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

**on**
**"A Review of the NSF FY2020 Budget Request"**

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## Introduction

Chairwoman Stevens, Ranking Member Baird, and Members of the subcommittee, it is a privilege to be here with you today to discuss the President's Fiscal Year (FY) 2020 Budget Request for the National Science Foundation (NSF).

Established by the National Science Foundation Act of 1950 (P.L. 81-507), NSF is an independent Federal agency whose mission is "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 fundamental research across all fields of science, technology, engineering and mathematics (STEM) and all levels of STEM education. NSF is also committed to the development of a future-focused science and engineering workforce that draws on the talents of all Americans. NSF accounts for approximately 25 percent of the total Federal budget for basic research conducted at U.S. colleges and universities and has been vital to many discoveries that impact our daily lives and drive the economy. NSF is and will continue to be a respected steward of taxpayer dollars, operating with integrity, openness, and transparency.

A vibrant scientific workforce and breakthrough discoveries enabled by NSF investments sustain, accelerate, and transform America's globally preeminent innovation ecosystem. A long-term vision, belief in the promise of fundamental research, and commitment to pursuing risky, yet potentially extraordinary discoveries are the hallmarks of NSF. NSF's investments empower discoverers to ask the questions and develop the technologies that lead to the next big breakthroughs.

This was most recently illustrated by the Event Horizon Telescope (EHT) team's successful work to produce the first image of a black hole. EHT used a planet-scale array of eight ground-based radio telescopes forged through international collaboration to image the black hole at the center of Messier 87, a massive galaxy in the nearby Virgo galaxy cluster. This black hole resides 55 million light-years from Earth. This momentous achievement was the product of a team building on decades of investment in telescopes, computing, and training the next generation of scientists.

In FY 2020, NSF will continue to support the science, technology, innovation and workforce development that drives this Nation's economy, ensures the security of the American people, and guarantees the United States' place as a global power for generations to come. To achieve these goals, NSF will make strategic investments across the agency to support basic research, while putting an emphasis on convergence—interdisciplinary research that spans and integrates all areas of science.

NSF has made a strong commitment to agency-supported research infrastructure. In FY 2020, NSF is requesting $1.089 billion for its major multi-user research facilities, including for construction in the MREFC account. Major NSF research facilities range from research stations in Antarctica, to a fleet of academic research ships, to a suite of world-leading telescopes. This research infrastructure is critical for delivering frontier scientific results such as detections of gravitational waves and supports the research of tens of thousands of U.S. scientists and students.

In addition, FY 2020 investments support several of the Administration's Research and Development Budget Priorities, including artificial intelligence (AI); quantum information science (QIS) research; advanced manufacturing; and microelectronics and semiconductors. These investments will strengthen the Nation's innovation base and contribute to unparalleled job growth, continued prosperity, and national security.

In FY 2020, NSF expects to evaluate approximately 46,100 proposals through a competitive merit review process and make approximately 10,400 new competitive awards, 8,000 of which will be new research grants and the remainder of which will be contracts and cooperative agreements. The number of new research grants decreases by roughly 11 percent from previous levels, in keeping with the overall change in total NSF funding. This process involves approximately 224,000 proposal reviews, engaging on the order of 32,000 members of the science and engineering community participating as panelists and proposal reviewers. In a given year, NSF awards reach over 1,800 colleges, universities, and other public and private institutions in 50 states, the District of Columbia, and U.S. territories. In FY 2020, NSF support is expected to reach approximately 348,400 researchers, postdoctoral fellows, trainees, teachers, and students, with 93 percent of the agency's annual budget used to fund research and education grants and research infrastructure in the science and education communities.

**The President's Fiscal Year 2020 Budget Request**

NSF's FY 2020 Budget Request is $7.066 billion, a 9.6 percent decrease from the FY 2018 Actual level and a 12.6 percent decrease from the FY 2019 Enacted level. With this level of funding, NSF will support basic research across all fields of science and engineering that create knowledge while investing in priority areas like:

- Advancing NSF's Big Ideas - bold questions that will drive NSF's long-term research agenda;

- Accelerating focused, cross-disciplinary efforts that will have impact in a short timeframe around two of the Big Ideas: Harnessing the Data Revolution and the Future of Work at the Human-Technology Frontier.
- Research and Development Priorities such as AI and Quantum Information Science.
- Continuing the Antarctic Infrastructure Modernization for Science project; and
- Investing in two detector upgrades to operate at the High Luminosity-Large Hadron Collider (HL-LHC).

## *NSF's BIG IDEAS*

Increasingly, collaboration and convergence are necessary to achieving our mission, especially in a world of constrained budgets. NSF continues to emphasize its 10 Big Ideas, research agendas that identify areas at the frontiers of science and engineering, which promise to be among the most transformative in the coming decade. Of the 10 Big Ideas, six are identified as research ideas. These are opportunities for researchers to make the discoveries that will shape the future of everything from quantum computing, artificial intelligence, and agriculture to space exploration and medical innovation. Each of these Big Ideas will be supported by an investment in dedicated activities for the Idea, as well as additional foundational investments from across the agency. The other four are Enabling Big Ideas, which endeavor to make science and engineering more interdisciplinary and reflective of the rich diversity of the U.S., while supporting investments in infrastructure and risky, high-reward science. New agency FY 2020 investment in the Research Big Ideas is $180.0 million. For Enabling Big Ideas, the FY 2020 investment totals $117.5 million. NSF's 10 Big Ideas are as follows:

**Research Big Ideas:**

1. ***Harnessing the Data Revolution for 21st-Century Science and Engineering (HDR)***—Engaging NSF's research community in the pursuit of fundamental research in data science and engineering, the development of a cohesive, federated, national-scale approach to research data infrastructure, and the development of a 21st-century data-capable workforce.

2. ***The Future of Work at the Human Technology Frontier (FW-HTF)***—Catalyzing interdisciplinary science and engineering research to understand and build the human-technology relationship, design new technologies to augment human performance, illuminate the emerging socio-technological landscape, and foster lifelong and pervasive learning with technology.

3. ***Windows on the Universe (WoU): The Era of Multi-Messenger Astrophysics***—Using powerful new syntheses of observational approaches to provide unique insights into the nature and behavior of matter and energy and to answer some of the most profound questions before humankind.

4. ***The Quantum Leap (QL): Leading the Next Quantum Revolution***—Exploiting quantum mechanics to observe, manipulate, and control the behavior of particles and energy at atomic and subatomic scales; and developing next-generation quantum-enabled science and technology for sensing, information processing, communicating, and computing.

5. ***Understanding the Rules of Life (URoL): Predicting Phenotype***—Elucidating the sets of rules that predict an organism's observable characteristics, i.e., its phenotype.

6. ***Navigating the New Arctic (NNA)***—Establishing an observing network of mobile and fixed platforms and tools, including cyber tools, across the Arctic to document and understand the Arctic's rapid biological, physical, chemical, and social changes, in partnership with other agencies, countries, and native populations.

**Enabling Big Ideas:**

7. ***NSF INCLUDES***—Transforming education and career pathways to help broaden participation in science and engineering.

8. ***Growing Convergence Research at NSF (GCR)***—Merging ideas, approaches, tools, and technologies from widely diverse fields of science and engineering to stimulate discovery and innovation.

9. ***Mid-scale Research Infrastructure***—Developing an agile process for funding experimental research capabilities in the mid-scale range, spanning the midscale gap in research infrastructure. This is a "sweet spot" for science and engineering that has been challenging to fund through traditional NSF programs.

10. ***NSF 2026 Fund***—Stimulating and seeding investments in bold foundational research questions that are large in scope, innovative in character, originate outside of any particular NSF directorate, and may require a long-term commitment. This Big Idea is framed around the year 2026, providing an opportunity for transformative research to mark the Nation's 250th anniversary.

## *CONVERGENCE ACCELERATOR*

In the FY 2019 Budget Request to Congress, NSF unveiled the Convergence Accelerator, a new organizational framework that stands separately from the NSF research directorates, with its own budget, staff, and initiatives. The Convergence Accelerator will be a time-limited entity focused on specific research topics and themes. Those topics and themes will reward high-risk, innovative thinking to accelerate the discovery and innovation that remains the priority of NSF. The Accelerator is intended to be a new way of achieving rapid lab-to-market outcomes.

In FY 2020, the Convergence Accelerator will focus on topics shared by two of the 10 Big Ideas. One Accelerator track will focus on Harnessing the Data Revolution for 21st-Century Science and Engineering, and a second will focus on the Future of Work at the Human-Technology Frontier. Each will be funded at $30.0 million, plus each will seek to leverage $20.0 million in external partnerships.

NSF's support for the Big Ideas and the Convergence Accelerator reflects the agency's ongoing commitment to advancing science at the frontiers, while supporting the core fundamental research that has advanced the Nation since the agency's founding. Collaboration and convergence are required across NSF to achieve the agency's mission and support the maximum number of researchers. Science and engineering today requires innovative approaches to leveraging resources across all fields of science.

## *RESEARCH AND DEVELOPMENT PRIORITIES*

Basic research forms the core of NSF's work and has led to discoveries and innovations that have been awarded hundreds of Nobel Prizes, and changed humankind's conception of the universe and the known world. Basic research is responsible for advancing our knowledge of the universe, as well as innovations like high speed internet, nanotechnology, and advances in robotics that require understanding of the fundamental laws that govern the physical world. NSF funds basic research in all the agency's directorates and continues to fund research that transcends single disciplines.

In FY 2020, NSF will make investments that support the basic research that advances human knowledge and makes tomorrow's innovations possible. Additional investments will support the advancement of AI, research in advanced manufacturing, and advance discoveries in QIS and semiconductors and microelectronics research.

### ***Artificial Intelligence***

AI is advancing rapidly and holds the potential to transform American lives through improved educational opportunities, increased economic prosperity, and enhanced national and homeland security. NSF will continue significant investment in AI with **$492.0 million** in AI research in FY 2020. NSF supports fundamental research in machine learning, computer vision, and natural language processing, along with the safety, security, robustness, and explainability of AI systems; translational research at the intersection of AI and various science and engineering domains as well as economic sectors such as agriculture, manufacturing, and personalized medicine; and education and learning, including growing human capital and institutional capacity to nurture a next generation of AI researchers and practitioners.

### ***Advanced Manufacturing***

In FY 2020, NSF will invest **$268.0 million** in Advanced Manufacturing and continue to support the fundamental research needed to revitalize American manufacturing to grow the national prosperity and workforce, and to reshape our strategic industries. NSF research accelerates advances in manufacturing technologies with an emphasis on multidisciplinary research that fundamentally alters and transforms manufacturing capabilities, methods and practices. Investments in advanced manufacturing include research on highly connected cyber-physical systems in smart processing and cyber manufacturing systems, and activities that develop new methods, processes, analyses, tools, or equipment for new or existing manufacturing products, supply chain components, or materials. NSF's investments are expected to enable new functionalities to increase the efficiency and sustainability of the production of the next generation of products and services. These developments will yield advantages such as reduced time to market, new performance attributes, improved small-batch production, cost savings, energy savings, or reduced environmental impact from the manufacturing of products.

### ***Quantum Information Science***

Research in QIS examines uniquely quantum phenomena that can be harnessed to advance information processing, transmission, measurement, and fundamental understanding in ways that classical approaches can only do much less efficiently, or not at all. NSF will invest **$106.0 million** in QIS research and development in FY 2020, which strongly aligns with the Administration's priorities and the National Quantum Initiative to consolidate and expand the U.S.' world-leading position in fundamental quantum research and deliver proof-of-concept

devices, applications, tools, or systems with a demonstrable quantum advantage over their classical counterparts.

***Microelectronics***

Research in semiconductors and microelectronics is critical to future advances and security in several areas, including information technology, communications, sensing, smart electric grid, transportation, health, and advanced manufacturing. NSF will support research to address fundamental science and engineering questions on the concepts, materials, devices, circuits, and platforms necessary to sustain progress in semiconductor and microelectronic technologies. The FY 2020 investment of **$68.0 million** will strengthen America's capabilities and capacity for revolutionary microelectronics design, architecture, and fabrication, as well as high-performance computing. New discoveries will enable the nation to overcome crucial scientific barriers for emerging technologies such as artificial intelligence, quantum technologies, and interconnected autonomous systems, and they will strengthen U.S. scientific leadership, economic prosperity, and national security.

## *MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION*

The FY 2020 Request includes funding to continue construction on two projects: the Large Synoptic Survey Telescope (LSST) and the Antarctic Infrastructure Modernization for Science (AIMS). Funding is also proposed for two detector upgrades to operate at the High Luminosity-Large Hadron Collider (HL-LHC).

***The Large Synoptic Survey Telescope***

The LSST will be an 8-meter-class wide-field optical telescope capable of carrying out surveys of nearly half of the sky. It will collect nearly 40 terabytes of multi-color imaging data every night to produce the deepest, widest-field sky image ever. It will also issue alerts for moving and transient objects within 60 seconds of their discovery. The FY 2020 **request of $46.3** million represents year seven of its nine-year construction funding profile.

***The Antarctic Infrastructure Modernization for Science***

In FY 2020 **NSF requests $97.9 million** to continue to invest in the AIMS project, a necessity for maintaining U.S. scientific and geopolitical eminence across the continent of Antarctica. The AIMS project is the primary component of the McMurdo Station Master Plan, with a specific focus on the core elements of this critical logistics hub. AIMS will enable faster, more streamlined logistical and science support by co-locating or consolidating warehousing, skilled trades work, and field science support.

***High Luminosity-Large Hadron Collider***

The LHC is the world's largest and highest energy particle accelerator. Located near Geneva, Switzerland and operated by the European Organization for Nuclear Research (CERN), the LHC can accelerate and collide counter-propagating bunches of protons at a total energy of 14 tera-electron volts. A Toroidal LHC ApparatuS (ATLAS) and Compact Muon Solenoid (CMS) are two general purpose detectors used by researchers to observe these collisions and analyze their characteristics. In FY 2020, an investment of **$33.0 million is requested** to begin upgrades of components of the ATLAS and CMS detectors that will enable them to function at much higher

collision rates following an upgrade to the LHC to increase its luminosity. FY 2020 funding would represent year one of a five-year project.

***Mid-scale Research Infrastructure***

The Mid-scale Research Infrastructure project, an effort that will address a gap between small existing research infrastructure instrumentation and existing large facility funding, has a new, dedicated funding line in the MREFC account for which **$45.0 million is requested in FY 2020**. NSF will implement a high-priority, agency-wide mechanism that includes upgrades to major facilities as well as stand-alone projects, such that research infrastructure investments above $20 million are managed as a portfolio. Individual projects will be selected through a dedicated program solicitation developed in FY 2019 and NSF's merit review process.

***Daniel K. Inouye Solar Telescope and the Regional Class Research Vessels***

NSF will continue to manage the construction of both the Daniel K. Inouye Solar Telescope (DKIST) and the Regional Class Research Vessels (RCRV) in FY 2020. FY 2019 represented the final year of funding for DKIST within an 11-year funding profile and completion of construction is planned for no later than June 2020. The FY 2019 appropriations for RCRV of $127.1 will complete construction of three vessels. The RCRV project will help to satisfy the anticipated ocean science requirements for the Nation. The vessels are a major component in the plan for modernizing the U.S. Academic Research Fleet. Construction of three ships to support the anticipated demands for coastal oceanography in the Gulf of Mexico and the East and West coasts will minimize transits and maximize research time in each of these regions. NSF plans to fund the operations of three RCRVs without increasing current annual costs, which is a result of fleet right-sizing and modernization.

## *EDUCATION AND STEM WORKFORCE*

At NSF, our education activities are integrated with science and engineering, research and innovation. We recognize that combining the best that we know from research about learning and cognition with exciting opportunities to learn STEM is a winning combination for helping to effectively inspire the next generation STEM skilled workforce.

NSF's education and STEM workforce investments are primarily housed in the Directorate for Education and Human Resources but represent agency-wide investments in the education of tomorrow's scientists, engineers, and educators. NSF is committed to the education and training of a workforce for the 21st century economy. This workforce must be capable of adapting to the increasingly technical nature of work across all sectors. NSF works to prioritize programs that will provide experiential learning opportunities, as well as programs that prioritize computer science education and reskilling. Priority STEM education activities to prepare America's future workforce in FY 2020 are:

***The Graduate Research Fellowship Program***

The Graduate Research Fellowship Program (GRFP) recognizes students with high potential in STEM research and innovation and provides support for them to pursue research across all science and engineering disciplines. GRFP fellows may participate in Graduate Research Opportunities Worldwide (GROW), which provides opportunities to conduct research with international partner countries and organizations, and Graduate Research Internship Program (GRIP), which provides professional development through research internships at federal agencies. The GRFP program

will continue to align awards with NSF research priorities such as Big Data, AI, QIS, and NSF's 10 Big Ideas. In FY 2020, **NSF will invest $256.9 million in GRFP** and support 1,600 new fellows.

***Improving Undergraduate STEM Education***

In FY 2020, **$93.1 million** is requested for the Improving Undergraduate STEM Education (IUSE) initiative, which supports the development of the STEM and STEM-capable workforce by investing in the improvement of undergraduate STEM education, with a focus on attracting and retaining students and on degree completion. The initiative funds the development and implementation and the related research and assessment of effectiveness. Directorates across NSF invest in this program to support the development of a workforce that will be able to handle the real-world challenges of a STEM career.

***Advanced Technological Education***

In FY 2020, **$75.0 million** is requested for the Advanced Technological Education (ATE) program, which focuses on the education of technicians for the high-technology fields that drive our nation's economy. The program involves partnerships between academic institutions and industry to promote improvement in the education of science and engineering technicians at the undergraduate and secondary institution school levels. The ATE program supports curriculum development; professional development of college faculty and secondary school teachers; career pathways; and other activities.

***CyberCorps®: Scholarship for Service***

In FY 2020, **$55.1 million** is requested for The CyberCorps®: Scholarship for Service (SFS) program, which supports cybersecurity education at higher education institutions. SFS also focuses on workforce development by increasing the number of qualified students entering the fields of information assurance and cybersecurity, which enhances the capacity of the U.S. higher education enterprise to continue to produce professionals in these fields to secure the Nation's cyberinfrastructure.

***Robert Noyce Teacher Scholarship***

In FY 2020, **$47.0 million** is requested for the Robert Noyce Teacher Scholarship program, which seeks to encourage talented STEM majors and professionals to become K-12 mathematics and science teachers through funding provided to institutions of higher education towards scholarships, stipends, and programmatic support.

***Louis Stokes Alliance for Minority Participation***

In FY 2020, **$46.0 million** is requested for The Louis Stokes Alliance for Minority Participation (LSAMP) program, which assists universities and colleges in diversifying the nation's STEM workforce by increasing the number of STEM baccalaureate and graduate degrees awarded to populations historically underrepresented in these disciplines.

***Computer Science for All***

In FY 2020, **$20.0 million** is requested for Computer Science for All (CSforAll) to build on ongoing efforts to enable rigorous and engaging computer science education in schools across the Nation, to prepare the STEM workforce of the future. CSforAll aims to provide high school teachers with the preparation, professional development, and ongoing support that they need to

teach rigorous computer science courses and to give preK-8 teachers the instructional materials and preparation they need to integrate computer science and computational thinking into their teaching.

***ADVANCE***

In FY 2020, **$18.0 million** is requested for the NSF ADVANCE program, which increases representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce. ADVANCE is an integral part of the NSF's multifaceted strategy to broaden participation in the STEM workforce and supports the critical role of the Foundation in advancing the status of women in academic science and engineering.

***Hispanic Serving Institutions***

In FY 2020, **$15.0 million** is requested for the Hispanic Serving Intuitions (HSIs) program to continue to enhance the quality of undergraduate STEM education at HSIs and to increase retention and graduation rates of undergraduate students pursuing degrees in STEM at HSIs. In addition, the HSI Program seeks to build capacity in undergraduate STEM education at HSIs that typically do not receive high levels of NSF grant funding.

***Historically Black Colleges and Universities Excellence in Research***

In FY 2020, **$10.0 million** is requested for the Historically Black Colleges and Universities Excellence in Research (HBCU-EiR) program to support projects that enable STEM and STEM education faculty to further develop research capacity at HBCUs and to conduct research.

## *CONCLUSION*

The FY 2020 President's Budget Request for NSF represents a $7.066 billion investment in strengthening the nation's economy, security and global leadership through research in cutting-edge science and engineering and investments in STEM education and the future workforce. At this proposed level of funding, NSF would continue its work supporting research that advances national priorities such as growth in manufacturing, defense, and cybersecurity.

Over 50 percent of America's economic growth of the past 50 years is attributable to technological innovation. This innovation depends on significant investment in basic research. NSF had a role in the development of important advances such as the Internet, 3-D printing, and cell phones, and in responding to national and international crises. Since its creation by Congress in 1950, some 236 Nobel Prize winners have, at some point in their careers, been supported by NSF.

The discoveries and innovations funded by NSF have a long record of improving lives and meeting national needs. With the support of this Committee and the Congress, NSF will continue to invest in the fundamental research and the talented people – the discoveries and the discoverers – who improve our daily lives and transform our future.

Thank you for the opportunity to testify today and for your continued support of NSF. I will be pleased to answer any questions you may have.

# Dr. France A. Córdova
# Director
# National Science Foundation

France A. Córdova is an astrophysicist and the 14th director of the National Science Foundation (NSF), the only government agency charged with advancing all fields of scientific discovery, technological innovation, and science, technology, engineering and mathematics (STEM) education. NSF is an $8.1 billion independent federal agency; its programs and initiatives keep the United States at the forefront of science and engineering, empower future generations of scientists and engineers, and foster U.S. prosperity and global leadership.

Córdova is president emerita of Purdue University, and chancellor emerita of the University of California, Riverside, where she was a distinguished professor of physics and astronomy. Córdova was the vice chancellor for research and professor of physics at the University of California, Santa Barbara.

Previously, Córdova served as NASA's chief scientist. Prior to joining NASA, she was on the faculty of the Pennsylvania State University where she headed the department of astronomy and astrophysics. Córdova was also deputy group leader in the Earth and space sciences division at Los Alamos National Laboratory. She received her Bachelor of Arts degree from Stanford University and her doctorate in physics from the California Institute of Technology.

More recently, Córdova served as chair of the Board of Regents of the Smithsonian Institution and on the board of trustees of Mayo Clinic. She also served as a member of the National Science Board (NSB), where she chaired the Committee on Strategy and Budget. As NSF director, she is an ex officio member of the NSB.

Córdova's scientific contributions have been in the areas of observational and experimental astrophysics, multi-spectral research on x-ray and gamma ray sources and space-borne instrumentation. She has published more than 150 scientific papers. She has been awarded several honorary doctorates, including ones from Purdue and Duke Universities. She is a recipient of NASA's highest honor, the Distinguished Service Medal, and was recognized as a Kilby Laureate. The Kilby International Awards recognize extraordinary individuals who have made "significant contributions to society through science, technology, innovation, invention and education." Córdova was elected to the American Academy of Arts and Sciences and is a National Associate of the National Academies. She is also a fellow of the American Association for the Advancement of Science (AAAS) and the Association for Women in Science (AWIS).

Córdova is married to Christian J. Foster, a science educator, and they have two adult children.