opportunities to highlight critical climate science that NSF supports with Members of Congress and their staff through hearings, briefings, and information sharing. The agency can also connect Members of Congress with NSF-funded researchers in their district to discuss ways to share climate science through town forums, social media, local media, and more.

a. Relatedly, I have been talking about climate for decades in a way that Americans of all walks of life can relate to. How can Congress and I help NSF relay their research results to Americans of all backgrounds

We recommend highlighting NSF science that meets people where they are (both in interest and physical location) without using technical jargon. It's also important to frame the research you want to share in a way that will resonate with a particular audience by linking it to shared values, like family, nature, and community. To convey a sense of urgency, it can be useful to frame the topic in terms of safety and stability.

Appendix II

Additional Material for the Record

STATEMENT SUBMITTED BY REPRESENTATIVE ZOE LOFGREN

https://www.researchamerica.org/press-releases-statements/statement-on-house-gop-proposed-debt-limit-plan/

HOUSE GOP PROPOSED DEBT LIMIT PLAN

April 19, 2023

Research!America is disappointed in the proposed debt limit plan offered by House GOP leadership this afternoon. The Limit, Save, Grow Act of 2023 calls for a $130 billion cut to be taken entirely from just one category of federal spending – discretionary funding. Not only does discretionary funding account for less than a third (28%) of the annual budget, but it is the portion of the budget that supports national defense, medical research, science and technology (S&T) competitiveness, and other fundamental American priorities.

Chinese President Xi Jinping recently affirmed S&T investment as a top strategic priority: “We must regard science and technology as our primary productive force, talent as our primary resource, and innovation as our primary driver of growth.”

According to a public opinion survey Research!America commissioned in January 2023, 77% of Americans are concerned China will surpass the U.S. as the world’s leading S&T power. Notably, 6 in 10 Americans – a majority across party lines – believe Congress should invest more taxpayer dollars to advance S&T in the U.S.

Cuts of the magnitude proposed in the House GOP debt ceiling plan would leave the U.S. without the means to accelerate medical progress, remain competitive against China and other growing global economies, or retain unrivaled national defense capabilities. We urge Congress and the Administration to work on a bipartisan basis to address the debt limit in a manner that ensures current budget decisions advance rather than abandon the best interests of our nation and of the American people.

Contact Tim Haynes, Senior Director of Communications, at 571-482-2737 or thaynes@researchamerica.org with press inquiries.

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STUDY SUBMITTED BY REPRESENTATIVE BILL POSEY

United States Government Accountability Office

GAO

Report to Congressional Requesters

September 2022

FEDERAL RESEARCH

Information on Funding for U.S.-China Research Collaboration and Other International Activities

GAO-22-105313

GAO Highlights

Highlights of GAO-22-105313, a report to congressional requesters

Why GAO Did This Study

Federally funded research and development (R&D) contributes to innovation, the economy, and national security. To achieve their missions, federal agencies sometimes provide research funds to foreign entities such as universities, laboratories, and public health organizations. Agencies may also collaborate with foreign entities to access resources such as one-of-a kind scientific facilities. In fiscal year 2020, federal agencies obligated about $1.4 billion for R&D collaboration with foreign entities. The federal government also appropriated about $2 billion to multilateral institutions in fiscal year 2020 to promote U.S. and global security.

GAO was asked to review federal funds provided to China for collaborative research, and U.S. contributions to multilateral institutions. This report describes (1) the amount of funding departments and agencies provided to Chinese entities for collaborative research, (2) selected departments' and agencies' programs, activities, and results of collaborative research with Chinese entities, and (3) funding the U.S. government has provided to selected multilateral institutions that support activities in China.

GAO analyzed data from five agencies with the largest amount of funding for R&D. In consultation with the Departments of State and the Treasury, GAO analyzed publicly available data on eight selected multilateral institutions that provided funding and loans to China based on agency and multilateral institution's budget documents. GAO interviewed agency officials about the funding and activities.

View GAO-22-105313. For more information, contact Candice N. Wright at (202) 512-6888 or WrightC@gao.gov or Kimberly Gianopoulos at (202) 512-8612 or GianopoulosK@gao.gov.

September 2022

FEDERAL RESEARCH

Information on Funding for U.S.-China Research Collaboration and Other International Activities

What GAO Found

The U.S. government collaborates with and supports foreign entities such as those in China to, among other things, broaden U.S. access to scientific resources. Of the five agencies that GAO reviewed, the Centers for Disease Control and Prevention, the Department of Defense, and the National Institutes of Health obligated $28.9 million directly to Chinese entities from fiscal years 2015 through 2021. Neither of the other two agencies—the National Science Foundation and the Department of Energy—provided awards directly to Chinese entities. Chinese entities also received federal research funds through subawards to do a portion of the work. The full extent of that funding is not known due to limitations in the data provided in accordance with federal subaward reporting requirements.

Examples of Resources Available Through International Research Collaborations

Source: GAO analysis of agency documents. | GAO-22-105313

The awards funded by the Centers for Disease Control and Prevention, the Department of Defense, and the National Institutes of Health focused on multiple scientific disciplines, including public health and biological sciences. For example, the Centers for Disease Control and National Institutes of Health funded Chinese entities to conduct a wide range of research, including disease surveillance, vaccination studies, and the development of new drugs. Additionally, the Department of Defense funded research in areas such as alternative technologies to propel vehicles such as drones. These awards provided directly to Chinese entities resulted in scientific articles, data collection systems, and international workshops.

The U.S. government, along with other donors, provides funding to some multilateral institutions—such as the United Nations. Multilateral institutions support activities worldwide, including in China, in areas such as agriculture, infrastructure, and economic development. According to State and Treasury officials, multilateral institutions specify how funding should be used, and which countries should receive funding.

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Abbreviations

ADB	Asian Development Bank
CDC	Centers for Disease Control and Prevention
Chinese CDC	Chinese Center for Disease Control and Prevention
CRS	Congressional Research Service
DOD	Department of Defense
DOE	Department of Energy
FAR	Federal Acquisition Regulation
FFATA	Federal Funding Accountability and Transparency Act of 2006
FSRS	FFATA Subaward Reporting System
GEF	Global Environment Facility
IBRD	International Bank for Reconstruction and Development
IFAD	International Fund for Agricultural Development
NIH	National Institutes of Health
NSF	National Science Foundation
OMB	Office of Management and Budget
R&D	research and development
State	Department of State
Treasury	Department of the Treasury
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
USAID	U.S. Agency for International Development
WHO	World Health Organization

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September 29, 2022

The Honorable Michael McCaul
Ranking Member
Committee on Foreign Affairs
House of Representatives

The Honorable Elise Stefanik
House of Representatives

Federally funded research and development (R&D) is a key contributor to innovation, the economy, and national security. Federal agencies fund R&D at universities, colleges, and other nonprofit and for-profit organizations to support their missions in areas including public health, energy security, and science advancement. To achieve these missions, federal agencies sometimes collaborate with foreign entities, such as those in China, to leverage talent or other resources around the world. In fiscal year 2020, the U.S. government obligated about $1.4 billion for R&D with multiple foreign entities, including those in China according to the National Science Foundation (NSF).[1] Foreign entities can receive federal research funds in two ways:

- directly from an agency as a recipient of a federal award; or
- indirectly as a subrecipient of federal research funds through a subaward to perform part of the work for a federal award recipient.[2]

The U.S. government also contributes to multilateral institutions like the World Bank and the United Nations (UN). In fiscal year 2020, the federal

[1]National Science Foundation, National Center for Science and Engineering Statistics, *Federal Funds for Research and Development* (Alexandria, VA.: Apr. 28, 2022). The U.S. obligated a total of about $167 billion for R&D in fiscal year 2020.

[2]2 C.F.R. part 200, which provides guidance for grants and agreements, including cooperative agreements, defines a recipient as "an entity, usually but not limited to non-federal entities that receives a federal award directly from a federal awarding agency. The term recipient does not include subrecipients or individuals that are beneficiaries of the award." A subrecipient is defined as "an entity, usually but not limited to non-federal entities that receives a subaward from a pass-through entity to carry out part of a Federal award; but does not include an individual that is a beneficiary of such award. A subrecipient may also be a recipient of other federal awards directly from a Federal awarding agency." 2 C.F.R. § 200.1. Though subrecipients can include lower tier subrecipients that receive federal research funds through subawards from higher tier subrecipeints, this report focuses on funding provided to direct recipients of federal awards and subrecipients who receive subawards from federal award recipients.

government appropriated about $2 billion to multilateral institutions to promote U.S. and global security according to Congressional Budget Justifications. These institutions provide assistance to foreign entities to support health, education, infrastructure, environmental, and governance in the developing world.

You asked us to review federal funds provided to Chinese entities for collaborative research and U.S. contributions to multilateral institutions. This report describes (1) the amount of funding departments and agencies provided to Chinese entities for collaborative research, (2) selected departments' and agencies' programs and activities, and results of their collaborative research with Chinese entities, and (3) funding the U.S. government has provided to selected multilateral institutions that support activities in China. For the purposes of this report, the term "Chinese entities" refers to government agencies, research institutions, universities, and laboratories located in mainland China and Hong Kong.[3]

For the first and second objectives, we selected five agencies with the largest amount of funding for R&D—the Centers for Disease Control and Prevention (CDC), the Department of Defense (DOD), the Department of Energy (DOE), the National Institutes of Health (NIH), and the National Science Foundation (NSF). According to the most recent data available, in fiscal year 2020, these agencies accounted for over 80 percent of all federal R&D obligations.[4]

For the first objective, we analyzed annual obligations data for research grants and cooperative agreements with Chinese entities from each of the

[3]We included federal research funds provided to entities in Hong Kong, a Special Administrative Region of China, due to the recent change in the treatment of the region by the U.S. government. In July 2020, Executive Order 13936 ended U.S. recognition of the Special Administrative Region of Hong Kong because the President determined it was no longer sufficiently autonomous to justify differential treatment in relation to China. The executive order directed agencies to take specified actions to suspend or eliminate preferential treatment for Hong Kong because of China's decision to impose new national security legislation in the region.

[4]To identify federal agencies with the largest amount of funding for federal research, we reviewed several public sources of information such as NSF reports on R&D obligations, federal spending data on the USAspending.gov website, and previous GAO reports on federal research funding.

five selected agencies for fiscal years 2015 through 2021.[5] These funds were provided by federal agencies directly to Chinese entities in mainland China and Hong Kong. We corroborated the agency data by comparing it with data from USAspending.gov, the official source of spending data submitted by federal agencies, and determined the agency data to be sufficiently reliable for the purposes of our reporting objectives.[6] For the second objective, we analyzed relevant agency documents, including award progress reports, and interviewed relevant agency officials on these activities.

For the third objective, we reviewed Department of the Treasury's (Treasury) and Department of State's (State) Congressional Budget Justifications for fiscal years 2015 through 2022, annual enacted appropriations acts, and State's annual report on U.S. Contributions to International Organizations for fiscal years 2015 through 2020 (the most current data available), to gather information on multilateral assistance.[7]

For each multilateral institution listed in State's budget justifications, we reviewed its website and annual reports to determine whether the institution made funding or loans available to China. Based on this analysis, we identified one trust fund—the Global Environment Facility—and two multilateral development banks—the World Bank International Bank for Reconstruction and Development, and the Asian Development Bank.

We also selected five UN agencies that the U.S. government funds—the Children's Fund, the World Health Organization, the Development Programme, the International Fund for Agricultural Development, and the

[5]Agencies we reviewed provided data on Federal Acquisition Regulation-based (FAR) contracts with Chinese entities but the purpose of these contracts was not for collaborative research. For this reason, we excluded FAR-based contracts from our analysis.

[6]The USAspending.gov website is the official source of spending data submitted by federal agencies pursuant to Federal Funding Accountability and Transparency Act of 2006 (FFATA), as amended by the Digital Accountability and Transparency Act. Pub L. No. 109-282, 120 Stat. 1186 as amended by The Digital Accountability and Transparency Act of 2014, Pub. L. No. 113-101, 128 Stat. 1146 (codified as amended at 31 U.S.C. § 6101 note).

[7]For information on U.S. contributions to UN agencies, see Department of State, *Congressional Budget Justification Department of State, Foreign Operations, and Related Programs*, for fiscal years 2017–2022; Department of the Treasury, *International Programs Congressional Justification for Appropriations*, for fiscal years 2017–2022; and Department of State, *Report to Congress on U.S. Contributions to International Organizations*, for fiscal years 2015–2020.

Industrial Development Organization—with the highest expenditures in China in 2019 and 2020. In addition, we discussed these data with Treasury and State officials and found them to be sufficiently reliable for the purposes of this report. The funding analyzed in our third objective covers a range of activities such as infrastructure, education, and economic development. For additional information on our scope and methodology, see appendix I.

We conducted this performance audit from June 2021 to September 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

International Research Collaboration Supported by the U.S.

The U.S. government supports international research collaborations to acquire new knowledge and understanding in the areas of scientific development.[8] For example, DOD's International Science and Technology Engagement Strategy states "the U.S. must stay abreast of emerging science and technology around the world, leverage others' investments, and actively seek leading-edge research collaborations."[9] Additionally, the Department of Health and Human Services' Global Strategy states that building its collective capacity to respond to emerging

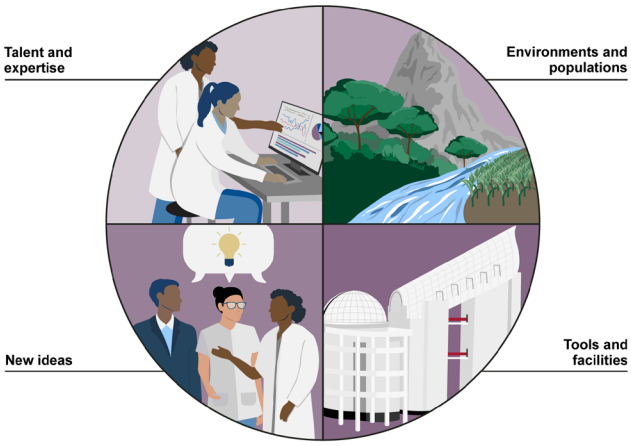
[8]The U.S. provides funding for different types of research including basic research, applied research, and development activities with foreign entities. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge or understanding of the fundamental aspects of phenomena and of observable facts, which should exclude research directed toward a specific application or requirement. Applied research is original investigation undertaken in order to acquire new knowledge that is directed toward a specific practical aim or objective. Experimental development is creative and systemic work, drawing on knowledge gained from research and practical experience, which is directed at producing new processes or improving existing products or processing. Office of Management and Budget, *Circular No. A-11, Preparation, Submission, and Execution of the Budget* (Washington, D.C.: August 2021).

[9]DOD, *DOD International Science and Technology Engagement Strategy* (Dec. 11, 2020).

health threats through collaboration with international partners is a key priority for the agency.[10]

Federal departments and agencies benefit from collaborating with foreign entities by broadening their access to scientific resources (see fig. 1).

Figure 1: Examples of Resources Available Through International Research Collaborations



Source: GAO analysis of agency documents. | GAO-22-105313

For example, collaboration with foreign entities can provide researchers in the U.S. with access to one-of-a-kind scientific tools like the Experimental Advanced Superconducting Tokamak in China. In this example, such access can advance U.S. research in fusion energy.

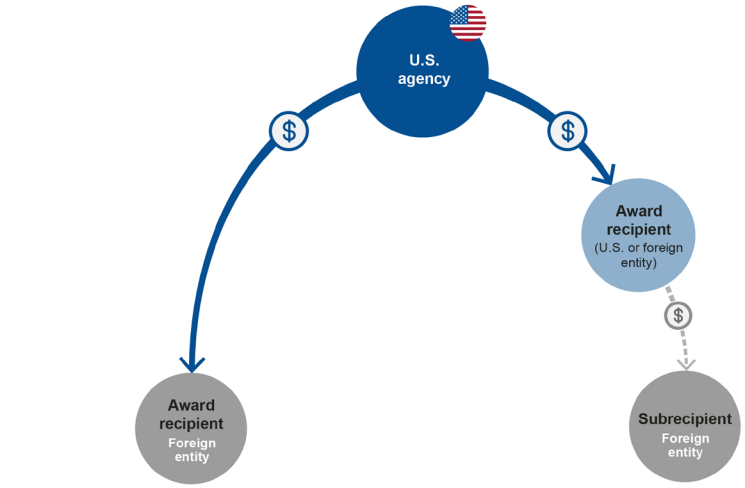
[10]U.S. Department of Health and Human Services, *The Global Strategy of the U.S. Department of Health and Human Services* (Washington, D.C.: May 20, 2016).

Process for Providing Research Funds

U.S. agencies provide federal research funds to foreign and domestic entities, primarily through grants and cooperative agreements.[11] Federal research funds are generally provided directly by a federal agency to an award recipient or indirectly through a U.S. or foreign award recipient to a subrecipient (see fig. 2).

[11]A grant is a legal instrument of financial assistance between a federal awarding agency and an award recipient that is used to carry out a public purpose authorized by law. Grants are not used to acquire property or services for the federal awarding agency's direct benefit or use. Grants also do not provide for substantial involvement of the federal agency in carrying out the activity contemplated by the award. A cooperative agreement is similar to a grant, however a cooperative agreement provides for substantial agency involvement in carrying out the activity defined in the agreement. See 2 C.F.R. § 200.1.

Figure 2: Process for Providing Federal Research Funds to Foreign Entities



Source: GAO analysis of federal regulations. | GAO-22-105313

Note: The funding process depicted above is the same for any domestic or foreign entity receiving federal research funds.

An award recipient is an entity, either foreign or domestic, that receives an award directly from a federal awarding agency.[12] A subrecipient is an entity that receives funds to carry out part of the work. An award recipient can pass on some portion of the funds to a subrecipient to conduct part of the work. The subrecipient receives the funds through a subaward from the award recipient.[13] This entity is often referred to as a first-tier

[12]See 2 C.F.R. § 200.1.

[13]See 2 C.F.R. § 200.1.

subrecipient. These subrecipients, in turn, can pass on a portion of the funds they receive to other subrecipients (second-tier, third-tier, etc.).

A federal awarding agency has a direct relationship with an award recipient and no direct relationship with a subrecipient.[14] Agencies report information on funds provided to award recipients and require these recipients to report on their first-tier subawards in government-wide systems.[15]

Agencies report information on funds provided to award recipients on USAspending.gov in accordance with the reporting requirements in the Federal Funding Accountability and Transparency Act of 2006 (FFATA) as amended. The website also includes subaward data reported by award recipients in the government-wide FFATA Subaward Reporting System (FSRS). Award recipients provide data on first-tier subawards in FSRS to meet the FFATA reporting requirements.[16]

U.S. Funding Provided to Multilateral Institutions

The U.S. also funds multilateral institutions such as the World Bank and the UN to advance a more secure, economically prosperous, and democratic world and address global issues such as poverty, inequality,

[14]In August 2020, the Office of Management and Budget (OMB) issued final guidance revising sections of its Guidance for Grants and Agreements. The Supplemental Information portion of the Federal Register Notice issuing this guidance noted as part of its response to comments that federal agencies do not have a direct relationship with subaward recipients. Office of Management and Budget, Guidance for Grants and Agreements, 85 Fed. Reg. 49506, 49508 (Aug. 13, 2020) (codified at 2 C.F.R. pts. 25, 170, 183 and 200).

[15]In accordance with FFATA and implementing guidance, agencies are required to disclose certain information about federal awards that equal or exceed the micro-purchase threshold on a single public-facing, searchable website. In addition, award recipients are required to report specified information on first-tier subawards—with some exceptions—associated with these awards in the FFATA Subaward Reporting System (FSRS). The goal of the reporting is to increase transparency and publicly available information on federal spending. Since 2010, agencies have required award recipients to report subaward information in FSRS. USAspending.gov, the public facing searchable source of spending data includes data submitted by federal agencies and award recipients pursuant to FFATA as amended, including data from government-wide reporting systems, such as the Federal Procurement Data System, the System for Award Management, and FSRS. Pub L. No. 109-282, 120 Stat. 1186 as amended by The Digital Accountability and Transparency Act of 2014, Pub. L. No. 113-101, 128 Stat. 1146 (codified as amended at 31 U.S.C. § 6101 note); 2 C.F.R. pt. 170.

[16]2 C.F.R. part 170, which includes guidance for FFATA required recipient subaward reporting for grants and cooperative agreements, defines recipient as "a non-Federal entity or Federal agency that received a Federal award." 2 C.F.R. § 170.332.

and climate change, according to the Departments of State and Treasury. Multilateral development banks such as the World Bank receive contributions from member country governments. Each member country has voting shares determined mainly by the size of their contributions. According to a Congressional Research Service report, the U.S. is the largest stockholder in most of the multilateral development banks and has maintained this position to preserve veto power in some institutions over major policy decisions[17]

U.S. assistance to the UN consists of assessed and voluntary contributions. Assessed contributions are required dues shared among UN member states to pay for the expenses of the organization. The UN's regular budget, peacekeeping operations, and specialized agencies are funded mainly by assessed contributions. Voluntary contributions support UN funds, programs, and offices.

Extent of Federal Funds Provided for Collaborative Research with Chinese Entities Is Not Fully Known

Three of the five agencies we reviewed reported providing research funds directly to Chinese entities. Chinese entities also received additional federal research funds through subawards from award recipients. Information on the full extent of that funding is unknown due to limitations in the data provided in accordance with federal subaward requirements.

Three Agencies Reported Providing Research Funds Directly to Chinese Entities

Three of the five agencies we reviewed provided funds to Chinese entities directly through grants and cooperative agreements from fiscal years 2015 through 2021 (see table 1). The CDC, NIH, and DOD provided 22 awards totaling $28.9 million directly to Chinese entities including universities and other research institutions.

CDC awarded over half of the funding ($15 million) through cooperative agreements to Chinese entities focused on applied research. The remaining funds were awarded by NIH ($13.6 million) and DOD ($0.4

[17]See Congressional Research Service (CRS), *Multilateral Development Banks: U.S. Contributions FY2000–FY2020* (Jan. 23, 2020). According to CRS, the U.S. is a member of the following multilateral development banks: the World Bank and four regional development banks, including the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, and the Inter-American Development Bank. For additional information, see Congressional Research Service, *Multilateral Development Banks: Overview and Issues for Congress* (Feb. 11, 2020).

million) through grants that focused on a mix of basic and applied research.[18] The remaining two agencies we reviewed—NSF and DOE—did not provide awards directly to Chinese entities in fiscal years 2015 through 2021. For information on ways these agencies collaborated with Chinese entities on research without exchanging funds, see appendix II.

Table 1: Federal Funding Provided to Chinese Entities through Awards, Fiscal Years 2015–2021

Agency	Award Mechanism	Type of Research	Number of Awards	Total obligated funds (millions of dollars)
Centers for Disease Control and Prevention	Cooperative Agreements	Applied (3)	3	15.0
National Institutes of Health	Grants	Applied (7) Basic (8)	15	13.6
Department of Defense (DOD)[a]	Grants	Applied (3) Basic (1)	4	0.4
Total			**22**	**28.9**[b]

Source: GAO analysis of agency data. | GAO-22-105313

Note: Funding data included in this table show Chinese entities that were award recipients of a grant or cooperative agreement. Funds passed on by award recipients to Chinese subrecipients are not included.

[a]In 2015, the DOD's Office of Naval Research awarded one grant to the City University of Hong Kong in the amount of $198,050. DOD obligated $99,025 for the award in the first year. The awardee disbursed $10,439 and returned the remaining $88,586 of the obligated funds to the agency.

[b]Total obligated funds may not sum precisely to total shown because of rounding.

Our review of agency funding data also showed that CDC, NIH, and DOD provided awards to 13 Chinese entities (see table 2). Three Chinese entities—the University of Hong Kong, Peking University, and the Chinese Center for Disease Control and Prevention (Chinese CDC)—received 84 percent of direct funding. Two of these three entities—the University of Hong Kong and the Chinese CDC—received awards from more than one agency.

[18]Individual agency obligations do not sum precisely to $28.9 million due to rounding.

Table 2: Chinese Entities that Received Federal Funding for Research Collaboration, Fiscal Years 2015–2021

Chinese Entity	Centers for Disease Control and Prevention	National Institutes of Health	Department of Defense	Total obligated funds (millions of dollars)
University of Hong Kong	1	1	1	10.7
Peking University	-	3	-	8.8
Chinese Center for Disease Control and Prevention	2	2	-	4.9
George Institute for Global Health China	-	1	-	1.0
Fudan University	-	1	-	0.7
Institut Pasteur of Shanghai	-	1	-	0.6
China Medical University	-	2	-	0.5
Southern Medical University	-	1	-	0.5
Wuhan University/Institut Pasteur of Shanghai[a]	-	1	-	0.5
Shanghai Institute of Materia Medica	-	1	-	0.3
Nanjing Medical University	-	1	-	0.2
City University of Hong Kong	-	-	2	0.1
Hong Kong Polytechnic University	-	-	1	0.05
Total	**3**	**15**	**4**	**28.9**

Source: GAO analysis of agency data. | GAO-22-105313

Note: (-) indicates no awards.

[a]According to the National Institute of Health (NIH) officials, the Principal Investigator associated with the award changed entities from the Institut Pasteur of Shanghai to Wuhan University. Officials stated that in 2017 the Institut Pasteur of Shanghai submitted a relinquishing statement to the agency to certify that they did not wish to replace the Principal Investigator and supported transferring the grant to Wuhan University in 2018. NIH approved the request to change the recipient institution and retain the original Principal Investigator. According to agency data, the Institut Pasteur of Shanghai received $310,230 of the award and Wuhan University received $206,820.

Over one-third of the funding ($10.8 million) to Chinese entities was provided to entities in Hong Kong, and the remaining $18.1 million awarded to entities in mainland China. As noted earlier, the U.S. government treated Hong Kong separately from China until July 2020. All four of DOD's awards were made to entities in Hong Kong. CDC and NIH made awards to entities in both Hong Kong and mainland China.

Of the 22 awards to Chinese entities, 17 were closed and five remained ongoing (NIH had three and CDC had two), as of July 2022.

Chinese Entities Received Additional Federal Research Funds through Subawards, but the Full Extent is Unknown

According to USAspending.gov data, U.S. award recipients from all five agencies we reviewed reported providing subawards to Chinese entities during fiscal years 2015 through 2021. Information on federal research funds provided through subawards to Chinese entities is not fully known because of limitations in the data provided in response to federal reporting requirements for subawards. Specifically:

- Award recipients are required to report information on first-tier subawards that are $30,000 or more.[19] Information on subawards that fall below $30,000 and those below the first-tier (e.g., second-tier or third-tier) is not required to be reported in government-wide systems.
- According to Office of Management and Budget guidance, the quality of data that award recipients report in FSRS is the legal responsibility of the award recipient. The guidance further provides that agencies are not required to certify the quality of subaward data reported in FSRS and made available on USAspending.gov.[20] As previously

[19]2 C.F.R. part 170 which includes implementing guidance to federal awarding agencies on recipient reporting of subawards in accordance with FFATA for grants and cooperative agreements, includes an award term for inclusion in award that meet the funding threshold regarding recipient subaward reporting requirements. This award term also exempts recipients that, in the previous tax year, had a gross income, from all sources, under $300,000 from reporting subawards. In addition, the requirements of 2 C.F.R. part 170 do not apply to individuals who receive a federal award and allow for OMB to exempt classes of federal awards or recipients when exceptions are not prohibited by statute. See 2 C.F.R. § 170.110 (b), (c).

[20]Office of Management and Budget, *Appendix A to OMB Circular No. A-123, Management of Reporting and Data Integrity Risk.* M-18-16, June 6, 2018. According to the same OMB guidance, agencies are responsible for resolving audit findings that may indicate if recipients are not complying with subaward reporting requirements. In addition, certain audits undertaken in accordance with the Single Audit Act include a compliance review of FFATA required subaward data. 2 C.F.R. pt. 200, Appendix XI, 3-L-1, July 2022. (This Compliance Supplement identifies compliance requirements expected to be considered as part of an audit required by the 1996 Amendments to the Single Audit Act.)

discussed, a federal awarding agency has a direct relationship with an award recipient, but has no direct relationship with subrecipients.[21]

Federal Awards Provided to Chinese Entities Focused on a Range of Scientific Disciplines, Including Public Health and Biological Sciences

Three of the five agencies (CDC, NIH, and DOD) funded Chinese entities through grants and cooperative agreements to conduct a range of research. CDC and NIH funded biomedical and public health research, while DOD funded research in other scientific disciplines. These awards provided directly to Chinese entities resulted in joint publications, information sharing, and workshops.

CDC and NIH Funded Chinese Entities to Conduct Public Health and Biomedical Research

CDC and NIH funded Chinese entities to conduct a wide range of research, including disease surveillance, vaccination studies, and the development of new drugs (see table 3). According to CDC and NIH, China provides a unique ecological environment where researchers can combat infectious diseases that could pose a threat to the U.S. and globally.

Table 3: Examples of Federal Funding Provided Directly to Chinese Entities for Public Health and Biomedical Research, Fiscal Years 2015–2021

U.S. Agency	Research Purpose
Centers for Disease Control and Prevention (CDC)	Disease surveillance and epidemiology • Assess incidences and identify causes of recurring and emerging infectious diseases • Determine risk factors and severity of influenza infections in specific groups, such as older adults, children, and pregnant women

[21]Guidance for Grants and Agreements, 85 Fed. Reg. 49506, 49508 (Aug. 13, 2020) (codified at 2 C.F.R. pts. 25, 170, 183, and 200). Certain agencies have additional vetting requirements for subawards. For example, the U.S. Agency for International Development (USAID) has guidance referred to as *Mission Order 21,* which requires that certain individuals and non-U.S. organizations undergo vetting. The vetting requirements apply to certain contractors and subcontractors, recipients of grants and cooperative agreements, trainees and students, and recipients of cash or in-kind assistance, with some exceptions. The guidance states that USAID's West Bank and Gaza Mission is required to ensure that applicable vetting approval is obtained before a subaward is made, and mandatory provisions are included in subaward documents, as applicable. For additional information, see GAO, *West Bank and Gaza Aid: Should Funding Resume, Increased Oversight of Subawardee Compliance with USAID's Antiterrorism Policies and Procedures May Reduce Risk*s, GAO-21-332 (Washington, D.C.: Mar. 29, 2021).

U.S. Agency	Research Purpose
	Vaccination coverage and effectiveness • Assess economic benefits of increased influenza vaccination coverage • Promote seasonal influenza vaccination among specific populations such as people with chronic diseases and health care workers Capacity building and program management activities • Strengthen ability to prepare for emerging and re-emerging infectious diseases • Support epidemic and pandemic preparedness activities
National Institutes of Health (NIH)	Disease surveillance and transmission studies • Determine resistance level to dengue among vector populations in urban and rural environments Longitudinal studies on health and retirement among elderly Chinese • Evaluate dementia among elderly Chinese Therapeutic and drug development studies • Explore new therapeutics to treat malignancies associated with Kaposi's sarcoma • Generate data to help design new HIV drugs Vaccination studies • Identify and characterize new malaria vaccine candidates

Source: GAO analysis of CDC and NIH documents. | GAO-22-105313

CDC-funded research. Based on our review of agency documents, we determined that CDC award recipients focused on (1) surveillance, epidemiology, and pathogenicity of emerging, re-emerging, and novel viruses and (2) vaccination coverage and effectiveness.[22] For example, one award to the University of Hong Kong monitored (1) cases of laboratory-confirmed influenza infections and illness among older adults, the severity of influenza on adult health and functionality, and (2) the potential impact of different vaccination strategies, including receiving once or twice-annual vaccinations among participants. Collectively, these efforts were part of two immunogenicity studies: examining twice-annual influenza vaccinations and alternate vaccination strategies in older adults.

[22]Pathogenicity refers to a bacterium, virus, or other microorganism's ability to cause disease following infection. Centers for Disease Control and Prevention, "Glossary," Atlanta, GA: July 2, 2024, accessed June 1, 2022, https://www.cdc.gov/csels/dsepd/ss1978/glossary.html#:~:text=pathogenicity%20the%20ability%20of%20an,who%20then%20experience%20clinical%20disease. In addition, epidemiology studies the distribution (frequency, pattern) and determinants (causes, risk factors) of health issues or events in specific populations. Centers for Disease Control and Prevention, "What is Epidemiology?" Atlanta, GA: June 17, 2016, accessed June 1, 2022, https://www.cdc.gov/careerpaths/k12teacherroadmap/epidemiology.html#:~:text=By%20definition%2C%20epidemiology%20is%20the,state%2C%20country%2C%20global.

In addition to studying influenza seasonal trends, the CDC works with entities like the Chinese CDC to monitor other emerging infectious diseases. For example, a 2017 CDC-funded project collected blood samples in China from local residents and citizens returning from travel during the Zika epidemic in 2016 to monitor mosquito-borne diseases such as Zika and dengue.[23]

Other CDC-funded research activities focused on vaccination effects and benefits of increased vaccination within certain populations. In addition to monitoring influenza among at-risk populations, the CDC works with the Chinese CDC to promote influenza vaccination policy as part of a global health strategy to support public health systems. For example, Chinese CDC researchers sought to understand whether workplace requirements or on-site vaccination sites, common tools in the U.S. and Canada, could be similarly effective in China. As part of the project, the team developed an "Influenza Prevention and Control Strategy" for the 2018–2019 and 2019–2020 seasons, issued technical guidelines, and promoted materials online and in Chinese journals.

In interviews, CDC officials characterized collaborative research with the Chinese CDC as public health research and highlighted the 30 year partnership with China-based collaborators to support and enhance influenza research among animals and humans and inform seasonal trends.

NIH-funded research. Based on our review of agency documents, we determined that NIH award recipients focused on biomedical research with Chinese entities. Specifically, NIH awards to Chinese entities focused on (1) monitoring disease transmission and (2) supporting a longitudinal study examining elderly health and retirement. For example, based on our review of progress reports, we determined that an NIH-funded award to Southern Medical University in Guangzhou conducted field sampling and molecular studies in China to determine resistance levels of dengue-carrying mosquitoes.

[23]A pregnant woman may transmit Zika, which has the potential to cause severe brain defects and other challenges during birth, to her fetus. Centers for Disease Control and Prevention, "Zika Virus," Atlanta, GA: May 20, 2019, accessed June 14, 2022, https://www.cdc.gov/zika/about/overview.html, and "About Dengue: What You Need to Know," Atlanta, GA: Sept. 23, 2021, accessed June 14, 2022, https://www.cdc.gov/dengue/about/index.html. Approximately half of the world lives in areas at-risk areas for dengue.

Another NIH-funded grant with a Chinese entity focused on developing therapeutics and antiviral drugs to target specific diseases. For example, one award to the Shanghai Institute of Materia Medica studied the coreceptor, proteins that serve as the binding sites for molecules and viruses similar to the human immunodeficiency virus.

NIH officials told us that the agency only funds biomedical programs and activities with Chinese entities. According to the 2019 U.S.-China Program for Biomedical Research Cooperation agreement, cooperative medical research benefits both countries.[24] Officials noted that biomedical activities between both countries have recently increased because of the agreement. Projects in the agreement cover allergy, immunology, infectious diseases, cancer, mental health, Parkinson's disease, and stroke research.

DOD Funded Chinese Entities to Conduct Research in Other Scientific Disciplines

Based on our review of agency documents, we determined that DOD award recipients addressed a range of scientific topics, including alternative technologies to propel vehicles such as drones (see table 4).

Table 4: Department of Defense (DOD) Research Funding Provided Directly to Chinese Entities, Fiscal Years 2015–2021

Research Purpose
• Apply probabilistic and statistical methods to improve battery life
• Compare impacts of applying a fully electronic technology to study air flow of vehicles such as drones
• Develop feedback method for video-based tracking control and test new methods using robotic platforms
• Hold international conference on molecular electronic materials and other topics

Source: GAO analysis of DOD documents. | GAO-22-105313

Note. All four of the awards funded by DOD were made to entities in Hong Kong.

For example, one award to the City University of Hong Kong conducted research on applying probabilistic and statistical methods to improve the optimization of run time of portable electronics and distributed grid systems. In interviews, officials stated this award was funded by the Navy

[24]U.S. Department of Health and Human Services, *U.S.-China Program for Biomedical Collaborative Research (R01 Clinical Trial Optional)* (Washington, D.C.): accessed Sept. 23, 2022, https://grants.nih.gov/grants/guide/rfa-files/rfa-ca-19-009.html.

International Cooperative Opportunities in Science and Technology to address naval science and technology challenges.

Another award to the Hong Kong Polytechnic University examined air flow control and the role of plasma actuators to advance aerodynamic performance and capabilities of unmanned aerial vehicles and micro aerial vehicles.[25] According to DOD, because of the emerging role of aerial vehicles in intelligence, surveillance and reconnaissance applications, such research can advance the agency's understanding in these areas.

Federal Awards Provided to Chinese Entities Resulted in Joint Publications, Information Sharing, and Workshops

We found three main kinds of results of awards provided by federal agencies to Chinese entities (see fig. 3).

Figure 3: Results of Collaborative Research between the U.S. and Chinese Entities

Source: GAO analysis of agency documents; Irina Strelnikova/adobe.stock.com (image, far right). | GAO-22-105313

Joint publications. Based on our review of award documents, we determined that federal research funds provided to Chinese entities resulted in scientific and academic articles. For example, researchers on

[25]A plasma actuator is a device that could be used for active flow control. It can delay or eliminate flow separation, and thus improve aerodynamic performance of airfoils, straight wings, delta wings, aircraft, and bluff bodies. See Jinjun Wang and Lihao Feng, *Flow Control Techniques and Applications* (Cambridge, UK: Cambridge University Press, 2018).

one CDC award published articles on influenza illness and hospitalizations among young children.[26] Other examples include an NIH-funded award at Wuhan University that resulted in publications on the replication and persistence of Kaposi's sarcoma-associated herpesvirus. Similarly, a DOD award to the Hong Kong Polytechnic University led to four academic articles and two conference papers.

Information sharing. Based on our review of award documents, we determined that federal research funds provided to Chinese entities also resulted in data collection systems, improved frameworks, and policy and technical guidance updates. These efforts facilitate sharing of information and enhance global access to public health data, according to award documents. For example, one NIH award to the National School of Development of Peking University resulted in a website that provides project data, documentation, and updates of recent progress on the China Health and Retirement Longitudinal Study. Another collaborative CDC project established an epidemiological information collection system, similar to platforms in Europe and the U.S.[27]

Workshops. Based on our review of award documents, we determined that federal research funds provided to Chinese entities resulted in workshops, conferences, or poster presentations. For example, one CDC award to the Chinese CDC resulted in presentations at national and provincial conferences in 2020 on influenza illnesses and hospitalizations among children in Suzhou. The award also resulted in a series of workshops to test and update a risk assessment tool for an avian strain of influenza, making it more applicable to conditions in China. During one of the workshops, researchers conducted a tabletop exercise, creating different scenarios for influenza pandemic preparedness and response. Similarly, a DOD-funded award, in 2015, to the City University of Hong Kong resulted in an international conference on molecular electronic materials and devices.

[26]W. Zhang, J. Gao, L. Chen, J. Tian, M. Biggerstaff, S. Zhou, S. Situ, Y. Wang, J .Zhang, A.J. Millman, C.M. Greene, T. Zhang, and G. Zhao. "Estimated influenza illnesses and hospitalizations averted by influenza vaccination among children aged 6-59 months in Suzhou, China, 2011/12 to 2015/16 influenza seasons," *Vaccine*, vol. 38, no. 51 (2020): 8200–8205.

[27]CaliciNet is the U.S. national norovirus outbreak surveillance network of federal, state, and local public health laboratories in the U.S.

The U.S. Contributed Funding to Some Multilateral Institutions that Support Activities in China

The U.S. government, along with other donors, provided funding from fiscal years 2015 through 2020 to some multilateral institutions that, in turn, supported a range of activities worldwide including in China. Multilateral institutions fund projects such as education, infrastructure, and economic development.[28] According to State and Treasury officials, multilateral institutions specify how funding should be used and which country should receive funding.[29]

From fiscal years 2015 through 2020, the U.S. government provided approximately $9.6 billion to the eight selected multilateral institutions that funded activities in China, among other locations.[30] For example, one multilateral institution that received U.S. funding—the International Bank for Reconstruction and Development—reported loan agreements with 78 countries in 2021, of which China was one.

Of the $9.6 billion, the U.S. provided about $1.6 billion in appropriated funds to a trust fund and multilateral development banks and obligated about $8 billion for selected UN agencies. The U.S. was one of many donor countries to provide funding to multilateral institutions that fund activities in China. According to State and Treasury officials, U.S. funding to multilateral institutions was pooled with funding from other donors, and thus cannot be directly attributed to activities multilateral institutions funded in China or in other countries.

The U.S. government provided about $1.6 billion in appropriated funds for one trust fund and two multilateral development banks that reported funding programs or loans in China (see table 5). Trust funds address specific issues by providing support for global public goods, fragile and

[28]This section of the report analyzes funding data from fiscal years 2015 through 2020 because it was the most recent data available across the selected multilateral institutions. The funding information includes all sectors, and is not limited to research.

[29]While the U.S. government does not control how multilateral institutions use U.S. funding, it may retain some influence, according to U.S. officials. The U.S. is often the largest or among the largest shareholders or donors to many multilateral institutions. As a large shareholder or donor, the U.S. at a high level may advocate for policies in its interests, have voting power, or exercise veto rights depending on the multilateral institution.

[30]The selected multilateral institutions are: Global Environment Facility (GEF), World Bank's International Bank for Reconstruction and Development (IBRD), Asian Development Bank (ADB), the UN Children's Fund (UNICEF), the UN World Health Organization (WHO), the UN Development Programme (UNDP), the UN International Fund for Agricultural Development (IFAD), and the UN Industrial Development Organization (UNIDO).

conflict-affected states, disaster prevention and relief, global and regional partnerships, and knowledge and innovation. Multilateral development banks provide countries with financial assistance, such as loans, to promote economic and social growth.

Table 5: U.S. Appropriations Provided to Selected Multilateral Institutions that Subsequently Provided Funds to Member Countries, Including China, Fiscal Years 2015–2020

	Appropriations (millions of dollars)
Trust fund	
Global Environment Facility (GEF)	870
Multilateral development banks	
World Bank International Bank for Reconstruction and Development (IBRD)	586
Asian Development Bank (ADB)[a]	112
Total	**1,568**

Source: GAO analysis of annual enacted appropriations acts. | GAO-22-105313

Note: Funds shown in the table were provided to multilateral institutions that fund multiple countries, including China. Congress appropriates funds for international financial institutions to the Department of the Treasury, which then pays those funds to multilateral institutions. Congress appropriates GEF funds for payment to IBRD, which is the trustee for GEF.

[a]Beginning in fiscal year 2017, appropriations for the ADB have only been provided for the Asian Development Fund, which does not provide funding to China. Funds shown in the table were appropriated for the ADB in fiscal years 2015 and 2016, and do not include appropriations for the Asian Development Fund.

State and Treasury Congressional Budget Justifications describe the U.S. government's rationale for funding multilateral institutions.

Global Environment Facility. GEF funds activities in countries with developing economies to address international environmental issues. GEF programs around the world address health and safety issues that may affect Americans, such as preventing toxins from entering U.S. food, water, and air, and supporting U.S. companies by conserving fish stocks and curbing illegal international logging.

International Bank for Reconstruction and Development. IBRD is a World Bank agency that provides loans at market-based interest rates to middle-income countries for economic and social development activities. Contributing to the World Bank enables the U.S. to maintain shareholding and voting power and promotes U.S. foreign policy objectives.

Asian Development Bank. ADB provides funding to the private sector and long-term loans at market-based interest rates to middle-income Asian countries to support infrastructure and economic development. ADB supports markets and economies in countries that are important to U.S. strategic interests and assists countries in addressing environmental issues.

The U.S. government also obligated about $8 billion for five UN agencies that funded activities in China, among other locations (see table 6).[31]

Table 6: U.S. Obligations for Selected United Nations (UN) Agencies that Funded Activities in Multiple Countries, Including China, Fiscal Years 2015–2020

Agency	Obligations (millions of dollars)
UN Children's Fund	4,159
UN World Health Organization	2,252
UN Development Programme	1,401
UN International Fund for Agricultural Development	184
UN Industrial Development Organization	12
Total	**8,008**

Source: GAO analysis of the Department of State annual report, U.S. Contributions to International Organizations. | GAO-22-105313

Note: Funds shown in the table were provided to multilateral institutions that fund multiple countries, including China. Congress appropriates contributions to U.S. agencies to meet annual obligations of membership in international multilateral organizations, including the United Nations. The Departments of State and Treasury manage the obligation and disbursement of those funds to UN agencies.

State and Treasury Congressional Budget Justifications describe how U.S. funding for the UN promotes U.S. security interests by supporting stability in global economy and politics, among other outcomes. For example, UNDP's mission is to promote sustainable development, democratic governance and peace building, and climate and disaster resilience. Additionally, IFAD is an UN multilateral fund that addresses poverty and malnutrition and works to improve farmers' productivity and incomes. IFAD promotes U.S. interests by reducing poverty and increasing economic growth in rural areas.

[31]We are reporting obligations data for the five UN agencies because U.S. appropriations data are not available for UNICEF, WHO, UNDP, and UNIDO. Rather than appropriating funding directly to UN agencies, Congress appropriates funding to accounts managed by federal agencies that obligate and disburse the funding to the selected UN agencies.

The selected multilateral institutions support countries globally, including China, to achieve outcomes such as improving infrastructure, addressing climate and environmental issues, improving childhood education, addressing health disparities, and promoting economic development (see table 7).[32]

Table 7: Examples of Selected Multilateral Institutions' Goals and Activities in China

Multilateral Institution	Goals and Objectives	Activities
Asian Development Bank (ADB)	Support China through knowledge transfer, such as policy-oriented technical assistance. Mitigate and adapt to climate change, strengthen regional cooperation in China and with other countries, and reduce poverty and inequality.	ADB provided technical assistance, such as policy research on ecological protection and rural vitalization. ADB provided loans, equity investments, and other funding for projects in areas such as microfinance, farmers' access to financing, and economic and social infrastructure.
Global Environment Facility (GEF)	Support work to address environmental issues, including biodiversity loss, control of chemicals and waste, climate change, management of international waters, and land degradation.	GEF provided funding for projects in areas such as wetland protection and migratory bird conservation in China.
United Nations Children's Fund (UNICEF)	Improve the health and nutrition of children and decrease their mortality and poverty rates. Improve the quality and inclusivity of education with a focus on girls. Protect children from violence, abuse, and bullying, including online exploitation.	China participated in UNICEF projects in areas such as early childhood development, poverty reduction, and social protection programs, which included information, policy dialogues, and network and partnership building.
United Nations Development Programme (UNDP)	Work in partnership with China to ensure inclusive and environmentally sustainable development and strengthen resilience to natural disasters and public health emergencies.	UNDP provided funding for projects in areas such as alleviating poverty, reducing pollutants, and empowering women from ethnic minorities to participate in industry.
United Nations Industrial Development Organization (UNIDO)	Promote inclusive and sustainable industrial development by achieving low-carbon economic growth, addressing food insecurity, and strengthening international cooperation.	UNIDO provided funding for projects in areas such as advancing economic competition, reducing poverty, improving food safety, and establishing eco-effective urban development.

[32]In 2015, the UN adopted 17 sustainable development goals that address poverty, health, education, equality, economic growth, sustainability and infrastructure, the environment and climate, peaceful and just societies, and global partnership. These goals apply across all UN agencies, including UNICEF, WHO, UNDP, IFAD, and UNIDO. Additionally, the GEF, the World Bank, and the ADB have acknowledged dedication to achieving the UN sustainable development goals. The sustainable development goals are not reproduced in table 7.

Multilateral Institution	Goals and Objectives	Activities
United Nations International Fund for Agricultural Development (IFAD)	Reduce rural poverty and support inclusive access to markets, such as for owners of small farms. Strengthen environmental sustainability and climate resilience.	IFAD provided funding for projects in areas such as poverty reduction and rural revitalization. IFAD established the China-IFAD South-South and Triangular Cooperation Facility to increase global exchanges, innovation, and investment in rural areas.
United Nations World Health Organization (WHO)	Reduce health inequity in China, such as inequity resulting from discrimination or disadvantage of employment, gender, ethnicity, sexual orientation, physical or mental impairment, or socioeconomic status. Strengthen health systems to achieve universal health coverage, and reduce morbidity and mortality rates.	China participated in a WHO malaria elimination program, E-2020, which included WHO-provided guidance, forums, and advisory bodies.
World Bank International Bank for Reconstruction and Development (IBRD)	Support environmentally sustainable, socially inclusive, and competitive development of the private sector. Gradually decrease IBRD funding of activities in China.	IBRD provided loans in areas such as rural development, energy, transport, education, health, urban development, and the environment. IBRD provided technical assistance on economic and financial topics.

Source: GAO analysis of documents published by the selected multilateral institutions. | GAO-22-105313

Agency Comments and Our Evaluation

We provided a draft of our report to CDC, DOD, DOE, NIH, NSF, State, and Treasury. DOD, DOE, NIH, NSF, and State did not have comments on the draft of our report. CDC and Treasury provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretaries of Defense, Energy, Health and Human Services, State, and Treasury, the Director of the National Science Foundation, and other interested parties. In addition, the report is available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact Candice N. Wright at (202) 512-6888 or WrightC@gao.gov or Kimberly Gianopoulos at (202) 512-8612 or GianopoulosK@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may

be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Candice N. Wright
Director, Science, Technology Assessment, and Analytics

Kimberly Gianopoulos
Director, International Affairs and Trade

Appendix I: Objectives, Scope, and Methodology

Our objectives for this report were to describe (1) the amount of funding departments and agencies provided to Chinese entities for collaborative research, (2) selected departments' and agencies' programs and activities, and results of their collaborative research with Chinese entities, and (3) funding the U.S. has provided to selected multilateral institutions that support activities in China.[1]

For the first and second objectives, we selected for review the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), the Department of Defense (DOD), the Department of Energy (DOE), and the National Science Foundation (NSF). We selected these federal agencies based on NSF's report on federal obligations for research and development, prior GAO work, and publicly available data in USAspending.gov. [2] The USAspending.gov website is the official source of spending data submitted by federal agencies and includes subaward data reported by award recipients.

Our analysis of grants and cooperative agreements award data published in a government-wide public database of federal spending—USAspending.gov—showed that from fiscal years 2015 through 2021, NIH and CDC accounted for over 95 percent of U.S. federal awards made directly to Chinese entities. DOD, DOE, and NSF each had at least five award recipients that reported subawards to Chinese entities. In addition, based on the most recent data available, NSF's Federal Funds for Research and Development: Fiscal Years 2020–21, these five agencies accounted for over 80 percent of all federal research and development obligations in fiscal year 2020.

To examine how the selected agencies fund collaborative research with Chinese entities, we collected and analyzed annual obligations data from the five selected agencies for research grants and cooperative

[1]In July 2020, Executive Order 13936 ended the U.S. recognition of the Special Administrative Region of Hong Kong because the President determined it was no longer sufficiently autonomous to justify differential treatment in relation to China. The executive order directed agencies to take specified actions to suspend or eliminate preferential treatment for Hong Kong because of China's decision to impose new national security legislation in the region. For the purposes of this report, we have treated Hong Kong as a part of China.

[2]GAO, *Federal Research: Agency Actions Needed to Address Foreign Influence,* GAO-22-105434 (Washington, D.C: Oct. 5, 2021) and *Federal Research: Agencies Need to Enhance Policies to Address Foreign Influence,* GAO-21-130 (Washington, D.C.: Dec. 17, 2020).

agreements with Chinese entities for fiscal years 2015 through 2021.[3] These funds were provided directly from a federal award agency to a Chinese entity in mainland China and Hong Kong. We analyzed award information, such as entity name, location, amount funded, performance period and status (open or closed) from fiscal years 2015 through 2021. We also interviewed agency officials about the collection, management and reliability of their internal databases and processes. Award data provided by agencies were corroborated by the publicly available data on the USAspending.gov for three agencies with federal awards (CDC, DOD, and NIH). For NIH, we also compared their award data with information available on the Research Portfolio Online Reporting Tool, which provides information on NIH awards. We reviewed and discussed the methodology with agency officials and found these data to be sufficiently reliable for the purposes of our reporting objectives. For subaward data, we reviewed one public source—USAspending.gov—but did not find these data sufficiently reliable to report on for the purposes of our reporting objectives.[4]

To examine the selected agencies' programs, activities, and results of collaborative research with Chinese entities from fiscal years 2015 through 2021, we reviewed relevant agency documents, including interim and final progress reports. For NIH, we focused our review on awards valued at or above $100,000, and for NSF, we reviewed awards valued at or above $1 million. For the remaining agencies CDC, DOD, and DOE we reviewed documents for all award recipients. We also interviewed agency officials from CDC, DOD, DOE, NIH, and NSF about the programs, activities, and results of collaborative research with Chinese entities that these agencies funded.

To examine U.S. funding to multilateral institutions that support activities in China, we reviewed Department of Treasury's (Treasury) and Department of State's (State) Congressional Budget Justifications for fiscal years 2015 through 2022, and State's annual report on U.S. Contributions to International Organizations for fiscal years 2015 through

[3]Agencies we reviewed provided data on Federal Acquisition Regulation-based (FAR) contracts with Chinese entities but the purpose of the contracts was not for collaborative research. For this reason, we excluded FAR-based contracts from our analysis.

[4]See the first section of this report for additional information on subawards.

2020 (the most current data available).[5] For each multilateral institution listed in State's budget justifications, we reviewed the institution's website and annual reports to determine whether the institution made funding or loans available to China. Based on this analysis, we identified three multilateral institutions that reported funding activities in China between 2018 and 2020: one trust fund—the Global Environment Facility, and two multilateral development banks—the World Bank International Bank for Reconstruction and Development and the Asian Development Bank. For each multilateral institution, we analyzed annual enacted appropriated funds for fiscal years 2015 through 2020.[6]

We also selected five United Nations (UN) agencies that the U.S. government funds—the Children's Fund, the World Health Organization, the Development Programme, the International Fund for Agricultural Development, and the Industrial Development Organization—because they were the five UN agencies with the highest expenditures in China in 2019 and 2020, according to UN documents. In addition, we discussed these data with Departments of the Treasury (Treasury) and State (State) officials and found them to be sufficiently reliable for the purposes of our reporting objectives. The funding analyzed in this objective included a range of activities such as infrastructure, education, and economic development.

We also interviewed relevant officials from State and Treasury, which obligate and disburse these contributions for the U.S. government. We reviewed the selected multilateral institutions' websites and public reports to gather information on the goals and activities of the multilateral institutions, including frameworks and priorities, programming directions, and country cooperation strategies. We also reviewed other documents on the selected multilateral institutions' partnerships with China.

[5]See Department of State, *Congressional Budget Justification Department of State, Foreign Operations, and Related Programs*, for fiscal years 2017–2022; Department of the Treasury, *International Programs Congressional Justification for Appropriations*, for fiscal years 2017–2022; and Department of State, *Report to Congress on U.S. Contributions to International Organizations*, for fiscal years 2015–2020.

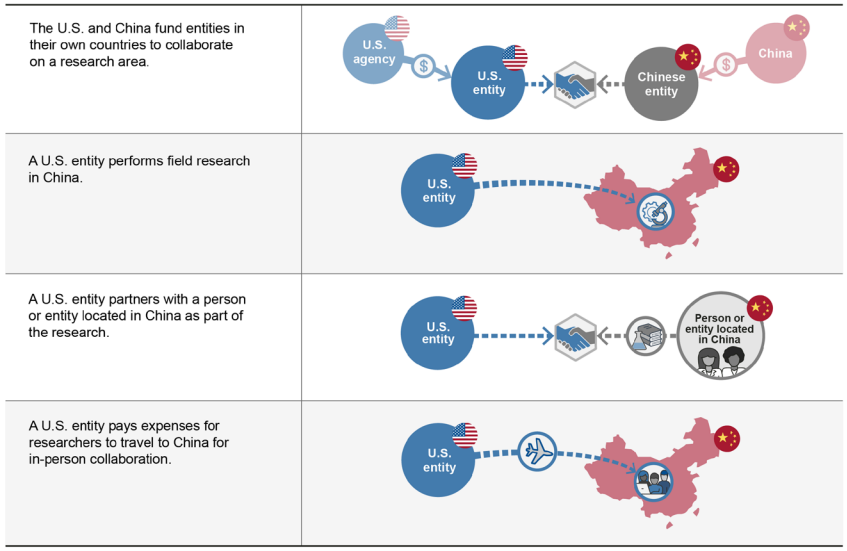
[6]Further Consolidated Appropriations Act, 2020, Pub. L. No. 116-94, 133 Stat. 2534 (2019); Consolidated Appropriations Act, 2019, Pub. L. No. 116-6, 133 Stat. 13; Consolidated Appropriations Act, 2018, Pub. L. No. 115-141, 132 Stat. 348; Consolidated Appropriations Act, 2017, Pub. L. No. 115-31, 131 Stat. 135; Consolidated Appropriations Act, 2016, Pub. L. No. 114-113, 129 Stat. 241 (2015); and Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130 (2014).

We conducted this performance audit from June 2021 to September 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Examples of Other U.S. Collaborations with Chinese Entities

The Department of Energy (DOE) and the National Science Foundation (NSF) provided examples of other research collaborations with Chinese entities in which the entity was neither an award recipient nor a subrecipient of federal research funds (see fig. 4).

Figure 4: Examples of Other Kinds of U.S. Research Collaboration with Chinese Entities



Source: GAO analysis of agency documents. | GAO-22-105313

Note: U.S. entities include agencies, universities, and national laboratories.

Table 8 provides examples of these research collaborations based on a review of select DOE and NSF documents, including annual reports, and supporting project documentation.

Table 8: Other DOE and NSF Research Collaborations with Chinese Entities, Fiscal Years 2015–2021

Agency	Research purpose
Department of Energy (DOE)	Clean energy (Clean Energy Research Center) • Contribute to improvements in technologies that have the potential to reduce emissions and dependence of commercial trucks on oil (Medium and heavy-duty trucks project) • Develop materials and a design that double thermal performance and reduces weight (Building energy efficiency project) • Investigate using additive manufacturing to print 3D molds for complex features sought by architects (Building energy efficiency project) • Develop technologies that promote energy and water security (Water and energy technologies project) • Help to develop new, efficient, low-cost, and clean transportation technologies (Clean vehicles project) Fusion energy • Understand and control plasma-material interface to improve long pulse discharge control and performance in experimental advanced superconductors • Adapt high performance scenarios from the DIII-D National Fusion Facility for the Experimental Advanced Superconducting Tokamak Climate impacts • Evaluate impacts of power grid operations from climate impacts on drought-susceptible regions • Increase understanding of climate events involving water • Develop tools for simulating physical and geochemical processes of basin-scale groundwater
National Science Foundation (NSF)	• Examine disease dynamics across a gradient of pathogen invasion, determine role of the environment in pathogen dynamics, and examine the role of host resistance • Examine the role that wastewater treatment plants play in antimicrobial resistance • Understand reciprocal relationships between different payments for ecosystem services • Broaden access to clean drinking water through technologies such as modular systems, water cleanup for reuse and recycle, and nanomaterials • Evaluate the interaction effects between socioeconomic and environmental processes over distances such as the trade of agricultural products on human and natural systems

Source: GAO analysis of department and agency documents. | GAO-22-105313

One example of a DOE-supported collaboration is the U.S.-China Clean Energy Research Center, a program completed in September 2021, where each country funded its own participants in their respective countries. In interviews, DOE officials described the Clean Energy Research Center as a program focused on research and development in clean coal, clean vehicles, and energy efficiency in buildings. The goal of the Center's Clean Energy Research Center Clean Vehicles project was to develop new, efficient, low-cost, and clean transportation and to advance technologies to the market. Scientists developed a China Vehicle Fleet Model, based on Argonne National Laboratory's U.S. model. In partnership with Aramco Services and the Chinese Society of Automotive Engineers, scientists produced a Chinese model that

considered alternative vehicle technologies and fuels, potential regulations, and energy and emissions policies. As part of this work, scientists collaborated with industry partners to review and continually improve the model's methodologies and interfaces.

NSF officials characterized research with Chinese entities as collaborations or partnerships, where the entity is neither a recipient nor a subrecipient of federal research funds. According to officials, these partnerships may accelerate discovery; enable access to expertise, infrastructure, or sites; and build broader communities of researchers. In our review of NSF's progress and final performance reports, we found examples where field work was performed in China, Chinese researchers were involved in the project through a Chinese-affiliated institution, or researchers traveled to China for conferences or workshops.

For example, an NSF award to Virginia Polytechnic Institute and State University examining the role of wastewater treatment plants in antimicrobial resistance included partners from the University of Hong Kong, Hong Kong Polytechnic University, the Chinese Academy of Sciences, and Nankai University, along with partners from India, the Philippines, Portugal, Sweden, and Switzerland. In addition to drafting manuscripts evaluating the impact of wastewater treatment practices on antimicrobial resistance, researchers collected and analyzed wastewater samples for COVID-19 monitoring. According to NSF officials, partners in China provided access to key sampling sites and made intellectual contributions as internationally-recognized scholars in wastewater treatment plant-mediated dissemination.

Appendix III: GAO Contact and Staff Acknowledgment

GAO Contacts	Candice N. Wright, (202) 512-6888 or WrightC@gao.gov. Kimberly Gianopoulos, (202) 512-8612 or GianopoulosK@gao.gov.
Staff Acknowledgments	In addition to the contacts named above, Farahnaaz Khakoo-Mausel (Assistant Director), Drew Lindsey (Assistant Director), Paul Kazemersky (Analyst-in-Charge), Emily Weisenberger, Megan Knox, Michael Steinberg, Kumba Gaye, Eric Charles, Jenny Chanley, Amy Pereira, Ashley Alley, Louise Fickel, and Ryan Han made key contributions to this report.