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**on
A Review of the President's Fiscal Year 2024 Funding Request for
the National Science Foundation**

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Introduction

Chair Shaheen, Ranking Member Moran, and Members of the Subcommittee, 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.