ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelliegence Funding
(Dollars in Millions)

	FY 2019 Actual	FY 2020 (TBD)	FY 2021 Request[1]
BIO	$12.53	-	$38.09
CISE	297.00	-	525.44
EHR	-	-	37.59
ENG	119.92	-	159.19
MPS	23.52	-	87.34
SBE	12.25	-	20.44
Total	**$465.21**	**-**	**$868.09**

[1]Includes $30.0 million, split evenly between CISE and ENG, for AI-related research activities in the HDR and FW-HTF Big Ideas. For more information, see the individual Big Idea narratives in this chapter.

Overview

AI is advancing rapidly and holds the potential to vastly transform our lives. NSF has a long and rich history of supporting transformative research in AI, along with the closely related areas of data science and robotics. For example, NSF-funded researchers in the 1990s began working on what is now known as collaborative filtering. Today, collaborative filtering fuels the recommender engines on popular websites like Netflix and Amazon – the "you might also like" suggestions that propel a significant proportion of e-commerce activity. Similarly, NSF investments in understanding learning across the lifespan, in different species and contexts, have contributed to today's deep learning systems.

Today, NSF supports fundamental research, education and workforce development, and access to data and advanced computing research infrastructure that collectively enhance AI. NSF's ability to bring together numerous fields of scientific inquiry—including computer and information science; cognitive science and psychology; economics and game theory; engineering and control theory; ethics; linguistics; mathematics; and philosophy—uniquely positions the agency to lead the Nation in expanding the frontiers of AI. In FY 2021, NSF will increase support for foundational research in AI, including machine learning (ML) and deep learning, natural language technologies, knowledge representation and reasoning, and computer vision, along with the safety, security, robustness, and explainability of AI systems. In addition to foundational research in these areas, NSF also supports translational research that links AI innovation with science and the economy, including agriculture, manufacturing, transportation, and health. Equally important is NSF's investment in education and learning, which grows the human capital and institutional capacity needed to nurture the next generation of AI researchers and practitioners. Finally, advances in AI rely upon access to data as well as NSF-funded advanced computing research infrastructure.

Through collaboration and coordination with the Office of Science and Technology Policy, NSF leadership is helping to drive and coordinate AI R&D efforts across the federal government. For example, the NSF Director co-chairs the National Science and Technology Council's Select Committee on AI, which advises the White House on interagency AI R&D priorities and establishes structures to improve government planning and coordination. In June 2019, the Select Committee issued an update to the 2016 *National Artificial Intelligence Research and Development Strategic Plan*[1] that identified eight strategic priorities and provided a coordinated federal strategy for AI R&D that will help the United States continue to lead

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[1] www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf

the world in cutting-edge advances in AI that will grow the economy, increase our national security, and improve quality of life. The goals outlined below directly address many of these strategic priorities.

Goals

1. *Fundamental AI Research:* Invest in fundamental AI research that will give rise to transformational technologies and, in turn, breakthroughs across all areas of science and engineering and across all sectors of society. This includes research investments in:
   - Knowledge representation, planning, human language technologies, ML and deep learning, multi-agent systems, and computer vision;
   - Human-AI collaboration, including the development of AI systems that complement and augment human capabilities, with increasing focus on the future of work;
   - Explainability, fairness, and transparency of AI systems to provide the ability to ensure, assess, and ultimately demonstrate these traits in AI systems; and
   - AI safety and security to develop systems whose decisions are well understood and whose trustworthiness can be measured.
2. *Education and Workforce Development*: Develop AI systems that enhance learning for all and grow the next generation of talent to advance the U.S. AI R&D workforce, including those working on AI systems and those working alongside them.
3. *Access to Data and Advanced Computing Research Infrastructure:* Provide access to advanced, scalable computing resources and enhance the availability of deep, high-quality, and accurate training datasets in order to advance AI research and education.
4. *Public-Private Partnerships:* Continue to pursue collaborations with other federal agencies, industry, and nonprofits to coordinate and accelerate advances in AI research and education.

FY 2021 Investments

Goal 1: Fundamental AI Research
In FY 2021, NSF will build on prior year investments and increase funding for fundamental AI research:
- In FY 2019, NSF and DARPA partnered on the Real-Time Machine Learning (RTML) program to explore high-performance, energy-efficient hardware and machine-learning architectures that can learn from a continuous stream of new data in real time. The NSF-DARPA collaboration on RTML will enable cross-pollination of ideas and co-design of RTML algorithms and hardware through FY 2021.
- In FY 2019, NSF and Amazon began a collaboration to jointly support research focused on AI fairness with the goal of jointly contributing $20.0 million ($10.0 million each) over three years to trustworthy AI systems that are readily accepted and deployed to tackle grand challenges facing society. Specific topics of interest include, but are not limited to, transparency, explainability, accountability, potential adverse biases and effects, mitigation strategies, validation of fairness, and considerations of inclusivity.
- In FY 2020, NSF is partnering with four other federal agencies, the U.S. Department of Agriculture's National Institute of Food and Agriculture, Department of Homeland Security's Science & Technology Directorate, Department of Transportation's Federal Highway Administration, and the U.S Department of Veterans Affairs, on the new National AI Research Institutes program. In FY 2020, NSF plans to fund up to six multidisciplinary, multi-institutional research institutes—at up to $20.0 million each over five years—that will serve as national hubs for universities, federal agencies, industry, and nonprofits to advance AI research and workforce development in key areas while addressing grand challenges. Key foci for the FY 2020 AI Institutes include foundations of ML; trustworthy AI; AI-driven innovation in agriculture and food systems; AI-augmented learning; AI for accelerating molecular synthesis and manufacturing; and AI for discovery in physics. In FY 2021, NSF plans to fund additional AI Institutes.

- Through the HDR Big Idea, NSF will continue to support fundamental research in data science and engineering and with increased support for research on critical new methods and advances in AI, notably in ML and deep learning. In addition, through the FW-HTF Big Idea, NSF will continue to support socio-technical research enabling a future where intelligent technologies collaborate synergistically with humans to achieve broad participation in the workforce and improve the social, economic, and educational benefits across a range of work settings.
- NSF will continue investments in robotics and autonomous systems that exhibit significant levels of both computational capability and physical complexity, including research related to the design, application, and use of robotics to augment human function, promote human-robot interaction, and increase robot autonomy.

Goal 2: Education and Workforce Development
- As part of the National AI Research Institutes program as discussed above, NSF plans to fund an AI Research Institute in Augmented Learning in FY 2020 at up to $20.0 million over five years. AI-Augmented Learning includes AI-driven innovations to radically improve human learning and education writ large—in formal settings (e.g., preK-12, undergraduate, graduate, vocational education); training, on-the-job and across the lifespan; as well as informal settings (e.g., museums, nature centers, libraries; TV/film; crowd-sourcing and citizen science; on-line experiences).
- In support of the 2019 *Federal Cybersecurity Research and Development Strategic Plan*,[2] and the Presidential Executive Order on *America's Cybersecurity Workforce*,[3] NSF will address a critical shortage of cybersecurity educators and researchers in priority areas including the cybersecurity aspects of AI, through the NSF CyberCorps®: Scholarship for Service program.
- In FY 2021, the NSF Graduate Research Fellowship Program (GRFP) will encourage applications from students wanting to conduct AI-related research. The NSF GRFP recognizes and supports outstanding graduate students in NSF-supported STEM disciplines who are pursuing research-based master's and doctoral degrees at accredited United States institutions.
- The NSF Research Traineeship (NRT) program advances graduate education by combining interdisciplinary training with innovative professional development activities to educate the next generation of scientists and engineers capable of solving convergent research problems in areas of national need. In FY 2021, NRT will expand to include a special focus on traineeships in AI.
- In FY 2021, NSF will continue support at the K-12 and undergraduate levels for enhancing the core computer science (CS) and computational thinking (CT) competencies necessary for the next generation of AI researchers and practitioners. For example, NSF's Computer Science for All: Researcher Practitioner Partnerships program will support research and partnership efforts to provide all U.S. students the opportunity to participate in CS and CT education in their schools at the preK-12 levels. Likewise, the Improving Undergraduate STEM Education: Computing in Undergraduate Education program will support teams of Institutions of Higher Education (IHEs) in re-envisioning the role of computing in interdisciplinary collaboration within their institutions. NSF will also encourage partnering IHEs to integrate the study of ethics into their efforts.

Goal 3: Access to Data and Advanced Computing Research Infrastructure
- NSF supports a range of advanced computing systems and services for the full range of computational- and data-intensive research across all areas of science and engineering, including AI. For example, in September 2019, Frontera, the largest and most powerful supercomputer NSF has ever supported, came online to serve the Nation's science and engineering research community. The system, located at the University of Texas at Austin's Texas Advanced Computing Center and named the fifth fastest supercomputer in the world, will enable access to advanced computing resources for AI research. NSF will continue these investments in FY 2021.

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[2] www.nitrd.gov/pubs/Federal-Cybersecurity-RD-Strategic-Plan-2019.pdf
[3] www.whitehouse.gov/presidential-actions/executive-order-americas-cybersecurity-workforce/

- In FY 2019, NSF put in place a five-year cooperative agreement for $5.0 million with the University of California-San Diego, University of California-Berkeley, and University of Washington for the establishment and operation of CloudBank, an entity that will help the computer science community access and use public clouds for research and education by delivering a set of managed services designed to simplify access to public clouds. CloudBank will specifically enable new research in AI by broadening the access and impact of cloud computing across the many fields of computer science research and education.
- For FY 2021, NSF will continue to collaborate with other federal agencies to enable researcher access to deep, high-quality, and accurate federal training datasets.

Goal 4: Public-Private Partnerships
- In FY 2021, pursuant to the other three goals described above, NSF will continue to engage other stakeholders in its portfolio of AI research, education, and infrastructure investments. Specifically, NSF will place a priority on developing partnerships with other federal agencies, like-minded international funders, and especially the private sector, including private industry, foundations, and nonprofits, as an increasingly important means to maximize the scientific, economic, and societal impacts of its investments. A key focal point of the public-private partnerships in AI research, education, and research infrastructure will be via the National AI Research Institutes program, enabling large-scale, long-time-horizon challenges in areas of national importance.