United States Government Accountability Office

Report to Congressional Addressees

December 2022

FEDERAL RESEARCH AND DEVELOPMENT

Funding Has Grown since 2012 and Is Concentrated within a Few Agencies

GAO-23-105396

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GAO Highlights

Highlights of GAO-23-105396, a report to congressional addressees

Why GAO Did This Study

Scientific and technological innovation are critical to long-term U.S. economic competitiveness, prosperity, and national security. The U.S. has long been a global leader in advancing the frontiers of science and technology. Increased competition from other countries has led some experts to express concern that the U.S. may be losing its competitive edge in certain technologies. Agencies are investing in various R&D initiatives, including those that are of strategic national importance, such as network and information technology, nanotechnology, quantum information science, and global environmental changes.

This report describes (1) trends in federal R&D funding over the last 10 years and (2) the funding and organization for selected multi-agency R&D initiatives, among other objectives.

To address these objectives, GAO analyzed data published by the National Science Foundation on annual R&D expenditures and examined Office of Management and Budget (OMB) data. GAO also reviewed agency documentation and collected written responses to structured questions on federal R&D from the Chief Financial Officer or budget office from the five agencies that fund most R&D.

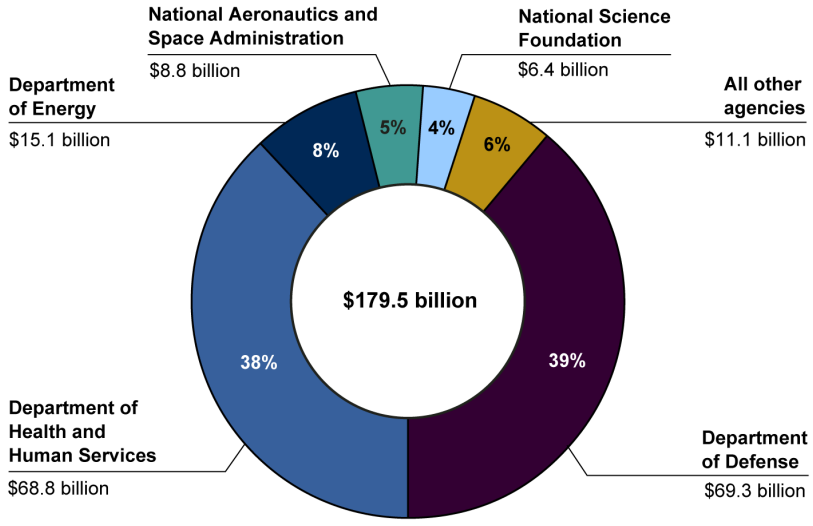
In addition, GAO interviewed officials from OMB and the Office of Science and Technology Policy, including the Directors of the National Coordination Offices for selected multi-agency R&D initiatives, which are coordinated under the auspices of the National Science and Technology Council.

View GAO-23-105396. For more information, contact Candice N. Wright at (202) 512-6888 or wrightc@gao.gov.

What GAO Found

Federal research and development (R&D) funding has increased since 2012—most recently because of COVID-19 stimulus funding. Five agencies obligated the majority of federal R&D funding with the Departments of Defense (DOD) and Health and Human Services (HHS) accounting for nearly 80 percent in fiscal year 2021 (see figure). HHS has mainly funded research, while DOD mainly funds development. However, HHS has become a major funder of development in recent years because of COVID-19 stimulus funding. HHS averaged less than 1 percent in development funding through fiscal year 2019 but reported 37 percent of its R&D obligations were for development in fiscal year 2021. Of the estimated $179.5 billion in federal R&D obligations in fiscal year 2021, about two-thirds went to organizations outside the federal government. In fiscal year 2021, industry, universities, and colleges received the majority of these external R&D obligations—almost $90 billion.

Federal Research and Development Obligations, Fiscal Year 2021



Source: GAO analysis of data from NSF's *Survey of Federal Funds for Research and Development.* | GAO-23-105396

Note: FY 2021 data are estimates provided by federal agencies to the National Science Foundation.

Federal funding also includes four multi-agency initiatives in areas identified as having long-term national importance, such as quantum information science and nanotechnology. These initiatives coordinate activities in areas that are too broad or complex to be addressed by one agency alone. For example, more than 60 agencies participate in an initiative on network and information technology, which includes investments in artificial intelligence and machine learning. Not all participating agencies contribute funding to such initiatives. Funding for these initiatives increased over the previous decade, and accounted for roughly $14 billion in fiscal year 2020, just under 9 percent of the total federal R&D budget.

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Abbreviations

DOD	Department of Defense
DOE	Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
FFRDC	federally funded research and development center
HHS	Department of Health and Human Services
NASA	National Aeronautics and Space Administration
NCO	National Coordination Office
NCSES	National Center for Science and Engineering Statistics
NIH	National Institutes of Health
NITRD	Networking and Information Technology Research and Development
NNI	National Nanotechnology Initiative
NQI	National Quantum Initiative
NSF	National Science Foundation
NSTC	National Science and Technology Council
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
RDT&E	Research, Development, Test and Evaluation
R&D	research and development
S&T	science and technology
STEM	science, technology, engineering, and mathematics
USGCRP	U.S. Global Change Research Program

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December 15, 2022

The Honorable Jon Tester
Chair
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Eddie Bernice Johnson
Chairwoman
The Honorable Frank D. Lucas
Ranking Member
Committee on Science, Space, and Technology
House of Representatives

Scientific and technological innovation are critical to long-term U.S. economic competitiveness, prosperity, and national security. The United States has long been a global leader in advancing the frontiers of science and technology because of its public and private investments in research and development (R&D)—the creative and systematic work undertaken to increase knowledge and to devise new applications of available knowledge.[1] As the pace of innovation has quickened, competition in the global economy has accelerated. The United States remains at the forefront of scientific and technological discovery and is the world's single largest R&D funder.[2] However, other countries, such as China, are also making considerable investments in R&D and the U.S. lead has been decreasing in recent years, according to the National Science Foundation (NSF).[3]

Increased competition from other countries has led some experts to express concern that the United States may be losing its competitive advantage in certain technologies that have critical applications in

[1]National Science Foundation, National Center for Science and Engineering Statistics, *Definitions of Research and Development: An Annotated Compilation of Official Sources*, NCSES 22-209 (Alexandria, VA: May 19, 2022).

[2]American Association for the Advancement of Science, *Federal R&D Budget Trends: A Short Summary* (Washington, D.C.: January 2019).

[3]National Science Foundation, National Science Board, *The State of U.S. Science & Engineering: 2022 Science & Engineering Indicators*, NSB-2022-1 (Alexandria, VA: January 2022).

manufacturing, medicine, and national security. This outlook calls for perspective and insight on how the U.S. federal government supports R&D, what types of research it funds, and how that funding is directed.[4]

Over the last 5 years, federal R&D spending has averaged about 9 percent of the discretionary budget. Nearly all federal R&D spending is contained within the discretionary budget (over 99 percent). While broadly overseen by the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP), these funds flow from more than 30 federal agencies into federal and non-federal labs—including those of industry, academia, and the nonprofit sector.[5]

We have prepared this report, under the authority of the Comptroller General, to assist Congress with its oversight responsibilities for R&D. This report describes (1) trends in federal R&D funding over the last 10 years, (2) how the federal government funds R&D, and (3) the funding and organization for selected multi-agency R&D initiatives.

To address all three objectives, we analyzed R&D funding and planning documents from OMB, OSTP, and the five agencies with the largest amount of funding for federal R&D, according to fiscal year (FY) 2020 OMB budget authority data provided by OMB and the agencies. Specifically, we selected the Department of Defense (DOD), Department of Energy (DOE), Department of Health and Human Services (HHS), National Aeronautics and Space Administration (NASA) and NSF. We collected written responses to structured questions on several topics related to each agency's R&D funding from the Office of the Chief Financial Officer or the budget office from each of the selected agencies.

In addition, we collected written responses to structured questions from 15 agency sub-divisions.[6] We selected the agency sub-divisions that,

[4]Data on federal R&D funding comes from two main sources: the R&D chapter from the *Analytical Perspectives* of the President's Budget from OMB and the *Survey of Federal Funds for research and Development* from NSF's National Center for Science and Engineering Statistics (NCSES). OMB reports data on federal R&D budget authority while NCSES reports more detailed R&D obligations data.

[5]OSTP was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976, Pub. L. No. 94-282, § 203, 90 Stat. 459, 463, codified as amended at 42 U.S.C. §§ 6611-6626.

[6]Sub-division refers to organizational components within the agencies, such as, directorates, or offices that conduct R&D.

together, contributed at least 75 percent of their parent agency's total R&D funding.[7] As a result, we selected four sub-divisions from DOD (Departments of the Air Force, Army, and Navy, and the Missile Defense Agency); three from DOE (National Nuclear Security Administration, the Office of Science, and the Office of Energy Efficiency and Renewable Energy); one from HHS (National Institutes of Health); two from NASA (Science Mission Directorate and Exploration Systems Development Mission Directorate); and five from NSF (Directorate(s) for Mathematical & Physical Sciences, Computer and Information Science and Engineering, Geosciences, Biological Sciences, and Engineering). In some cases, we interviewed officials from selected agencies to clarify or supplement written responses to structured questions about their R&D portfolios and budget development process. We also interviewed officials from OMB and OSTP about their roles in the R&D funding process, including priority setting and coordination, among other topics.

To describe trends in federal R&D funding over the last 10 years, we analyzed data published by NSF on annual research and development expenditures for FY 2012 - FY 2021 from the *Survey of Federal Funds for Research and Development*[8] and also examined budget data from the OMB's MAX Information System.[9] We analyzed R&D budget authority data from OMB MAX to determine the proportion of federal R&D spending as a percent of discretionary spending. NSF's survey is the primary source of information about U.S. federal R&D funding. To understand the NSF survey data and assess its reliability for our reporting purposes, including any limitations or caveats associated with it, we interviewed officials who manage the database and reviewed reports that incorporated and used the information. We also reviewed the NSF survey user's guide and guidance for how agencies should characterize their

[7]We chose the 75 percent threshold because we determined that it constituted a substantial proportion of the funding for our selected agencies, while keeping the number of selected sub-divisions to a manageable number.

[8]National Science Foundation, National Center for Science and Engineering Statistics, *Survey of Federal Funds for Research and Development*, Volume 70 (FYs 2020-2021), April 28, 2022.

[9]MAX.gov is a government-wide website that is supported by OMB and used to pass budget information securely between OMB and federal agencies during the budgeting process. Specifically, OMB compiles data from federal agencies in OMB MAX to provide reports presenting budgetary and financial data, such as *Analytical Perspectives* and the *Budget Appendix*. The data undergo rigorous review by OMB. MAX contains numerous edit checks to help ensure data consistency.

R&D. We determined that the NSF survey data were reliable for the purposes of our report. To describe R&D trends, we use the term "funding" or "funding levels" throughout in general context. However, when referring to budget authority, obligations, or outlays, we indicate specifically as such.[10] Unless otherwise stated, we report funding in nominal terms (not adjusted for inflation), and all years refer to fiscal years.

To describe how the federal government funds R&D, we reviewed relevant documentation, including statutes and guidance for R&D budgeting.[11] For example, we reviewed OMB Circular No. A-11, OMB's *FY 2019 Budget Guidance Memorandum,* No. M-17-28*,* and OMB and OSTP's annual R&D priorities memorandum.[12] In addition, we reviewed reports from our selected agencies, budget justifications and planning documents, as well as GAO reports to describe the federal budget process.

To describe the funding and organization for multi-agency R&D initiatives, we reviewed four multi-agency R&D initiatives under the auspices of the National Science and Technology Council (NSTC) that were established by law or through executive authority, that submit annual budget and

[10]An obligation is a definite commitment that creates a legal, government responsibility for payment of goods and services ordered or received. An agency incurs an obligation, for example, when it places an order, signs a contract, or awards a grant. An outlay refers to the issuance of checks, disbursement of cash, or electronic transfer of funds made to liquidate a federal obligation.

[11]For example, we reviewed statutes such as the Budget and Accounting Act of 1921, Pub. L. No. 67-13, 42 Stat. 20 (codified in relevant part as amended at 31 U.S.C. § 1101-1558) and the Federal Funding Accountability and Transparency Act of 2006, Pub. L. No. 109-282, 120 Stat. 1186, 1187, as amended by the Digital Accountability and Transparency Act of 2014, Pub. L. No. 113-101, 128 Stat. 1146, 1148 (31 U.S.C. § 6101 note).

[12]OMB Circular No. A-11 provides detailed guidance to executive departments for preparing, submitting, and executing the President's budget. OMB, Circular No. A-11*, Preparation, Submission, and Execution of the Budget* (Aug. 6, 2021), OMB memo M-17-28 provides guidance to agencies on discretionary budget submission and mandatory budget proposals, among other topics. OMB Memorandum, No. M-17-28, *Fiscal Year (FY) 2019 Budget Guidance* (July 7, 2017). OMB and OSTP's annual R&D priorities memo provides overarching guidance to agencies on R&D budget priorities as they draft their budget requests for the next fiscal year, according to OMB. OMB and Office of Science and Technology Policy Memorandum No. M-22-15, *Memorandum for the Heads of Executive Department Agencies* (July 22, 2022).

coordination reports to OMB, and have national coordination offices.[13] These initiatives are: Networking and Information Technology Research and Development (NITRD), National Nanotechnology Initiative (NNI), National Quantum Initiative (NQI), and U.S. Global Change Research Program (USGCRP). We gathered and reviewed information on the initiatives, such as their annual reports to Congress.

We analyzed information published by NSTC in the supplements to the President's Budget for each of the initiatives for FY 2012 through FY 2022. Data presented in the annual supplements are collected from the participating agencies by OMB as part of the annual budget formulation process. Specifically, we analyzed NSTC reported funding and, in some cases, consulted with OMB and OSTP officials to clarify the budget information reported in these documents for the agencies' R&D investments. We met with the directors of the national coordination offices for each of the R&D initiatives to understand their views on the initiative priorities, participating agency funding contributions, and, roles of OSTP and NSTC in R&D planning, among other topics.

We conducted this performance audit from September 2021 to December 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

Overview of Federal R&D

Federal investments in R&D are necessary to help drive emerging technologies that will power future industries, spur innovation across the economy, and sustain the United States' global leadership in science and technology. Federal R&D spans multiple agency portfolios—over 30 federal agencies support R&D in the United States. Specifically, in FY 2021, 33 federal agencies (14 federal departments and 19 independent agencies) provided funds to support R&D, according to data from NSF's

[13]NSTC was established by Executive Order on November 23, 1993. Exec. Order No. 12881, as amended, Establishment of the National Science and Technology Council, 58 Fed. Reg. 62,491 (Nov. 26, 1993).

National Center for Science and Engineering Statistics (NCSES).[14] Further, the budget authority for R&D exceeded $1 billion for 10 federal agencies in FY 2021.

OMB defines federal R&D investments as basic research, applied research, or experimental development (see table 1). DOD characterizes its R&D funding as Research, Development, Test, and Evaluation. DOD shares similar definitions of basic and applied research, but includes additional categories of development (see app. I for more information).

Table 1: Types of Research and Development

Type	Description
Basic research	Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts.
Applied research	Original investigation undertaken in order to acquire new knowledge. Applied research is, however, directed primarily towards a specific practical aim or objective.
Experimental development	Creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes.

Source: OMB Circular No. A-11, *Preparation, Submission, and Execution of the Budget.* | GAO-23-105396

Agency mission and the role of R&D in accomplishing the mission determine the type of R&D that agencies support. Some agencies tend to support more basic research, such as NSF's scientific focus on the frontiers of knowledge in fields like computer science, mathematics, and biology. In contrast, other agencies support more developmental research, such as DOD's aim to develop technologies that can provide a future military competitive edge.

According to NSF's *Survey of Federal Funds for Research and Development,* university researchers receive more federal funding for basic and applied research than for experimental development. Generally, universities receive funds for discovery-oriented research to acquire knowledge or research new capabilities, such as how to incorporate artificial intelligence systems in public services to support human decision-making. Industry researchers tend to receive more funding for use-inspired research and development, which aims to

[14]The National Science Foundation conducts an annual *Survey of Federal Funds for Research and Development*. For the FYs 2020 - 2021 cycle, the target population consists of the 33 federal agencies that conduct R&D (excluding the Central Intelligence Agency) that reported R&D data.

produce new or improved products and technology. Much of federal experimental development funding is provided to industry to support next-generation technology for defense applications, such as autonomous or unmanned systems, or military weapons, including hypersonic and directed energy, among others.

Table 2 identifies the missions of selected agencies and provides illustrative examples of their R&D priorities and activities.

Table 2: Examples of Research and Development (R&D) Areas by Selected Agency

Agency	Mission	Illustrative Examples of R&D Efforts
Department of Defense	To provide the military forces needed to deter war and protect the security of the United States.	Biotechnology, artificial intelligence, directed energy (laser and high-power microwaves), cybersecurity, advanced materials, hypersonics, and renewable energy generation and storage.
Department of Energy	To ensure U.S. security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.	Clean energy, advanced manufacturing, industrial decarbonization, climate change, artificial intelligence, machine learning, nuclear waste cleanup, nuclear weapons stockpile maintenance, and cybersecurity.
Department of Health and Human Services—National Institutes of Health	To seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability.	Acute and lasting effects of the COVID-19 pandemic, opioid epidemic, mental health, neuroscience, cancer, health disparities and inequities, and the human health impacts of climate change.
National Aeronautics and Space Administration	To explore the unknown in air and space, innovate for the benefit of humanity, and inspire the world through discovery.	Long duration human deep space exploration, astronaut health during long duration missions, space communications and navigation to provide services for human exploration, climate change, space weather science, and aircraft and propulsion technologies to reduce carbon emissions from aviation.
National Science Foundation	To promote the progress of science; advance the national health, prosperity, and welfare; secure the national defense; and other purposes.	Clean energy, climate change, advanced manufacturing, wireless technologies, artificial intelligence, biotechnology, microelectronics and semiconductors, and quantum information science.

Source: GAO analysis of agency documentation. I GAO-23-105396

OSTP and OMB, both in the Executive Office of the President, provide high-level oversight of the federal R&D enterprise. Specifically, OSTP facilitates the coordination of the federal R&D agencies through a council, the NSTC. For some R&D initiatives that involve more than one agency, the council acts as a coordinating body. Its work is carried out through committees, subcommittees, and interagency working groups for specific science and technology topics. Table 3 provides a brief description of the roles and responsibilities of the entities involved in the coordination and oversight of federal R&D.

Table 3: Federal Entities that Provide Oversight and Coordinate Research and Development (R&D)

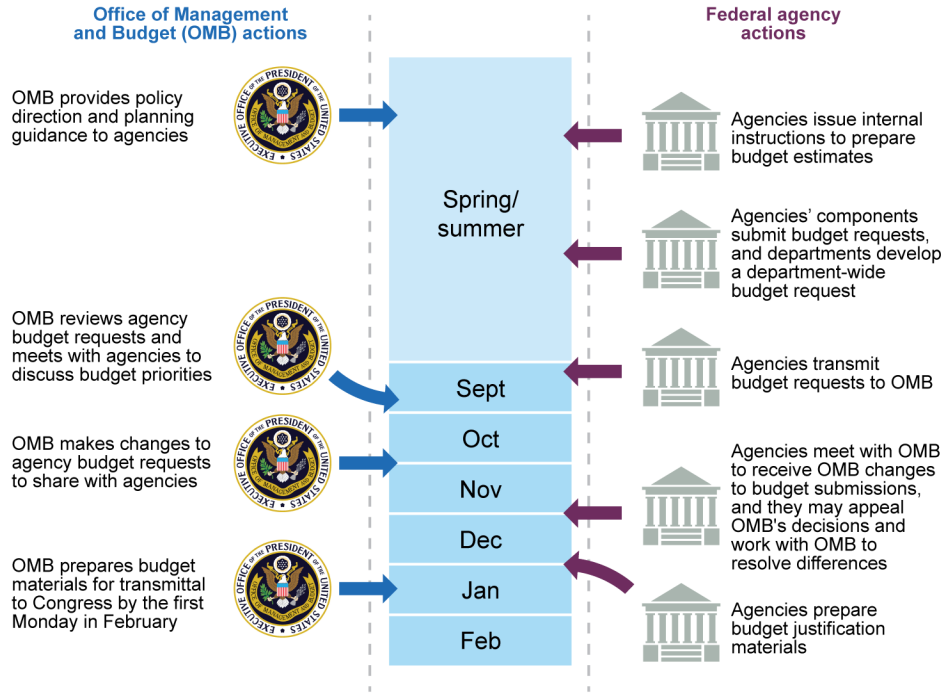
Federal Entity	Description of Roles and Responsibilities
Office of Management and Budget (OMB)	OMB evaluates, formulates, and coordinates budget and management policies and objectives among federal departments and agencies, including for R&D.
Office of Science and Technology Policy (OSTP)	OSTP advises the Executive Office of the President on issues involving science and technology and leads an interagency activity to develop and implement science and technology policies and programs that are coordinated across federal agencies.
National Science and Technology Council (NSTC)	NSTC is responsible for preparing R&D strategies that are coordinated across federal agencies in order to accomplish national goals. NSTC is a cabinet-level council of advisers to the President and is the principal means for the administration to coordinate federal science and technology policy and for monitoring agency research and development programs across the government.

Source: GAO analysis of agency documents and correspondence with OSTP. I GAO-23-105396

The Federal Budget Process for Determining Program Funding Levels including R&D

The federal budget process provides the means for the federal government to make informed choices when determining R&D funding levels among competing national needs and policies, allocating resources for those priorities, and ensuring the laws are executed according to those priorities. As shown in figure 1, preparation of the President's budget request begins when the White House—primarily through OMB—provides policy direction and guidance to the federal agencies. After receiving the President's budget, Congress formulates and enacts the appropriations bill or bills. After the President signs the appropriations, federal agencies execute the budget appropriations in accordance with the authority provided by Congress.

Figure 1: Process and Notional Timeline for Preparing the President's Budget Request



Source: GAO budget glossary and correspondence with OMB. | GAO-23-105396

- **OMB.** According to OMB Circular No. A-11, OMB is responsible for evaluating the effectiveness of agency programs, policies, and procedures for R&D; assessing competing funding demands among agencies; and setting funding priorities. OMB also provides top-line budget numbers to agencies based on presidential R&D priorities to inform their development of agency budget submissions.[15] According to OMB officials, OMB does not develop a centrally-derived cost estimate for the entirety of the federal R&D enterprise.
- **Federal agencies.** Agencies are, among other things, responsible for developing proposed budget estimates based on OMB guidance and providing supporting documentation to OMB for consideration as part of the President's Budget. Agencies work with OMB to ensure that the President's budget request reflects presidential R&D priorities, program performance, and budget constraints.

[15]OMB Circular No. A-11, *Preparation, Submission, and Execution of the Budget*, § 10.8.

- **Congress.** Congress may opt to agree with all, part, or none of the President's budget request, and it may express different R&D priorities through the appropriations process because it has the constitutional power of the purse. The House and Senate Appropriations Committees and Subcommittees develop appropriations bills for specific federal agencies or programs.

After Congress passes the appropriations bills, the President can either sign them into law or veto them. Once the President signs an appropriations bill, OMB and the agencies begin to manage and oversee the federal funding. The President, OMB, and agencies execute the budget in accordance with the enacted budgetary laws, which provide limited authority for them to adjust their spending after enactment of the appropriations and other spending bills. The enacted spending bills provide "budget authority" for the agencies to incur obligations. The agencies incur "obligations" after they enter into legally binding commitments, such as employing personnel or awarding contracts. Finally, when agencies disburse payments, or make "outlays," they liquidate these obligations.

Five Agencies Account for a Majority of Federal R&D Obligations, which Have Grown Overall Since FY 2012

Based on our analysis of NSF data for FY 2012 - FY 2021, five agencies accounted for the majority of federal R&D funding, with funding most heavily concentrated in DOD and HHS. In addition, overall obligations grew by approximately 30 percent between FY 2012 and FY 2021. Obligations for research trended somewhat differently than those for development over this period, with life sciences accounting for much of the increase in basic and applied research obligations. Meanwhile, the share of allocations among industry, universities and colleges, and federal agencies shifted slightly.

R&D Obligations Have Increased Overall and Are Largely Concentrated in DOD and HHS

Federal R&D obligations have increased overall since FY 2012, according to our analysis of obligations data from NSF's *Survey of Federal Funds*

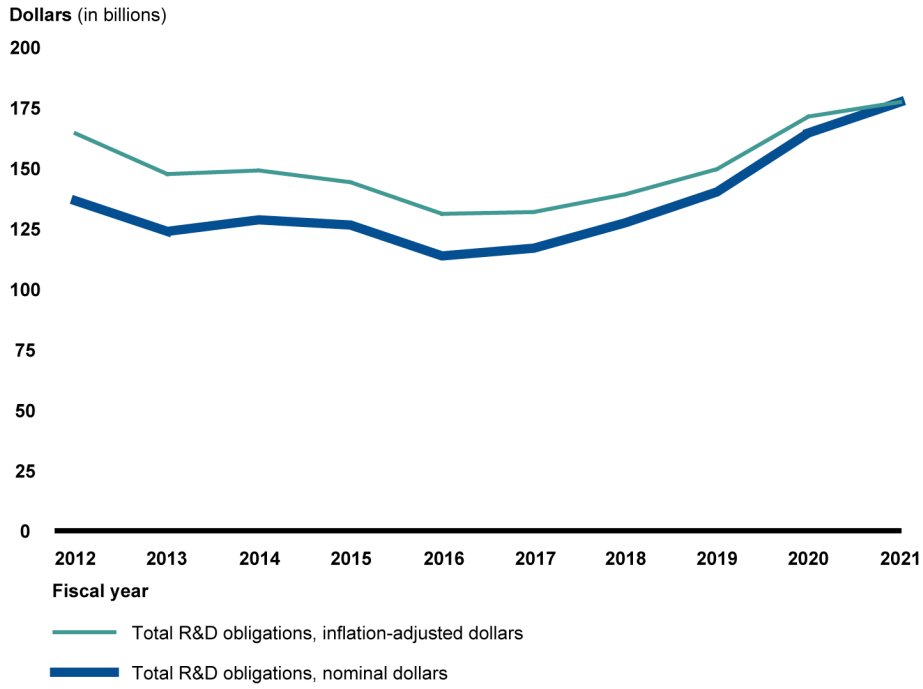
for Research and Development.[16] As shown in figure 2, these trends are generally consistent for both nominal and inflation-adjusted dollars.[17]

Overall, during the past 10 years, R&D obligations grew from $138.5 billion in FY 2012 to an estimated $179.5 billion in FY 2021, an increase of approximately $41 billion (30 percent). Inflation accounted for about $28 billion of the $41 billion increase.

[16]Actual data are collected for the fiscal year just completed, FY 2020 (i.e., October 1, 2019 through September 30, 2020 and the current fiscal year, FY 2021). FY 2020 data are completed transactions contained in Volume 70. FY 2021 data are estimates provided by federal agencies to the National Science Foundation. NSF refers to FY 2021 data as 'preliminary' in survey documentation because the data will be updated in the subsequent volume of the survey. We refer to FY 2021 data as 'estimates' throughout this report.

[17]We adjusted NSF's obligations using an inflation index from the St. Louis Federal Reserve designed specifically for R&D spending. Inflation adjusted dollars are reported in FY 2021 dollars and will be identified as inflation adjusted.

Figure 2: Total Federal Research and Development Obligations in Nominal and Inflation-adjusted Dollars, FY 2012 to FY 2021

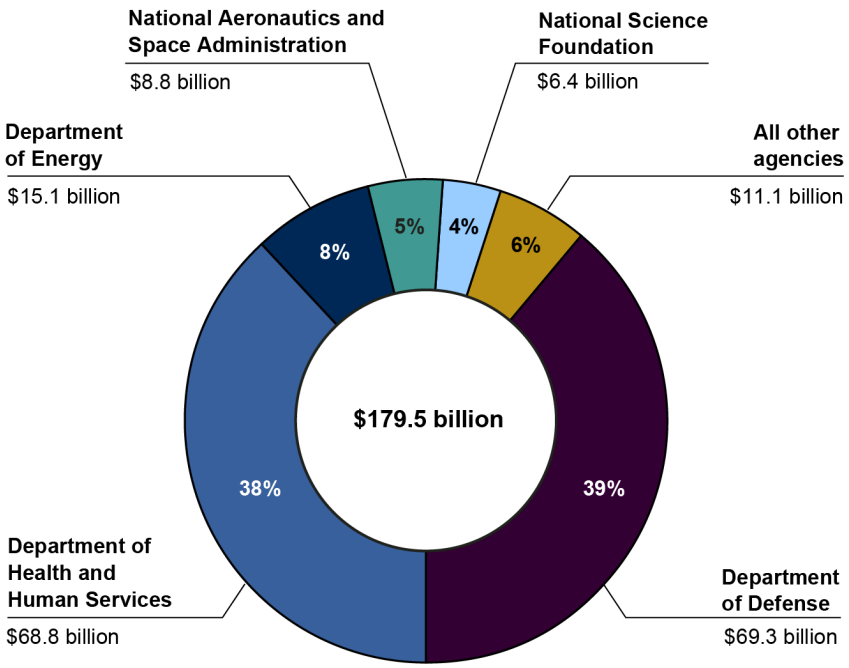


Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development*. I GAO-23-105396

Notes: FY 2021 data are estimates provided by federal agencies to the National Science Foundation. Excluded is research by foreign research entities and state and local governments because R&D obligations to these entities were not included in the detailed time series.

Further, we found that since FY 2012 R&D obligations have been concentrated most heavily within two agencies—DOD and HHS. For example, in FY 2021, DOD and HHS accounted for nearly 80 percent of federal R&D obligations (see fig. 3).

Figure 3: Federal Research and Development Obligations, FY 2021



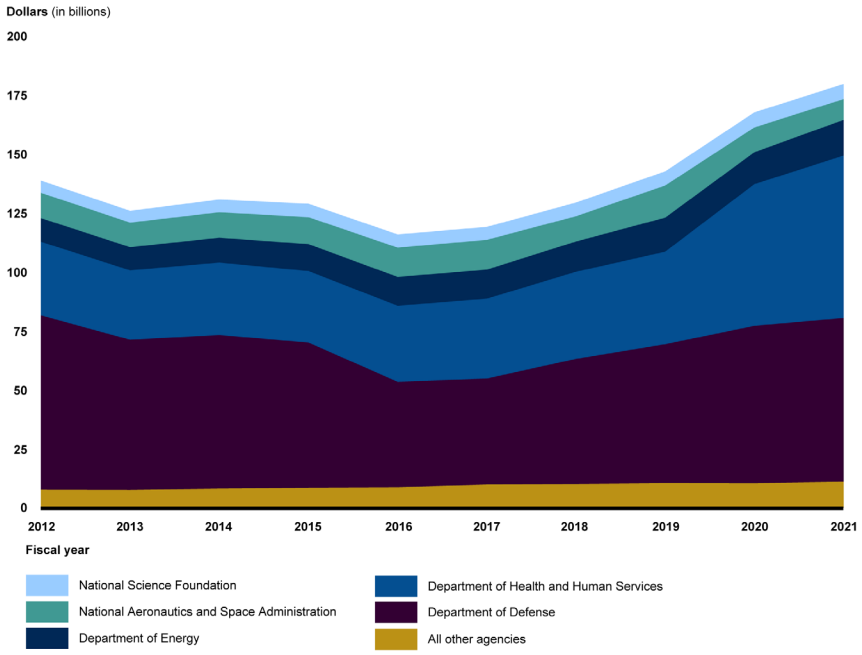
Source: GAO analysis of data from NSF's *Survey of Federal Funds for Research and Development.* I GAO-23-105396

Note: FY 2021 data are estimates provided by federal agencies to the National Science Foundation.

However, as seen in figure 4, within a period of overall growth, obligation levels varied somewhat since FY 2012. Specifically, total R&D obligations declined from FY 2012 to FY 2016, but then increased from FY 2017 through FY 2021.[18]

[18]Our analysis does not include annual amounts for the 'physical assets' category, which can include spending on both R&D facilities and major fixed equipment that support R&D programs as explained in OMB Circular No. A-11, *Preparation, Submission, and Execution of the Budget*, § 84.2(b) (Schedule C). NSF's Survey of Federal Funds for Research and Development uses the category 'R&D plant' to include spending on both R&D facilities and major equipment, following OMB guidance for reporting on 'physical assets.' Federal obligations for physical assets (which includes NSF's 'R&D plant' category) are substantially smaller than those for 'conduct of research and development' including basic research, applied research, and experimental development. OMB Circular No. A-11, § 84.2(c) (Schedule C).

Figure 4: Federal Research and Development Obligations by Selected Agencies and All Other Agencies, FY 2012 to FY 2021



Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development.* | GAO-23-105396

Notes: Beginning with FY 2016, agency reported obligations for R&D represent a refinement to the category of development, more narrowly defining it to be 'experimental development.' According to the National Science Foundation (NSF), the Office of Management and Budget (OMB) updated the definition of 'development' to better align with international guidelines for reporting R&D funding in OMB Circular No. A-11, specifically citing and excluding the Department of Defense (DOD) Operational Systems Development (OSD) (Budget Activity 7) from development obligations (NSF, National Center for Science and Engineering Statistics, *Statistical Definition of Development Clarified: Effect on Reported Federal R&D Totals*, NSF 21-326 (Alexandria, VA: Apr. 2021). Following this, NSF revised the reporting instructions for the FYs 2016-2017 volume of the survey to exclude OSD from development obligations data. Therefore, it is important to keep this change in measurement of these data for FYs 2016 and after in mind when making comparisons with the data for FY 2015 and earlier years. FY 2021 data are estimates provided by federal agencies to NSF. These trends are generally consistent for both nominal and inflation-adjusted dollars.

In examining R&D obligations over the past 10 years, it is important to note that OMB and NSF changed the measurement of the development component of R&D in FY 2016 in response to a 2015 change instituted by the Organisation for Economic Co-operation and Development (OECD).[19]

[19]The Organisation for Economic Co-operation and Development is an international organization of 38 member countries, including the United States, created to foster economic development. It also produces international guidelines for reporting on R&D funding.

Prior to FY 2016, the definition for “development” included both experimental and preproduction development.[20] Starting in FY 2016, the definition for ‘development’ excludes preproduction development. According to NSF, the new definition resulted in lower reported R&D funding by DOD and NASA. DOD was most affected, with $25 billion of formerly reported preproduction development excluded in FY 2016 and somewhat larger amounts in more recent years. Also, NASA reported a $2 billion decline in development in FY 2016 and thereafter.[21] No other agency indicated that the change in OMB’s official definition of R&D resulted in revisions to its reported R&D totals.

With the largest amount of federal R&D obligations, DOD consistently accounted for a majority of overall growth and decline from FY 2012 to FY 2018. As shown in table 4, this is true for the period before the FY 2016 development definition change as well as the period after, from FY 2016 to FY 2018. DOE, NASA and NSF all had increases in R&D funding between FY 2012 and FY 2015, with other agencies experiencing more moderate gains. In the two years following the change in development definition, DOD and HHS together accounted for the majority of overall growth in obligations, totaling $12.9 billion ($8.2 billion and $4.7 billion, respectively) of the $13.6 billion increase in funding for all agencies.

[20]Preproduction development is defined as non-experimental work on a product or system before it goes into full production, including activities such as tooling and development of production facilities according to OMB, Circular No. A-11, *Preparation, Submission, and Execution of the Budget*, § 84.2.

[21]NSF 21-326.

Table 4: Change in Federal Research and Development Obligations by Agency for Selected Intervals in Billions of Dollars between FY 2012 and FY 2021

	FY 2012 - 2015		FY 2016 - 2018		FY 2019 - 2021	
Agency	Dollar change	Percent change	Dollar change	Percent change	Dollar change	Percent change
Department of Defense	-12.3	-17%	8.2	18%	10.5	18%
Department of Energy	1.4	14%	0.6	5%	0.7	5%
Department of Health and Human Services	-0.9	-3%	4.7	15%	29.6	76%
National Aeronautics and Space Administration	0.7	7%	-1.7	-14%	-4.8	-35%
National Science Foundation	0.5	10%	0.3	5%	0.4	7%
All other agencies	0.8	10%	1.5	17%	0.6	5%
All agencies	-9.8	-7%	13.6	12%	37	26%

Source: GAO analysis of data from National Science Foundation's Survey of Federal Funds for Research and Development. I GAO-23-105396

Note: FY 2021 data are estimates provided by federal agencies to NSF.

Also of note in examining R&D obligations from FY 2012 to FY 2021, COVID-19 stimulus funding drove the largest year-to-year change for R&D obligations over the last 50 years, according to NSF.[22] In FY 2020, federal obligations totaled $167 billion, an increase of nearly 18 percent from FY 2019.[23] The last increase of this magnitude was a 21 percent year-to-year change in 1963 when NASA bolstered support for its space program, according to NSF.[24] Table 4 also illustrates this period of significant change between FY 2019 and FY 2021, with growth concentrated in HHS and decreases concentrated in NASA. Based on our analysis, the stimulus funding contributed to HHS experiencing a 53 percent increase in R&D obligations in FY 2020, accounting for 83 percent of the growth across all federal agencies. Selected agencies' R&D trends over the past 10 years and corresponding periods of growth and decline are further illustrated in table 4.

[22]National Science Foundation, National Center for Science and Engineering Statistics, *Driven by Stimulus Funding, Federal R&D Obligations Increased 18% in 2020; Largest Year-to-Year Change since 1963,* NSF 22-324 (Alexandria, VA: March 2022).

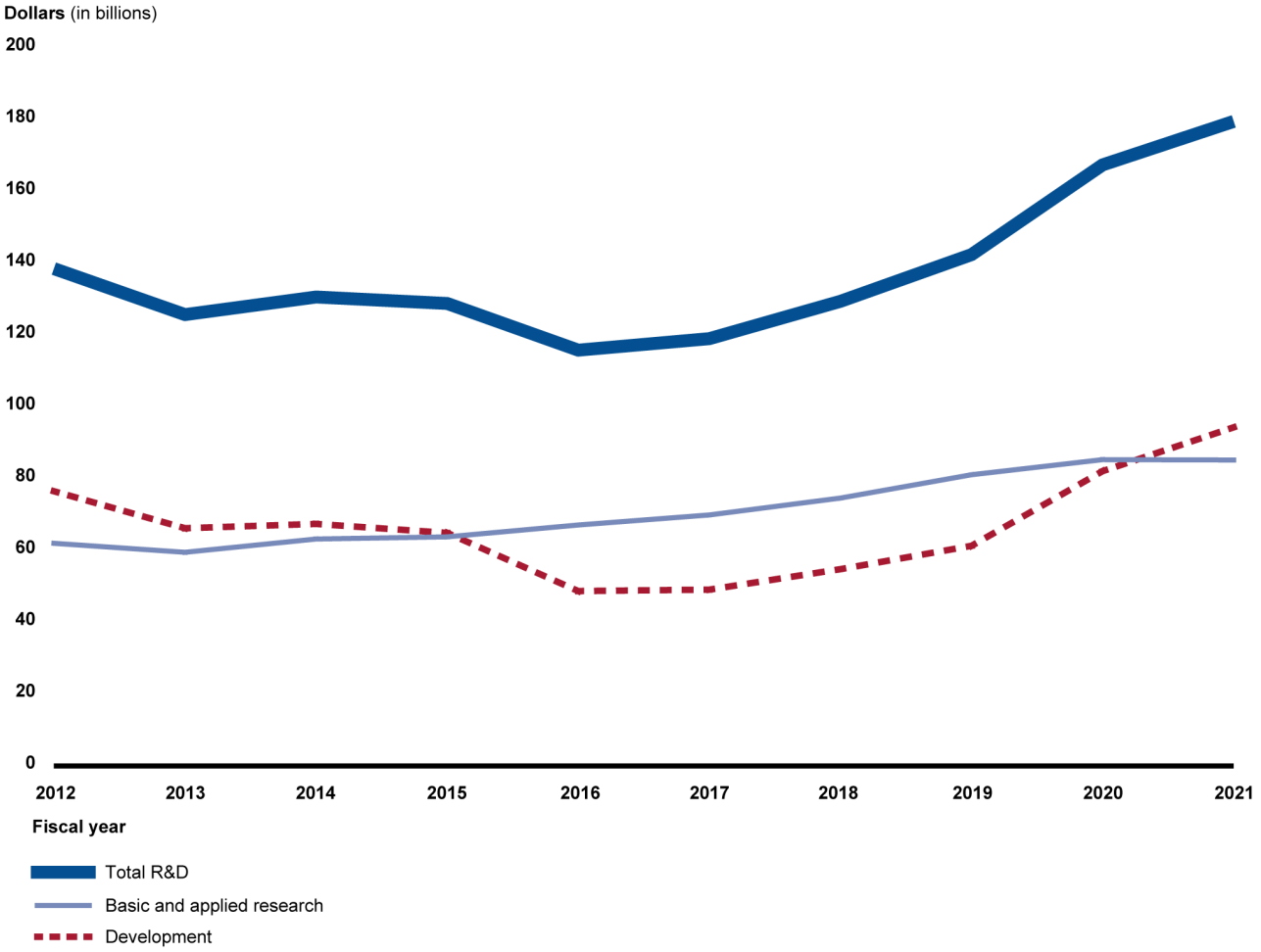
[23]NSF 22-324.

[24]NSF 22-324.

Obligations for Research Trended Differently than for Development between Fiscal Years 2012 and 2021

Throughout various agencies and programs, the federal government funds different types of research and development work—basic research, applied research, and development. We found that over the past decade, fluctuations in the middle of this period were mostly attributable to the changes in measurement of development obligations while subsequent increases in development obligations were largely the result of COVID-19 stimulus funding. In contrast, obligations for basic and applied research grew over the past decade (see fig. 5).

Figure 5: Federal Obligations for Research and Development (R&D), FY 2012 to FY 2021



Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development.* I GAO-23-105396

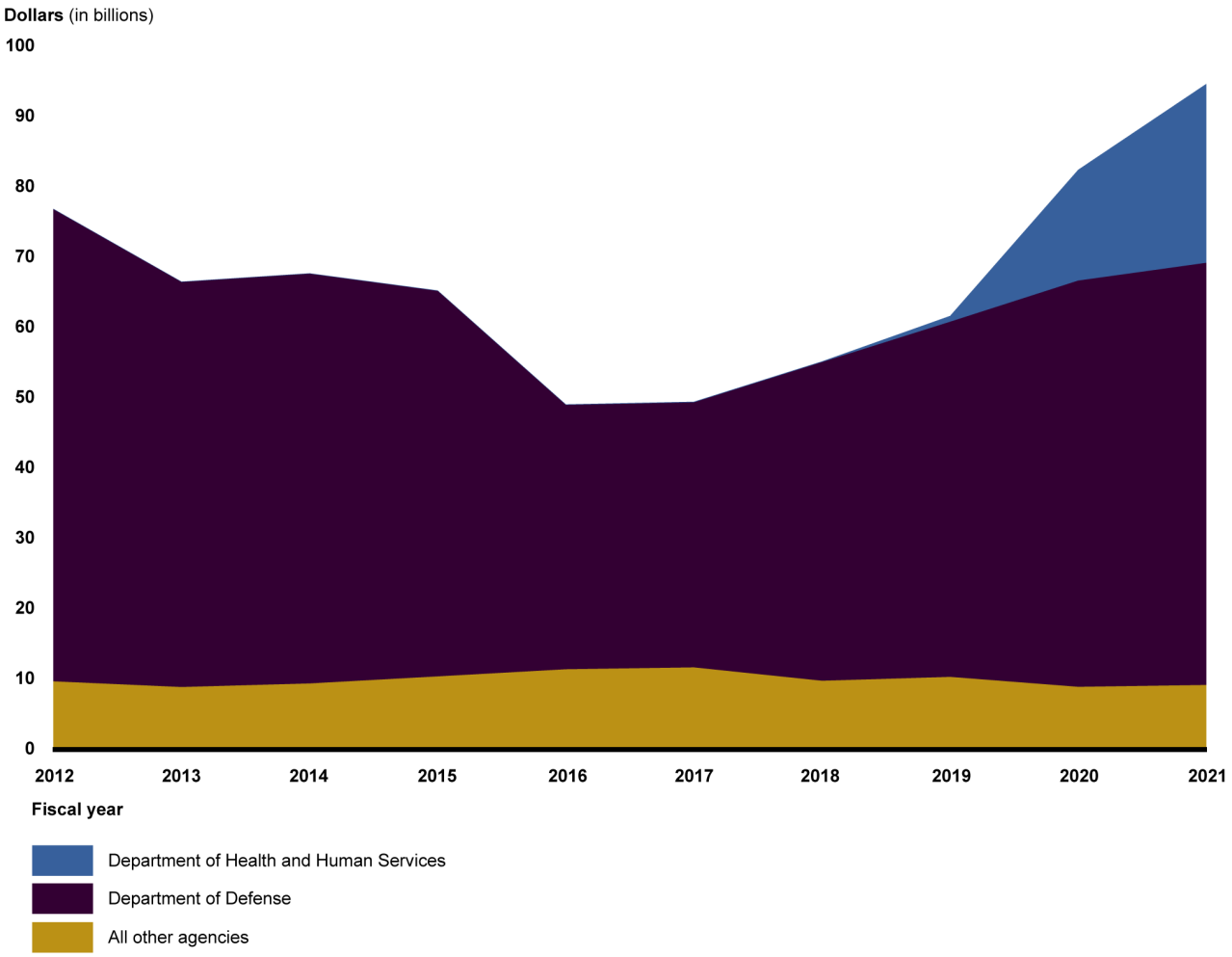
Notes: Not included in this analysis are annual amounts for the 'R&D plant' category. Beginning with FY 2016, agency reported obligations for R&D represent a refinement to the category of development, more narrowly defining it to be 'experimental development.' According to the National Science Foundation (NSF), the Office of Management and Budget (OMB) updated the definition of

'development' to better align with international guidelines for reporting R&D funding in OMB Circular No. A-11, specifically citing and excluding the Department of Defense (DOD) Operational Systems Development (OSD) (Budget Activity 7) from development obligations (NSF, National Center for Science and Engineering Statistics, *Statistical Definition of Development Clarified: Effect on Reported Federal R&D Totals*, NSF 21-326 (Alexandria, VA: Apr. 2021). Following this, NSF revised the reporting instructions for the FYs 2016-2017 volume of the survey to exclude OSD from development obligations data. Therefore, it is important to keep this change in measurement of these data for FYs 2016 and after in mind when making comparisons with the data for FY 2015 and earlier years. FY 2021 data are estimates provided by federal agencies to NSF. These trends are generally consistent for both nominal and inflation adjusted dollars.

As described above, two events during the decade help explain changes in reported federal R&D obligations over the past 10 years. First, when OMB modified its development definition in FY 2016, the removal of preproduction development resulted in lower reported development obligations by DOD and NASA, although these agencies continued to have this type of development funding. Figure 6 illustrates this decline, and also shows that development funding, even with the change in measurement, is highly concentrated within DOD, accounting for an average of 79 percent of all federal development obligations in the past decade. Second, HHS became a significant contributor to development spending in fiscal years 2020 and 2021 with funding made available through the federal COVID-19 response that was formerly referred to as Operation Warp Speed. Specifically, the Biomedical Advanced Research and Development Authority within HHS saw increased obligations from $736 million in FY 2019 to $16 billion in FY 2020.[25] From FY 2012 to FY 2019, HHS averaged less than 1 percent of development obligations.

[25]NSF 22-324.

Figure 6: Development Obligations for the Department of Defense (DOD), the Department of Health and Human Services and All Other Agencies for FY 2012 to FY 2021

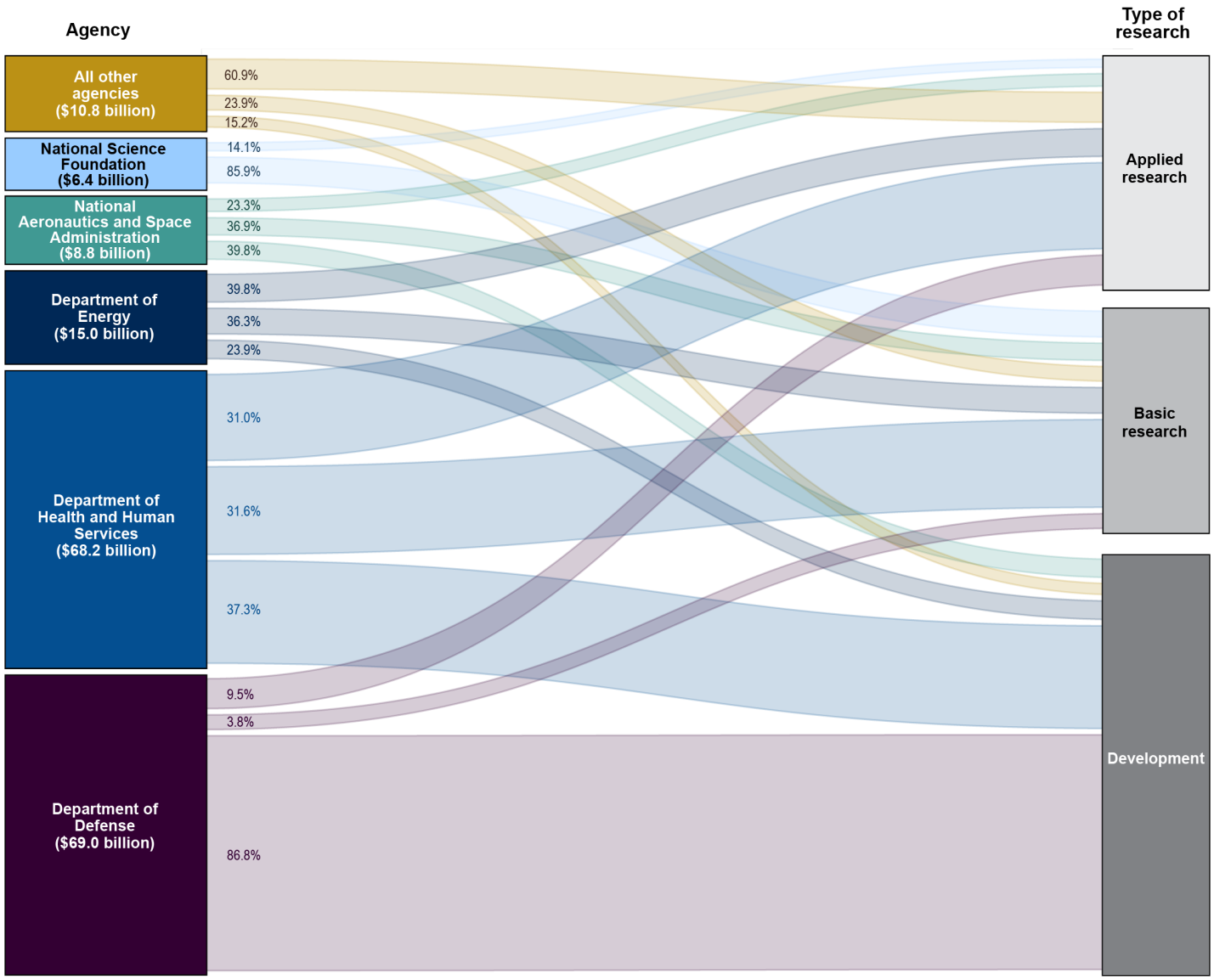


Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development.* I GAO-23-105396

Notes: Beginning with FY 2016, agency reported obligations for R&D represent a refinement to the category of development, more narrowly defining it to be 'experimental development.' According to the National Science Foundation (NSF), OMB updated the definition of development to better align with international guidelines for reporting R&D funding in OMB Circular No. A-11, specifically citing and excluding DOD Operational Systems Development (OSD) (Budget Activity 7) from development obligations (NSF, National Center for Science and Engineering Statistics, Statistical Definition of Development Clarified: Effect on Reported Federal R&D Totals, NSF 21-326 (Alexandria, VA: Apr. 2021). Following this, NSF revised the reporting instructions for the FYs 2016-2017 volume of the survey to exclude OSD from development obligations data. Therefore, it is important to keep this change in measurement of these data for FYs 2016 and after in mind when making comparisons with the data for FY 2015 and earlier years. FY 2021 data are estimates provided by federal agencies to NSF. These trends are generally consistent for both nominal and inflation adjusted dollars.

Over the past decade, the five agencies with the largest R&D obligations have consistently contributed to different types of R&D work. DOD is consistently the largest contributor to federal development spending and has allocated an average of 88 percent of its R&D obligations to development over the past 10 years. HHS obligations, in contrast, have been more evenly split between basic and applied research. Between FY 2012 and FY 2019, HHS averaged less than 1 percent in development obligations. In FY 2021, however, as shown in figure 7, HHS reported 37 percent of R&D obligations for development. As previously noted, this significant increase was the result of COVID-19 stimulus funding beginning in FY 2020. DOE consistently obligated a majority of its R&D funding towards basic and applied research, with an average of 77 percent of its funding going towards these two types of work combined over the past 10 years.

Figure 7: Federal R&D Obligations by Type of Research across Agencies, FY 2021



Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development.* I GAO-23-105396

Notes: FY 2021 data are estimates provided by federal agencies to the National Science Foundation. Percentages may not add to 100 because of rounding. Excluded is research by foreign research entities and state and local governments because R&D obligations to these research entities were not included in the detailed time series.

Share of R&D Funding Shifted Slightly among Industry, Universities and Colleges and Federal Agencies

The federal government relies on different entities and organizations to carry out research and development activities. These research entities are either federal government agencies (intramural) or organizations outside the federal government (extramural)—broadly comprising businesses, universities and colleges, nonprofits, federally funded research and development centers (FFRDCs),[26] state and local governments, foreign entities,[27] and private individuals.[28]

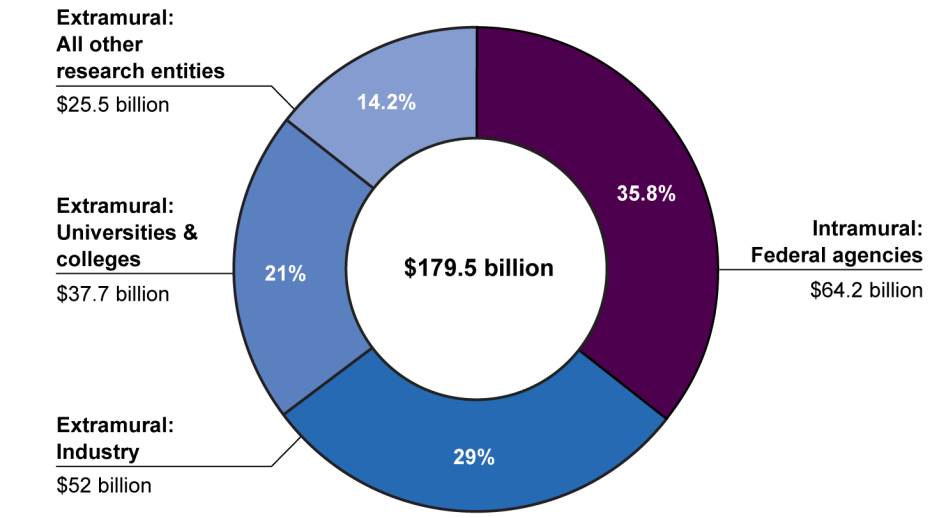
Of the estimated $179.5 billion in federal R&D obligations in FY 2021, roughly two-thirds ($115.3 billion) went to organizations outside the federal government (extramural), and the remaining one-third ($64.2 billion) funded intramural R&D within agencies of the federal government (see fig. 8). Of research organizations outside the federal government, industry and universities and colleges receive the majority of R&D obligations. In FY 2021, for example, these two categories combined received almost $90 billion (78 percent) in obligations to extramural research entities.

[26]Federally funded research and development centers (FFRDCs) are R&D-performing organizations that are exclusively or substantially financed by the federal government and are supported by the federal government either to meet a particular R&D objective or in some instances to provide major facilities at universities for research and associated training purposes, according to NSF. Each center is operated by contractors such as universities, non-profits, or businesses. Twelve federal agencies sponsor or co-sponsor a total of 42 FFRDCs in support of their missions in a broad range of areas—from energy and cybersecurity to cancer and astronomy.

[27]On average, foreign research entities received less than one percent of overall R&D obligations annually between FY 2012 and FY 2021.

[28]For the NSF *Survey of Federal Funds for Research and Development,* intramural research entities are defined as agencies of the federal government, including federal employees who work on R&D both onsite and offsite. Obligations reported under this category are for activities performed or to be performed by the reporting agency itself or are for funds that the agency transfers to another federal agency for performance of work, as long as the ultimate research entities is that agency or any federal agency. Intramural activities also include administrative costs and the cost of supplies and off-the-shelf equipment procured for use in intramural R&D.

Figure 8: Federal Obligations by Type of Research Entity, FY 2021



Source: GAO analysis of data from NSF's *Survey of Federal Funds for Research and Development*. I GAO-23-105396

Notes: FY 2021 are estimates provided by federal agencies to the National Science Foundation. The 'Extramural: All other research entities' category includes nonprofit institutions, federally funded research and development centers, state and local governments, and foreign research entities.

Three types of research entities—industry, universities and colleges, and intramural federal agencies—have consistently received most (averaging 85 percent) of the federal obligations for R&D since FY 2012, although their respective shares have shifted slightly over the decade. The remaining research entities, all extramural—FFRDCs, nonprofits, state and local governments, and foreign entities—received the remaining share (averaging 15 percent). Throughout the 10-year period, industry accounted for approximately one-third of federal R&D obligations, the largest share of all research entities. Federal agencies and universities and colleges have each accounted for approximately one-quarter of federal obligations during the past decade, with obligations to universities and colleges remaining stable throughout this period (averaging a 22 percent share). There was a notable increase in R&D obligations to federal agencies from FY 2017 through FY 2021, both in dollars and as a share of overall obligations, almost doubling in the dollar amount and rising by almost 10 percentage points from 26 percent of federal R&D

allocations in FY 2017 to 36 percent in FY 2021.[29] According to NSF, in FY 2020, the federal sector itself received the largest amount of federal R&D obligations ($51.5 billion) [30] Of this amount, $23.3 billion (14 percent of total R&D obligations) was for COVID-19 R&D.

The top five agencies with the largest share of R&D obligations have consistently relied on certain types of research entities to carry out their respective R&D activities over the past decade. For example, DOD consistently allocated over half of its R&D funding to industry. This is followed by approximately one-third of DOD obligations staying within the federal sector as intramural R&D over the past decade. Similarly, NASA consistently relied on a combination of industry, NASA's own researchers, and university-administered FFRDCs to conduct R&D. Over the 10-year period, an average of 54 percent of NASA's R&D obligations went to industry. HHS relied primarily on universities and colleges to conduct R&D, which have accounted for an average of 53 percent of its obligations in the past decade.[31]

While agency use of certain types of research entities has generally been consistent over the past decade, some agencies more recently have shifted spending to different types of research entities. For example, in FY 2021, HHS allocated 44 percent of obligations to federal agencies and 35 percent to universities and colleges (see fig. 9). This is a shift from FY 2012, when HHS allocated 21 percent of obligations to federal agencies and 57 percent to universities and colleges. As another example, NASA's allocations to industry have decreased every year since FY 2017 as funding to federal agencies has fluctuated, almost tripling in dollar terms in FY 2019 and then decreasing by 42 percent between FY 2019 and FY 2021. Other agencies, such as DOD and DOE, have remained relatively stable in this regard over the past decade. DOE allocates funds across a

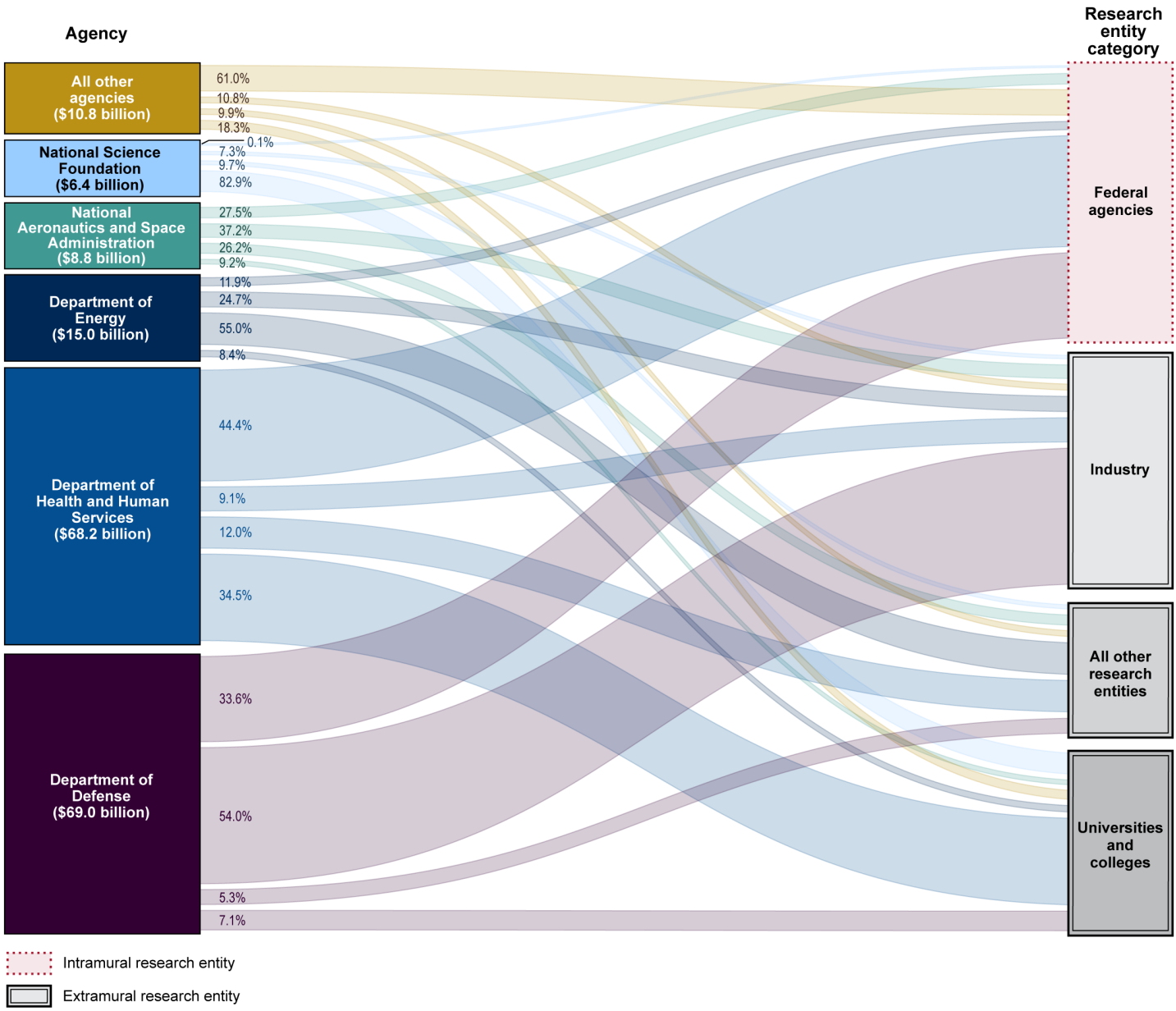
[29]Funding to intramural research entities (agencies of the federal government) includes obligations for R&D within federal labs and facilities but also includes the transfer of R&D funds within the federal government from one federal agency to another (e.g., transferring funding from DOD to a DOE FFRDC). Specifically, for the *Survey of Federal Funds for Research and Development*, agencies are instructed to include funds transferred to other agencies as federal intramural while agencies receiving funds are instructed to exclude those funds from their survey submission.

[30]NSF 22-324.

[31]According to NIH, more than 80 percent of NIH's funding is awarded for extramural research, largely through almost 50,000 competitive grants to more than 300,000 researchers at more than 2,500 universities and other research institutions in every state, the District of Columbia, Puerto Rico, and several tribes.

wide array of research organizations (industry, universities and colleges, and intramural federal agencies), with the greatest share of its R&D obligations going outside the federal government to FFRDCs managed and operated by industry, nonprofits, and universities and colleges. An average of 62 percent of DOE obligations went to FFRDCs in the past decade, more than any other federal agency.

Figure 9: Federal R&D Obligations by Type of Research Entity across Agencies, FY 2021



Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development*. I GAO-23-105396

Notes: FY 2021 data are estimates provided by federal agencies to the National Science Foundation. Percentages may not add to 100 because of rounding. The 'All other research entities' category includes nonprofit institutions and federally funded research and development centers. Excluded from this category is research by foreign research entities and state and local governments because R&D obligations to these research entities were not included in the detailed time series.

Life Sciences Accounted for Much of the Increases in Basic and Applied Research Funding

The basic and applied research funded by the federal government spans a full range of science and engineering fields: computer sciences and mathematics, engineering, environmental sciences, life sciences, physical sciences, psychology, social sciences, and other fields of science.[32] Because development has not been classified by science and engineering field, it is not reported in the Survey of Federal Funds for Research and Development.[33] In FY 2021, funding for basic and applied research accounted for $85 billion of the estimated $179.5 billion total of federal obligations for R&D.

Most fields of sciences and engineering experienced growth between FY 2012 and FY 2021 across both basic and applied research (see table 5). For example, federal obligations for computer science research doubled for applied research and increased by 44 percent for basic research, but were smaller than other major increases in terms of total dollars (approximately $2.6 billion combined for basic and applied research). By contrast, federal obligations for life sciences—the largest field of study in terms of federal obligations—increased for basic and applied research by about $11 billion (a 30 percent and 41 percent increase for basic and applied life sciences research, respectively).[34]

[32]NSF's *Survey of Federal Funds for Research and Development* uses eight broad field categories, each comprising a number of detailed fields. A discipline under one detailed field may be classified under another detailed field when the major emphasis is elsewhere. Research in biochemistry, for example, might be reported as biological, agricultural, or medical, depending on the focus of the project. No double counting is intended or allowed.

[33]According to NSF, under the redesign of the *Survey of Federal Funds for Research and Development*, NCSES will begin collecting 'fields of R&D' (previously referred to as 'fields of science') for development in addition to basic and applied research under Volume 71 (fiscal years 2021-2022).

[34]The field of life sciences includes five broad categories: agricultural sciences (e.g., food science and technology and horticulture), biological sciences (e.g., genetics, and neuroscience), environmental biology (e.g., ecosystem sciences), medical sciences (e.g., pathology and pharmacology), and other life sciences.

Table 5: Change in Federal Research Obligations by Field of Science and Engineering by Type of Research in Billions of Dollars, FY 2012 to FY 2021

	Basic Research			Applied Research		
Field of Science and Engineering	FY 2012	FY 2021	Percent change	FY 2012	FY 2021	Percent change
Computer sciences and mathematics	1.8	2.6	44%	1.7	3.5	100%
Engineering	3.5	2.9	-17%	7.9	11.4	43%
Environmental sciences	2.3	2.7	21%	1.6	1.9	16%
Life sciences	16	20.9	30%	15	21.1	41%
Physical sciences	4.6	7.4	63%	1.9	1.3	-28%
Psychology and social sciences	1.5	2.1	41%	1.7	2.5	41%
Other research	1.4	2.6	86%	1.1	2.3	100%

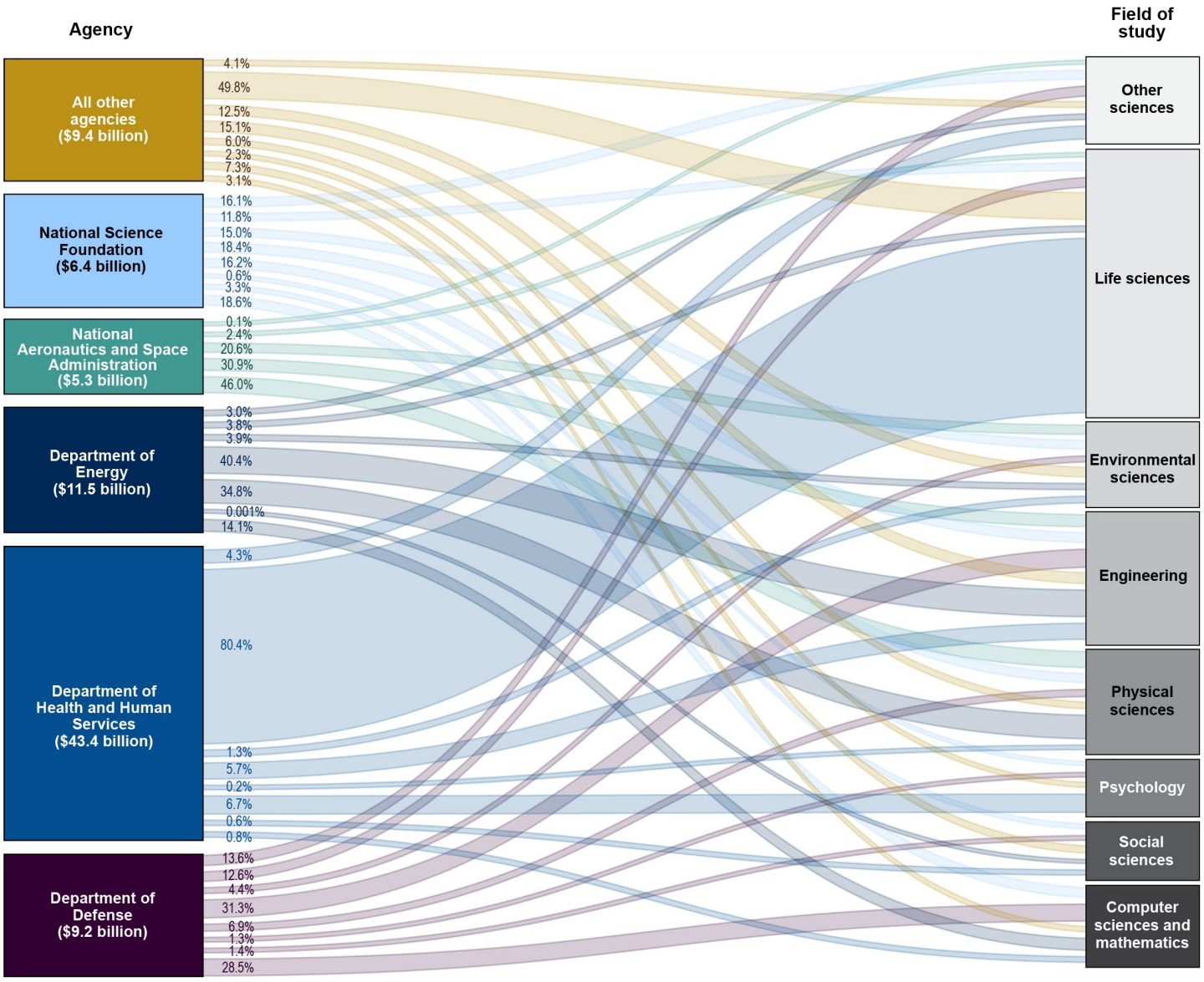
Source: GAO analysis of data from NSF's Survey of Federal Funds for Research and Development. I GAO-23-105396

Notes: The Survey of Federal Funds for Research and Development separates psychology and social sciences. We combined them due to their relatively small size compared to other fields of science and engineering. Percent change may not be exact due to rounding. FY 2021 data are estimates provided by federal agencies to the National Science Foundation.

Federal research obligations in the field of life sciences represent the largest share of all fields of science and engineering—nearly half of all federally supported basic and applied research falls under the category of life science. Over the past decade, funding for life sciences has consistently been evenly divided between basic and applied research. The dollar amount for life sciences funding increased from FY 2012 through FY 2021, with HHS (NIH) accounting for most of this increase. During this 10-year period, 78 percent of the growth in federal obligations for the field of life sciences was accounted for by the $9 billion growth in NIH obligations.[35] Figure 10 shows that in FY 2021, HHS allocated over 80 percent ($34.8 billion) of its federal R&D obligations to life sciences, funding the majority of basic and applied research in this field of study.

[35]In FY 2021, NIH's research obligations accounted for 97 percent of all research obligations for HHS.

Figure 10: Federal Research Obligations for Selected Fields of Science and Engineering, by Agency, FY 2021



Source: GAO analysis of National Science Foundation's *Survey of Federal Funds for Research and Development.* I GAO-23-105396

Notes: FY 2021 data are estimates provided by federal agencies to the National Science Foundation. Percentages may not add to 100 because of rounding. Excluded from this graphic is research by foreign research entities and state and local governments because R&D obligations to these research entities were not included in the detailed time series.

Research obligations in the next two largest fields—engineering and physical science—also grew over this period, with increases concentrated in specific agencies. DOE and HHS accounted for the majority of the growth in the field of engineering, the next largest field of research after life sciences. DOE increased its applied research obligations related to engineering from $1.9 billion in FY 2012 to $4.6 billion in FY 2021, more than doubling during the past decade. At HHS, both basic and applied research obligations in the field of engineering increased 76 percent from a combined $1.4 billion in FY 2012 to $2.5 billion in FY 2021. Basic and applied research obligations for physical sciences together increased by $2.4 billion (37 percent) from FY 2012 through FY 2021, with NASA accounting for $1.2 billion of that in basic research in physical science.

Federal R&D Funding Is Largely Driven by Agency Missions

While broadly overseen by OMB and OSTP, funding for federal agency R&D is largely determined by their established missions and other agency, administration, and congressional priorities. Discretion in executing their budgets varies by agency. Congressional appropriations also dictate the amount of time agencies have to obligate their R&D funds.

Agencies Prepare R&D Budgets for Their Established Missions in Consultation with OMB and OSTP

Federal R&D budgets are generally determined through a decentralized and iterative process of balancing individual agency R&D priorities, largely reflective of their respective missions, against other agency, administration, and congressional priorities. The agencies determine their R&D priorities as part of the overall budget planning and formulation process set by OMB to prepare annual agency budget requests. In what OMB officials described as both a top-down and bottom-up R&D budget process, officials from the five selected agencies we reviewed all cited agency missions as the starting point for determining R&D funding priorities followed by consideration of broader administration priorities. The agencies described formulating their R&D funding proposals as part of OMB's budget planning and formulation process to develop their annual budget requests.

OMB guides high-level federal agency R&D priorities through the annual budget formulation process. OMB coordinates the preparation of the President's consolidated budget request to Congress. Integral to this effort is OMB's Circular No. A-11, which provides specific guidance for agency submission of budget requests and justification materials to OMB. OMB Circular No. A-11 provides an overview of applicable budgetary laws, policies for the preparation and submission of budgetary estimates, as well as guidance regarding congressional review of budget requests and directions for budget execution. In particular, OMB Circular No. A-11

directs agencies to submit budget information about their R&D activities as basic research, applied research, or experimental development.

To provide top-down guidance on R&D priorities to federal agencies, OSTP and OMB jointly issue an annual R&D priorities memorandum, generally in the late summer, which provides an overview of the President's R&D priorities for agencies to consider when formulating their budgets.[36] OMB officials stated that the joint memo on R&D priorities serves as the overarching guidance to agencies on R&D budget priorities. They note that the development of the R&D memorandum is primarily a top-down process that is driven and defined by what the Administration seeks to prioritize in R&D each year. They added that OSTP and OMB staff work collaboratively on the document.

[36]The first R&D priorities memorandum was issued in 1995, according to OMB.

OMB and OSTP Research and Development (R&D) Priorities for Fiscal Year 2024

In July 2022, OMB and OSTP issued a joint memorandum that outlined seven broad multi-agency R&D priorities for the fiscal year 2024 budget:

(1) preparing for and preventing pandemics;
(2) reducing the death rate from cancer by half;
(3) tackling climate change;
(4) advancing national security and technological competiveness;
(5) innovating for equity;
(6) cultivating an equitable science, technology, engineering and math education, engagement, and workforce ecosystem; and
(7) promoting open science and community-engaged R&D.

The memorandum states that these priorities should be identified when they are included in agency budget submissions.

Source: GAO analysis of OMB and OSTP, Memorandum No. M-22-15, *Memorandum for the Heads of Executive Departments and Agencies on Multi-Agency Research and Development Priorities for the FY 2024 Budget* (July 22, 2022). | GAO-23-105396

According to OSTP officials and our analysis of the past R&D priority memos, a President's R&D priorities tend to remain largely stable over the term of a given administration. In our review of the 11 most recently issued R&D priority memos—spanning three presidential administrations—we also found continuity of certain R&D priorities within each of the last three administrations, though not between them.[37] For example, climate change was consistently identified as an R&D priority from memos issued from 2012 through 2015 and 2021 through 2022, but not in the memos issued from 2018 through 2020. OSTP officials told us that after a change in administrations, the new President appoints new senior leadership at OSTP and they generally adopt federal R&D priorities and science and technology policies and programs that had been signaled during the presidential campaign. The FY 2024 OMB and OSTP memorandums encouraged the agencies to focus resources on the multi-agency R&D priorities, where appropriate, as they develop their budget requests. This memorandum outlines seven broad multi-agency R&D priorities for the fiscal year 2024 budget (see sidebar).

OMB officials told us that because federal R&D is comprised of a broad array of disciplines and topical areas of national interest, the development of the federal R&D budget is both a top-down and bottom-up process. To determine agency-level R&D priorities, agency officials cited their missions as their starting point in the R&D prioritization process. They all described formulating their R&D funding proposals in concert with developing their annual budget requests following OMB's budget planning and memorandums. As OMB officials noted, R&D is central to the mission of some agencies and they are almost exclusively dedicated to R&D, such as NASA and NSF, while other agencies, such as DOD and DOE, support or conduct R&D as part of their mission. Agency budget officials stated that the R&D priorities for their agencies are based on mission-related needs documented in agency strategic plans, input from external experts, and administration and congressional priorities. For example:

- **DOD.** Officials from the Air Force, Army, Navy, and Missile Defense Agency stated that they begin developing their R&D priorities on the basis of DOD-wide strategy documents such as the National Security

[37]We reviewed memorandums prepared for the FY 2012 to FY 2024 budget years, except for the FY 2013 and FY 2018 budget years when no memorandums were prepared. According to OMB the FY 2013 budget year memorandum was not issued at least in part due to sequestration and the FY 2018 budget year memorandum was not issued due to the change in presidential administrations in 2016.

Strategy and National Defense Strategy. In addition, some DOD services and agencies cited using planning documents such as the Army's Modernization Priorities and the U.S. Strategic Command's annual Missile Defense Integrated Priority List for the Missile Defense Agency. The DOD Office of the Comptroller reviews initial budget submissions prepared by DOD services and agencies before they are submitted to OMB. An official from the DOD Comptroller's office stated that key elements of their review are the size of the funding and priorities, particularly the priorities set in the National Defense Strategy and those outlined by OMB.

- **DOE.** Officials from DOE's Office of Energy Efficiency and Renewable Energy (EERE), Office of Science, and National Nuclear Security Administration (NNSA) stated that their R&D priorities are reflective of their missions.
  - EERE officials stated that each EERE office develops a plan that articulates how its overarching goals, priority program thrusts, roadmaps, and prioritization methodologies align with overall EERE strategic priorities, and ultimately, with broader DOE and administration priorities. Each EERE office and subprogram develops technical roadmaps in consultation with industry, university, national laboratory, and other stakeholders and experts. These roadmaps help guide R&D investments, moving offices towards their program plan goals and building towards EERE and DOE strategic goals.
  - For the Office of Science, with its broad mission to deliver scientific discoveries and major scientific tools, officials stated that once the administration and DOE define the high-level priorities, each of their program offices establishes their specific research priorities. This is done with assistance from advisory panels and by panels of experts from the R&D community participating in workshops and roundtables, according to DOE officials.
  - NNSA officials stated that they strive to ensure that their budgeted activities support their mission to certify the nuclear stockpile without nuclear explosive testing, to ensure that the nuclear security enterprise advances capabilities needed to reduce global nuclear risk, and to support DOD and other mission partners.
- **HHS.** Officials from HHS's NIH stated that its NIH-wide strategic plan articulates the agency's highest R&D priorities. They said the NIH-wide strategic plan positions their agency to meet its mission by pursuing scientific opportunities when they arise, responding to ongoing, emerging, and re-emerging public health priorities, and

addressing rare diseases. The NIH-wide strategic plan complements and harmonizes NIH institutes' and centers' strategic plans across NIH, which addresses their individual missions. NIH also has topical NIH-wide strategic plans to address specific high priority areas such as minority health and health disparities, COVID-19, and women's health research. NIH officials added that all NIH research and training activities align with and reflect HHS's priority goals. NIH develops its strategic plans with input from experts, advisory committees, panels and the public.

- **NASA.** Officials from NASA's Exploration Systems Development Mission Directorate and its Science Mission Directorate both cited the administration and Congress as primary sources in developing their R&D priorities. Science Mission Directorate officials also cited National Academies of Science, Engineering, and Medicine committees as another source of R&D priorities.
  - Exploration Systems Development Mission Directorate officials recounted that they follow guidance from Congress and the White House. They described their directorate as focused on supporting NASA's exploration goals, such as exploring the surface of the moon and deep space. They cited a strategic document—a United States Space Priorities Framework, as their foundation for developing the agency's strategic plan as well as the priorities of their mission directorate.
  - Science Mission Directorate officials stated that in addition to direction from the administration and Congress, they also seek input from decadal surveys conducted by the National Academies of Science, Engineering, and Medicine committees on topics such as the National Academies' Decadal Survey Process in the fields of astrophysics, heliophysics, and planetary science. NASA is required by statute to enter into periodic agreements with the National Academies to conduct decadal surveys that "take stock of the status and opportunities for Earth and space science discipline fields and Aeronautics research and to recommend priorities for research and programmatic areas [for] the next decade."[38] In addition, the NASA Advisory Council, consisting of external experts, provides NASA with independent reviews of its activities broadly.

[38]National Aeronautics and Space Administration Authorization Act of 2008, as amended, Pub. L. No. 110-422, § 1104(a), 122 Stat. 4779 (codified as amended at 51 U.S.C. § 20305(a)).

- **NSF.** NSF program office officials stated that in addition to accounting for administration priorities, such as those outlined in the annual OMB and OSTP memorandums, they also incorporate input from the National Science Board, NSF's Strategic Plan, and the advisory committees for each NSF directorate. They also incorporate information provided by the National Academies of Science, Engineering, and Medicine decadal surveys on topics such as astronomy, biology, and genomics. NSF officials stated that while they use the OMB and OSTP annual R&D memoranda to identify high level R&D priorities for new investment, they consider these options within established constraints and the availability of funds for ongoing commitments.

After receiving budget requests from the agencies in the fall, OMB program examiners prepare options and analysis for decision by OMB and the White House as they draft the President's budget. OMB examiners may also consult with agencies during this process about R&D efforts and priorities insofar as those agency requests are first reviewed by the OMB program examiners responsible for the associated policy areas related to R&D. Prior to making their recommendations for funding, OMB examiners may ask for additional information from agencies. OMB officials stated that OMB and OSTP frequently attend agency program meetings together and that they regularly engage with OSTP when reviewing agency funding requests. After OMB makes its recommendations for funding, the agencies have an opportunity to appeal to OMB for adjustments before the President's budget is presented to Congress in February.

As part of the President's budget, OMB produces *Analytical Perspectives*, which helps the public better understand the budget by presenting economic and accounting analyses, information on federal receipts and collections, analyses of federal spending, and information on federal borrowing and debt, among other topics. Included in *Analytical Perspectives* is a chapter providing a government-wide view of budget requests for R&D.

Following submission of the President's budget to Congress, the size and scope of R&D funding for federal agencies is further shaped as it moves through the congressional budget and appropriations process. Appropriations bills are developed by the House and Senate Appropriations Committees. After Congress passes appropriations bills and the President signs them into law, agencies can begin to execute their R&D budgets.

Discretion in Executing R&D Budgets Varies by Agency

Agencies can only execute the budget in accordance with the budgetary laws as enacted, but they do have some discretion. The amount of discretion agencies have in executing their budgets for R&D programs depends on the prescriptiveness of the appropriations language for each agency, or any accompanying legislative reports or congressional explanatory statements about the appropriations. Federal agencies may receive differing levels of specificity from appropriations, reports, or the accompanying congressional explanatory statements. The explanatory statement accompanying DOD appropriations for research, development, test and evaluation (RDT&E) was relatively more prescriptive than for other agencies. For instance, the Navy's FY 2022 RDT&E amount is subcategorized and detailed in a series of tables listing more than 250 activities totaling over $22 billion in the appropriations' accompanying explanatory statement.[39] The activities range in amounts from under $1 million identified for a study looking at "Advanced Arresting Gear" totaling $147,000, to over $1 billion earmarked for a program titled "Conventional Prompt Strike."[40] In contrast, we found that NASA does not have as many restrictions on its R&D appropriation. For example, its FY 2022 appropriation provided NASA with $7.6 billion for the Science Mission Directorate, which the congressional explanatory statement directed toward implementing R&D recommendations outlined in the Earth Science, Heliophysics, Planetary Science, Astrophysics, and Biological and Physical Sciences decadal surveys.[41] For the Science Mission

[39]168 Cong. Rec. H1866, H2086-94 (daily ed. Mar. 9, 2022) (explanatory statement by Rep. DeLauro, Chair of the House Committee on Appropriations, regarding the House Amendment to the Senate Amendment to H.R. 2471, Consolidated Appropriations Act, 2022, div. C). DOD budget justifications and congressional appropriations reports and explanatory statements also typically describe RDT&E funding by the character of the work to be performed. This characterization consists of eight categories, each with RDT&E budget activity code (6.1 through 6.8) and a description. DOD's RDT&E budget activity codes are as follows: 6.1 (Basic Research); 6.2 (Applied Research); 6.3 (Advanced Technology Development); 6.4 (Advanced Component Development and Prototypes); 6.5 (System Development and Demonstration); 6.6 (RDT&E Management Support); 6.7 (Operational Systems Development); and 6.8 (Software and Digital Technology Pilot Programs).

[40]168 Cong. Rec. at H1796 (daily ed. Mar. 9, 2022) (explanatory statement by Rep. DeLauro, Chair of the House Committee on Appropriations, regarding the House Amendment to the Senate Amendment to H.R. 2471, Consolidated Appropriations Act, 2022, div. B).

[41]Consolidated Appropriations Act, 2022, Pub. L. No. 117-103, 136 Stat. 49, 134 and 168 Cong. Rec. at H2091 and H2089 (daily ed. Mar. 9, 2022) (explanatory statement by Rep. DeLauro, Chair of the House Committee on Appropriations, regarding the House Amendment to the Senate Amendment to H.R. 2471, Consolidated Appropriations Act, 2022, div. C).

Directorate, the explanatory statement directed funding in 21 areas, such as nearly $500 million for “Lunar Discovery” and $175.4 million for the James Webb Space Telescope.[42]

Agencies may also shift, or reprogram, funds within an appropriations account from one program to another. Generally, agencies may reprogram appropriated funds without additional statutory authority, but often they must provide some form of notification to the appropriations committees, authorizing committees, or both. The extent to which agencies can reprogram their funding depends on the limitations and conditions imposed by their appropriations acts. Congress provided varying limitations on the agencies’ ability to reprogram funds in the FY 2022 appropriations act.[43] For example, DOE, HHS, NASA, and NSF are required to notify the Senate and House Appropriations Committees before obligating funds through a reprogramming.[44] DOD’s FY 2022 reprogramming authority required that it submit a report not later than 60 days after enactment of its appropriation, to the congressional defense committees to establish the baseline for application of reprogramming and transfer authorities.[45] In addition, the amount of funds that each agency can reprogram differs. For example, DOE can reprogram up to $5 million or 10 percent of any program, project, or activity’s appropriated amount above its limitation, whichever amount is lower.[46] In contrast, HHS, NASA and NSF, can reprogram no more than $500,000 without congressional notification, and there are other parameters imposed if congress is notified, and for reprogrammings between appropriations.[47]

[42]168 Cong. Rec. at H1796-97 (daily ed. Mar. 9, 2022) (explanatory statement by Rep. DeLauro, Chair of the House Committee on Appropriations, regarding the House Amendment to the Senate Amendment to H.R. 2471, Consolidated Appropriations Act, 2022, div. B).

[43]Consolidated Appropriations Act, 2022, Pub. L. No. 117-103, 136 Stat. 49.

[44]Pub. L. No. 117-103, 136 Stat. at 233, div. D, tit. III, § 301(e) (DOE), 136 Stat. at 498, div. H. tit. V, § 514 (HHS), and 136 Stat. at 144, div. B, tit. V, § 505 (NASA, NSF). Although the appropriation act provides for prior committee approval, obtaining prior committee approval is not a binding legal requirement on the Executive Branch. *INS v. Chadha*, 462 919 (1983).

[45]Pub. L. No. 117-103, 136 Stat. at 174, div. C, tit. VIII, § 8007.

[46]Pub. L. No. 117-103, 136 Stat. at 233, div. D, tit. III, § 301(e).

[47]See, e.g., Pub. L. No. 117-103, 136 Stat. at 498, div. H, tit. V, § 514 (HHS), and 136 Stat. at 144, div. B, tit. V, § 505 (NASA, NSF).

Reprogramming that reduces funding, personnel, or results in savings also have different requirements or limitations for agencies.

Congressional appropriations also dictate the amount of time agencies have to obligate funds for R&D efforts. Three of our selected agencies (DOD, NASA and NSF) have at least two fiscal years to obligate funds for their R&D work.[48] The NIH Institutes and Centers within HHS have to obligate funds within the fiscal year.[49] At DOE, most of DOE's Office of Science and NNSA R&D programs receive no-year funds meaning the funds are available for obligation until expended.[50]

Four Selected Multi-agency Initiatives Are Organized and Funded by Participating Agencies

Four Federal Initiatives Are Organized to Coordinate R&D Activities

Four initiatives established by law or through executive authority represent a federal strategy to coordinate R&D investments across agencies in the following areas:

- Network and information technology[51]

[48]Pub. L. No. 117-103, 136 Stat. at 169-70, div. C, tit. IV (DOD), 136 Stat. at 134, div. B, tit. III (NASA), and 136 Stat. at 139, div. B, tit. III (NSF).

[49]Pub. L. No. 117-103, 136 Stat. at 448-51, div. H, tit. II.

[50]DOE's Office of Science appropriation provides that $7.475 billion are available until expended (no-year funds), and of that amount, $202 million are 2-year funds. Pub. L. No. 117-103, 136 Stat. at 225, div. C, tit. III. DOE's National Nuclear Security Administration appropriation provides that $15.92 billion are available until expended, and of that amount, $117.06 million are 2-year funds. Pub. L. No. 117-103, 136 Stat. at 227, div. C, tit. III.

[51]High-Performance Computing Act of 1991, as amended, Pub. L. No. 102-194, 105 Stat. 1594, relevant sections amended by the American Innovation and Competitiveness Act, Pub. L. No. 114-329, 130 Stat. 2969 (2017) (codified at 15 U.S.C. §§ 5501-5503, 5511-5512, 5521-5524, 5527, and 5541-5542 (2018)).

- Nanotechnology[52]
- Quantum information science and technology[53]
- Global change research[54]

Each of the four initiatives engages a consortium of federal departments and agencies that have relevant mission-driven research interests. These multi-agency initiatives were created to address challenges considered too broad or complex to be addressed by one agency alone and to promote communication and coordination among agencies with complementary activities.[55] In most cases, the initiatives were intended to address areas of long-term national importance. The initiatives have ensued from the integration of existing agency projects, according to documents we examined.

[52]21st Century Nanotechnology Research and Development Act, Pub. L. No. 108-153, 117 Stat. 1923 (2003) (codified at 15 U.S.C. § 7501 (2017)). This act was preceded by a Presidential Initiative and the FY 2001 Budget Request.

[53]National Quantum Initiative Act, as amended, Pub. L. No. 115-368, 132 Stat. 5092 (2018), as amended (to be codified at 15 U.S.C. §§ 8801-02, 8811-8815, 8831, 8841-42, 8851-52, *et seq*.).

[54]Global Change Research Act of 1990, Pub. L. No. 101-606, 104 Stat. 3096 (codified at 15 U.S.C. §§ 2921, and 2931-38 (2018)). This act was preceded by a Presidential Initiative in 1989 and the FY 1990 Budget Request.

[55]GAO has previously issued reports on these efforts that examined different aspects of the management and coordination of the global change, networking and information, nanotechnology, and quantum initiatives. For examples of GAO's work on nanotechnology, see GAO, *Nanotechnology: Better Guidance Is Needed to Ensure Accurate Reporting of Federal Research Focused on Environmental, Health, and Safety Risks*, GAO-08-402 (Washington, D.C.: Mar. 31, 2008) and GAO, *Nanotechnology: Improved Performance Information Needed for Environmental, Health, and Safety Research*, GAO-12-427 (Washington, D.C.: May 21, 2012); GAO, *Nanomanufacturing and U.S. Competiveness: Challenges and Opportunities*, GAO-14-618T (Washington, D.C.: May 20, 2014). For examples of GAO's work on global change, see GAO, C*limate Change: Future Federal Adaptation Efforts Could Better Support Local Infrastructure Decision Makers*, GAO-13-242 (Washington, D.C.: Apr. 12, 2013) and GAO, *Climate Change: Analysis of Reported Federal Funding*, GAO-18-223 (Washington, D.C.: Apr. 30, 2018). For an example of GAO's work on networking and information and technology, see GAO, *Information Security: Coordination of Federal Cyber Security Research and Development*, GAO-06-811 (Washington, D.C.: Sept. 29, 2006). For an example of GAO's work on quantum information science, see GAO, *Science and Technology: Considerations for Maintaining U.S. Competitiveness in Quantum Computing, Synthetic Biology, and other Potentially Transformational Research Areas*, GAO-18-656 (Washington, D.C.: Sept. 26, 2018).

OSTP has established a similar organizational structure for each of the four initiatives. Each is steered by an NSTC subcommittee, supported by a national coordination office, and carried out by interagency working groups whose subject matter experts recommend priorities for the coming year.[56] Specifically:

- **NSTC subcommittees.** Representatives from the relevant federal departments or agencies form a subcommittee and plan, coordinate budgets, and assess each initiative's activities.
- **National Coordination Offices (NCO).** The NCOs provide operational support by planning, coordinating, and hosting physical and virtual meetings and by preparing strategic plans, annual reports to Congress, and other documents required by statute or requested by the agencies. They also conduct public outreach on behalf of their respective initiatives and provide general administrative assistance to subcommittees and interagency working groups.
- **Interagency working groups.** These groups are composed of various agency personnel with technical expertise in the subject matter of interest, who help carry out the R&D initiatives. Their work is guided and overseen by the cognizant subcommittee. The working groups hold regular meetings and workshops, develop strategic planning documents, carry out collaborative projects, coordinate with international researchers, and conduct outreach to the federal and private sector.

The interagency groups help define interagency R&D priorities and activities, which are published in annual supplements to the President's budget, according to the directors of the NCOs.[57] The NCOs do not tell the agencies what their R&D priorities should be or direct the funding of any agency. Rather, the federal agencies establish their own R&D priorities within the four initiative areas. The NCO directors said their role is largely coordination. For example, NCOs may support sharing of

[56]The work of NSTC is organized under six primary committees: (1) S&T Enterprise; (2) Environment; (3) Homeland and National Security; (4) Science; (5) STEM education; and (6) Technology. Each of these committees oversees subcommittees and working groups focused on different aspects of science and technology and works to coordinate S&T programs across the federal government.

[57]These reports are required by Congress and part of the President's annual budget request. The reports provide supplemental information specific to the initiatives. NITRD, NQI, NNI, and USGCRP all submit annual supplements.

information, including research priorities, with the larger scientific community.

Scope and Funding Allocations Are Determined by Participating Agencies, and Funding Has Increased since Fiscal Year 2012

The scope of each initiative is considered to be the range of R&D programs and activities that the agencies have identified as relevant. Each initiative is funded by the respective R&D agencies' appropriations, not by any external or specified funding source.[58] The "budget" for each R&D initiative is, therefore, an aggregation of the relevant R&D spending plans by individual agencies.

It is up to each agency to determine which of its R&D activities fall within the scope of the initiative. For example, DOD does not report its climate R&D funding to USGCRP. According to DOD officials, most of DOD's R&D spending related to climate change is focused on adaptation and mitigation activities—that is minimizing and preparing for global change. In their view, this has historically been outside the scope of the USGCRP program.[59] Further, the amount of DOD's R&D on issues relevant to USGCRP has historically been modest—on the magnitude of several million dollars per year—and below DOD's reporting threshold, according to DOD officials.[60]

OSTP officials noted that agencies report the scope and the funding for each of the initiatives through an OMB cross-cut budget data request that is then published in the annual budget supplements.[61] The supplements provide information on the initiatives' budgets for the current and previous fiscal years and the proposed budgets for the next fiscal year. These cross-cut budgets are reported to OMB by agency budget offices, compiled by the NCOs, and reviewed by OSTP officials. According to OSTP officials, NCOs do not provide feedback to agencies regarding any R&D program scope, duplication, or adherence to strategic priorities. Agencies conduct their own prioritization process, during which they

[58]While the initiatives are all authorized by statute or executive authority, they do not have specific line item appropriations from Congress designated toward the work of the initiatives.

[59]OSTP officials noted that DOD's stated position has been that they are not included in the climate change budget cross-cut because its research activities are conducted for defense-related missions but DOD still contributes to the initiative's overall goals.

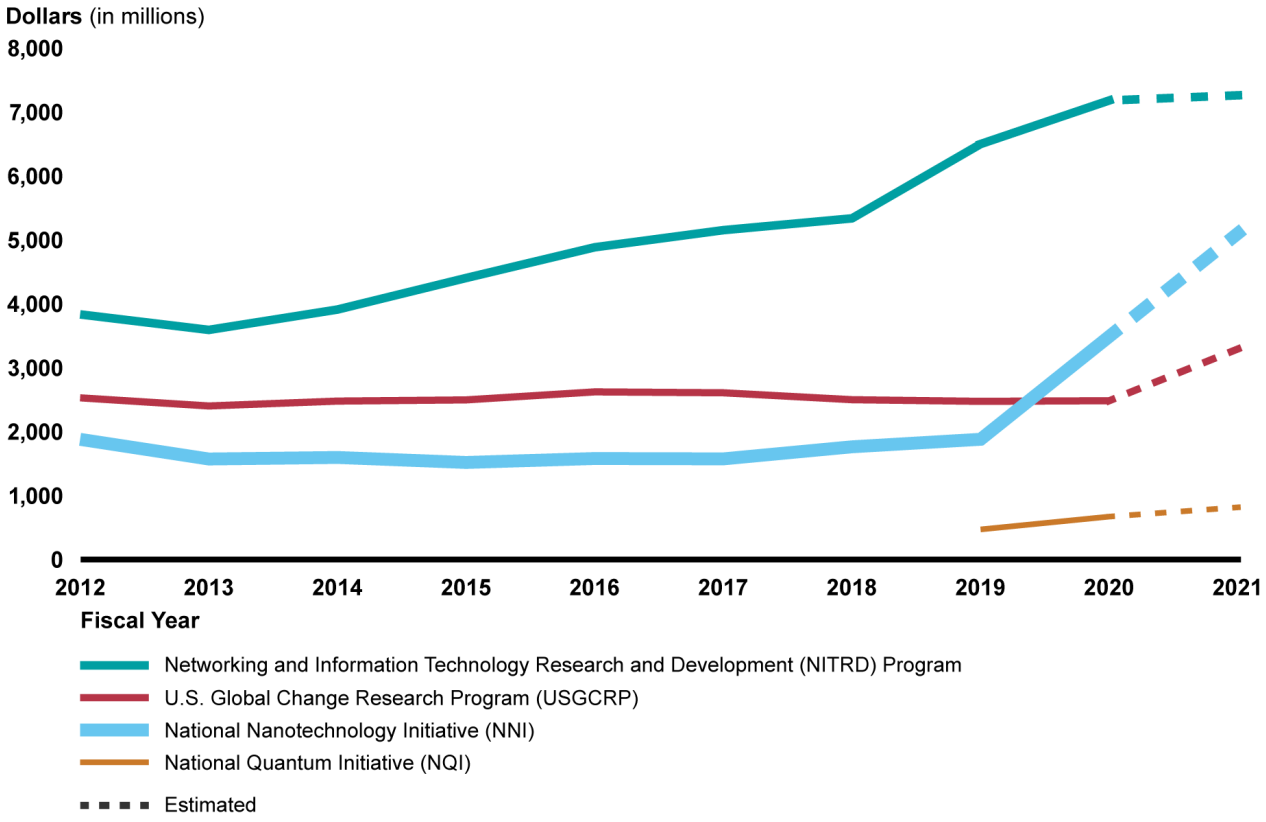
[60]DOD officials noted that DOD doesn't specifically invest in climate R&D areas because it can leverage technology and data from federal partner investments.

[61]OMB issues an annual budget data request to agencies for the purpose of collecting government-wide information on federal R&D funding levels for the initiatives.

weigh external factors, such as the activities of other agencies and the needs expressed by academic and private-sector research communities, and their external advisory bodies.

Figure 11 shows trends in funding by participating agencies for the four initiatives. As shown, USGCRP funding was generally flat from FY 2012 through FY 2020 while NITRD funding has steadily increased. Meanwhile, funding for NNI was generally stable until FY 2017 but significantly increased the following year due to supplemental funding for nanotechnology research related to COVID-19. NQI, the newest of the four initiatives, has seen its funding increase since it was established in 2018. Not all participating agencies allocate funding to the initiatives, however. For instance, 15 of the 21 participating agencies did not allocate funds to the NQI in FY 2020.

Figure 11: Multi-agency R&D Initiatives Funding in Millions of Dollars, Fiscal Years 2012 - 2021



Source: GAO analysis of Networking and Information Technology Research and Development (NITRD), U.S. Global Change Research Program (USGCRP), National Nanotechnology Initiative (NNI), and National Quantum Initiative's (NQI) annual *Supplement to the President's Budget* for fiscal years 2014 through 2022. | GAO-23-105396

Notes: NITRD, NNI and NQI report actual funding levels through FY 2020, while USGCRP generally reports enacted funding levels. Specifically, USGCRP reported enacted funding levels in FY 2012 and FY 2014 through FY 2021. However, in FY 2013, USGCRP reported an "operating" funding level, which is a budget that excludes capital investments. OMB officials stated that they believed USGCRP reported operating funding data in 2013 due to the federal sequestration that occurred that year.

Overall, NITRD consistently reports the most in funding, followed by USGCRP, NNI, and NQI. Changes in these funding levels may reflect evolving priorities over time both by the Administrations and by Congress.

Combined, the reporting of individual agency funding (i.e., budget authority) for activities included in the four initiatives accounted for roughly $14 billion in FY 2020, which was just under 9 percent of the government's total R&D budget authority.[62] The following pages summarize the four initiatives, including their program areas, participating agencies, funding contributors, and funding levels.

[62]According to OSTP officials, some agencies report the same funding to multiple cross-cuts, so it is possible for funding for one initiative to be double counted. For example, quantum funding in DOE is reported to both the NITRD and NQI cross-cut. However, OSTP officials noted that not all of funding for quantum science is double counted. In addition, it is possible that some federal R&D investments in the initiatives' topical areas are not captured within the annual reported totals because it can be challenging to identify all relevant R&D programs.

Source: tawanlubfah/stock.adobe.com. | GAO-23-105396

AT A GLANCE

NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD) PROGRAM

Established in 1991, this initiative seeks to continue U.S. technological leadership by accelerating development and deployment of advanced IT. The initiative originally focused on high-performance computing, IT, and networking. Its scope was later expanded to include big data, cyber-physical systems, privacy, cybersecurity, and artificial intelligence and machine learning research. As an interagency collaborative, the initiative is designed to address gaps in IT research and influence national and global IT research. Its R&D activities are closely aligned with those of the recently established National Artificial Intelligence Initiative.

Program Areas

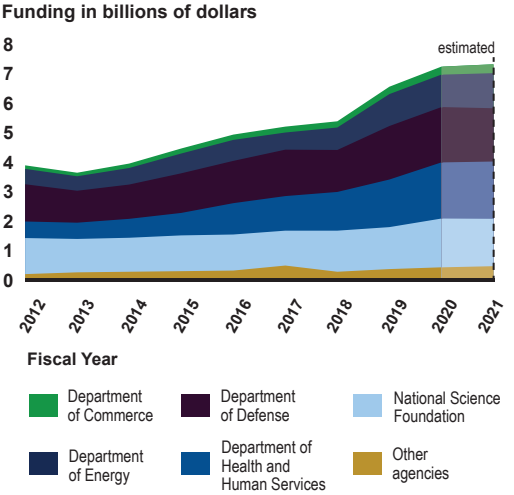
NITRD research projects and activities comprised 12 program areas in FY 2022:

1. Artificial intelligence R&D
2. Computing-enabled human interaction, communication, and augmentation
3. Computing-enabled networked physical systems
4. Cybersecurity and privacy
5. Education and workforce
6. Electronics for networking and information technology
7. Enabling R&D for high-capability computing systems
8. High-capability computing infrastructure and applications
9. Intelligent robotics and autonomous systems
10. Large-scale data management and analysis
11. Large-scale networking
12. Software productivity, sustainability, and quality

Generally, there is a close, though not strictly one-to-one match between program areas and the interagency groups. In FY 2022, NITRD had 12 interagency working groups. NITRD activities are coordinated by the National Science and Technology Council (NSTC) Subcommittee on Networking and Information Technology Research and Development.

Program Funding

Funding for the initiative has steadily increased since FY 2012. NITRD reported nearly a doubling of funding to $7.2 billion in FY 2020.



Source: GAO analysis of the Networking and Information Technology Research and Development (NITRD) Program's annual *Supplement to the President's Budget* for fiscal years 2014 through 2022. | GAO-23-105396

Agencies that participate in and/or report funding to the NITRD program

✓ Participates in the initiative (80 total)

$ Reports funding to support the initative (45 total)

Department of Agriculture	
Agricultural Research Service	✓ $
National Institute of Food and Agriculture	✓ $
Department of Commerce	
Census Bureau	✓
International Trade Administration	✓
National Oceanic and Atmospheric Administration	✓ $
National Institute of Standards and Technology	✓ $
National Telecommunications and Information Administration	✓
U.S. Patent and Trademark Office	✓
Department of Defense	
Air Force	✓ $
Air Force Research Laboratory	✓
Army	✓ $
U.S. Army Corps of Engineers	✓
Defense Advanced Research Projects Agency	✓ $
Defense Health Agency	✓
Defense Research and Engineering Network	✓
Defense Threat Reduction Agency	$
Joint Artificial Intelligence Center	✓
Missile Defense Agency	$
National Maritime Intelligence-Integration Office	✓
National Reconnaissance Office	✓
National Security Agency	✓
Navy	✓ $
Office of the Secretary of Defense	✓ $
Office of the Under Secretary of Defense for Research and Engineering	✓
Test Resource Management Center	✓
U.S. Cyber Command	✓
Department of Education	
Institute of Education Sciences	$
Department of Energy	
Advanced Research Projects Agency-Energy	✓ $
Artificial Intelligence and Technology Office	✓ $
National Nuclear Security Administration	✓ $
Office of Cybersecurity, Energy Security, and Emergency Response	✓ $
Office of Electricity	✓ $
Office of Energy Efficiency and Renewable Energy	✓ $
Office of Fossil Energy and Carbon Management	✓ $
Office of Nuclear Energy	✓ $
Office of Science	✓ $
Department of Health and Human Services	
Administration for Community Living	✓
Agency for Healthcare Research and Quality	✓ $
Agency for Toxic Substances and Disease Registry	✓
Centers for Disease Control and Prevention	✓
National Center for Health Statistics	✓
National Institute of Occupational Safety and Health	✓ $
Centers for Medicare and Medicaid Services	✓
Food and Drug Administration	✓ $
Health Resources and Services Administration	✓
Indian Health Service	✓
National Institutes of Health	✓ $
Office of the National Coordinator for Health Information Technology	✓
Substance Abuse and Mental Health Services Administration	✓

List of agencies continued on next page

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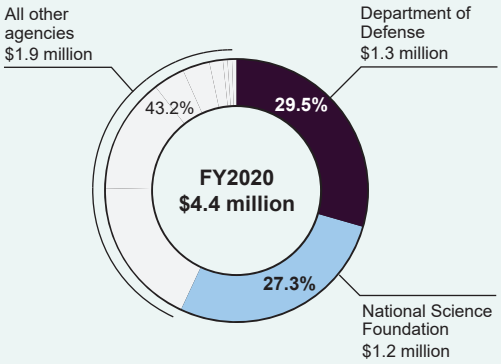
NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD) PROGRAM

Budget for the National Coordination Office

NITRD's National Coordination Office (NCO) plans, coordinates, and assists with its R&D activities. The office is funded through a distributed cost budget, a process involving the approved NCO activities and an assessment based in part on the relative level of funding agencies that have recently contributed to the initiative itself. In FY 2020, NITRD participating agencies contributed $4.4 million, of which about 60 percent was provided by DOD ($1.3 million) and NSF ($1.2 million). NITRD had one employee on detail from a participating agency within its NCO and 17 contractor staff as of August 2022. NITRD's NCO is supported by funding and services contracts through NSF.



Source: GAO review of OSTP's Annual *Interagency Funding for Activities of the NSTC* reports. | GAO-23-105396

Note: Percentages may not add to 100 because of rounding.

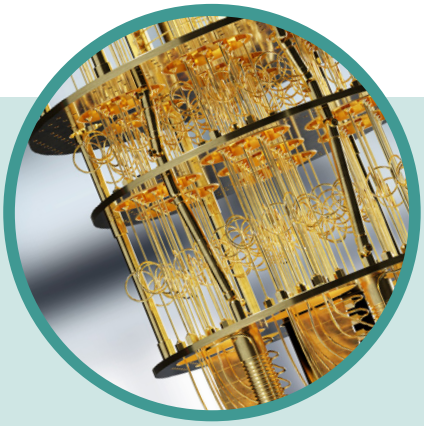
continued from previous page

Agencies that participate in and/or report funding to the NITRD program

✓ Participates in the initiative (80 total)

$ Reports funding to support the initative (45 total)

Department of Homeland Security	
Countering Weapons of Mass Destruction Office	$
Cybersecurity and Infrastructure Security Agency	✓
Science and Technology Directorate	✓ $
Transportation Security Administration	$
U.S. Coast Guard	$
Department of the Interior	
Bureau of Reclamation	$
Bureau of Safety and Environmental Enforcement	$
U.S. Geological Survey	✓ $
Department of Justice	
Drug Enforcement Administration	✓
Federal Bureau of Investigation	✓
National Institute of Justice	✓ $
Department of Labor	
Bureau of Labor Statistics	✓
Occupational Safety & Health Administration	✓
Department of State	✓
Department of Transportation	
Federal Aviation Administration	✓ $
Federal Highway Administration	✓ $
Federal Motor Carrier Safety Administration	✓ $
Federal Railroad Administration	✓ $
Federal Transit Administration	✓ $
The Intelligent Transportation Systems Joint Program Office	✓
Maritime Administration	✓
National Highway Traffic Safety Administration	✓
Pipeline and Hazardous Materials Safety Administration	✓ $
Department of the Treasury	
Financial Crimes Enforcement Network	✓ $
Department of Veterans Affairs	
The National Artificial Intelligence Institute	✓ $
Environmental Protection Agency	✓ $
Executive Office of the President	
Office of the Director of National Intelligence	
Intelligence Advanced Research Projects Activity	✓
Intelligence Community	✓
Office of Management and Budget	✓
Office of Science and Technology Policy	✓
Federal Communications Commission	✓
Federal Trade Commission	✓
General Services Administration	✓
National Aeronautics and Space Administration	✓ $
National Archives and Records Administration	✓ $
National Science Foundation	✓ $
National Transportation Safety Board	✓
Nuclear Regulatory Commission	✓
Social Security Administration	✓



Source: DP/stock.adobe.com. | GAO-23-105396

AT A GLANCE

NATIONAL QUANTUM INITIATIVE (NQI)

This initiative was established in 2018 and seeks to accelerate U.S. leadership in quantum information science, which is a unification of quantum mechanics and information theory—two foundational fields underpinning modern technology. Quantum Information Science (QIS) promises leap-ahead capabilities that may provide unprecedented computational speeds to help solve complex problems. Developed from key discoveries in the 1980s and experimentation in the 1990s, the field of quantum information science is still relatively nascent. This initiative has augmented its *National Strategic Overview for Quantum Information Science* through several strategic plans and reports. According to Office of Science and Technology Policy (OSTP) officials, research priorities are communicated through a wide range of public engagement, including reports and strategies published on quantum.gov and conferences and workshop presentations.

Program Areas

NQI research projects and activities comprise five program areas:

1. Quantum sensing and metrology
2. Quantum computing
3. Quantum networking
4. QIS for advancing fundamental science
5. Quantum technology

In fiscal year 2022, NQI had four interagency working groups. NQI's research in these five areas are coordinated by two National Science and Technology Council (NSTC) subcommittees: (1) the Subcommittee on Quantum Information Science and (2) the Subcommittee on Economic and Security Implications of Quantum Science. The first focuses predominantly on coordinating ongoing science and engineering efforts, along with developing a workforce, while the second focuses on the economic and security implications of federal investments in quantum information science.

Agencies that participate in and/or report funding to the NQI

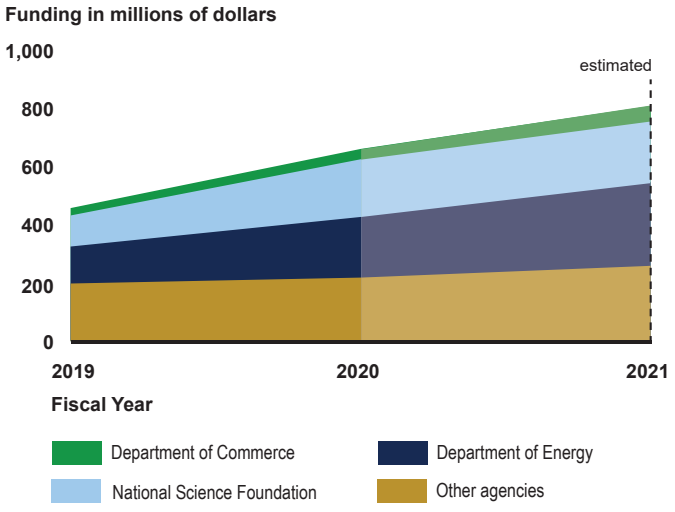
✓ Participates in the initiative (18 total)

$ Reports funding to support the initative (6 total)

Department of Commerce	$
National Institute of Standards and Technology	✓
Patent and Trademark Office	✓
Department of Defense	$
Air Force	✓
Army	✓
Defense Advanced Research Projects Agency	✓
National Security Agency	✓
Navy	✓
Office of the Under Secretary of Defense for Research and Engineering	✓
Department of Energy	$
National Nuclear Security Administration	✓
Office of Science	✓
Department of Health and Human Services	
National Institutes of Health	✓
Department of Homeland Security	$
Department of the Interior	
U.S. Geological Survey	✓
Department of Justice	
Federal Bureau of Investigation	✓
Department of State	✓
Executive Office of the President	
National Security Council	✓
Office of the Director of National Intelligence	
Intelligence Advanced Research Projects Activity	✓
Office of Management and Budget	✓
Office of Science and Technology Policy	✓
National Aeronautics and Space Administration	$
National Science Foundation	$

Program Funding

Funding for the initiative grew from $450 million in FY 2019 to $650 million in FY 2020.



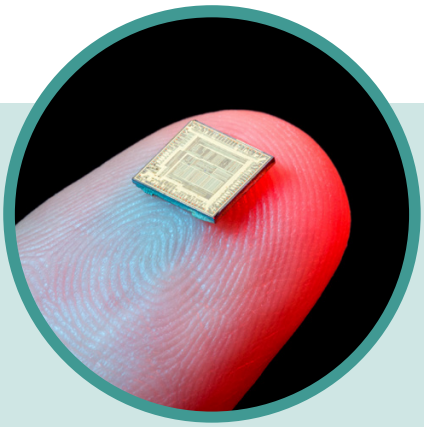
Source: GAO analysis of the National Quantum Initiative's (NQI) annual *Supplement to the President's Budget* for fiscal years 2019 through 2021. | GAO-23-105396

Budget for the National Coordination Office (NCO)

NQI's National Coordination Office provides operational support and technical expertise to the NQI program by planning, coordinating, and assisting R&D activities. The office does not have an official budget and its staff consists only of detailees from agencies, according to OSTP officials. NQI had five detailees from participating agencies within its NCO as of August 2022.

AT A GLANCE

NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)



Source: Szasz-Fabian Jozsef/stock.adobe.com. | GAO-23-105396

Established in 2000, this initiative seeks to expedite the discovery, development, and deployment of nanoscale science, engineering, and technology. Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers so as to harness the unique physical, chemical, and biological properties of nanoscale substances in fundamentally new and useful ways. Recognizing that unique size dependent properties of materials can occur beyond 100 nanometers, several NNI participating regulatory agencies have extended the length range of interest to 1000 nanometers. It has the potential to enable advances in areas as diverse as biomedicine, semiconductors, energy, agriculture, aerospace, and materials development. The initiative communicates research priorities and general information about nanotechnology to the nanotechnology community and the general public through its website Nano.gov, and through presentations at conferences and workshops, and engagement with researchers, students, teachers, and the private sector.

Program Areas

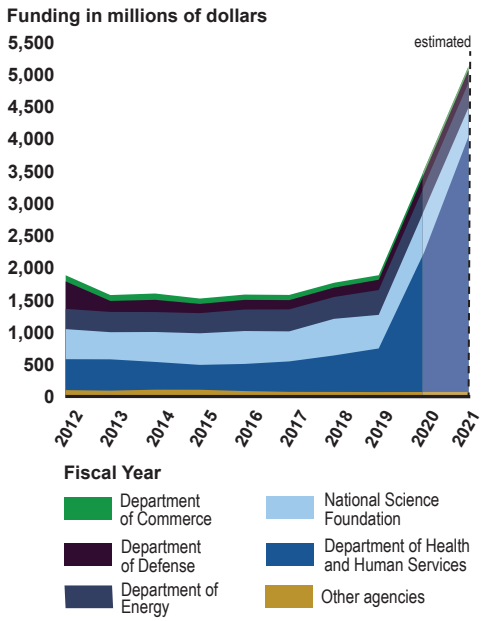
NNI research projects and activities comprise five program areas:

1. Foundational research
2. Nanotechnology-enabled applications, devices, and systems
3. Research infrastructure and instrumentation
4. Education and workforce development
5. Responsible development

In Fiscal Year 2022, NNI had 1 interagency working groups. NNI efforts are coordinated by the National Science and Technology Council (NSTC) Subcommittee on Nanoscale Science, Engineering, and Technology.

Program Funding

The size of the federal investment remained level through FY 2019 and saw significant spikes in FY 2020 and FY 2021 due to supplemental funding for nanotechnology research related to COVID-19 from the Biomedical Advanced Research and Development Authority. NNI investments in nanoscale science, engineering and technology have cumulatively totaled over $38 billion since 2001.



Source: GAO analysis of the National Nanotechnology Initiative's (NNI) annual *Supplement to the President's Budget* for fiscal years 2014 through 2022. | GAO-23-105396

Agencies that participate and/or report allocating funding to the NNI

✓ Participates in the initiative (44 total)
$ Reports funding to support the initative (28 total)

Department of Agriculture	
Agricultural Research Service	✓ $
Forest Service	✓ $
National Institute of Food and Agriculture	✓ $
Department of Commerce	
Bureau of Industry and Security	✓
Economic Development Administration	✓
International Trade Administration	✓
National Institute of Standards and Technology	✓ $
Patent and Trademark Office	✓
Department of Defense	
Air Force	✓ $
Army	✓ $
Defense Advanced Research Projects Agency	✓ $
Defense Threat Reduction Agency	✓ $
Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense	✓ $
Navy	✓ $
Office of the Under Secretary of Defense for Research and Engineering	✓ $
Department of Education	✓
Department of Energy	
Advanced Research Projects Agency-Energy	✓ $
Office of Energy Efficiency and Renewable Energy	✓ $
Office of Fossil Energy and Carbon Management	✓ $
Office of Nuclear Energy	✓ $
Office of Science	✓ $
Department of Health and Human Services	
Biomedical Advanced Research and Development Authority	✓ $
Centers for Disease Control and Prevention	
Agency for Toxic Substances and Disease Registry	✓
National Center for Environmental Health	✓ $
National Institute of Occupational Safety and Health	✓ $
Food and Drug Administration	✓ $
National Institutes of Health	✓ $
Department of the Interior	
Bureau of Reclamation	✓ $
Bureau of Safety and Environmental Enforcement	✓
U.S. Geological Survey	✓
Department of Justice	
National Institute of Justice	✓ $
Department of Labor	
Occupational Safety & Health Administration	✓
Department of State	✓
Department of Transportation	
Federal Highway Administration	✓ $
Department of the Treasury	✓
Consumer Product Safety Commission	✓ $
Environmental Protection Agency	✓ $

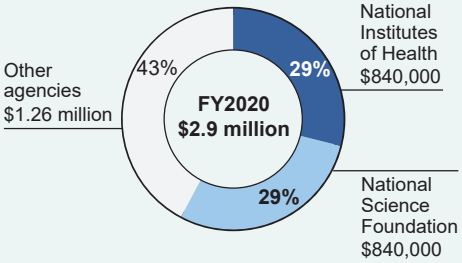
List of agencies continued on next page

continued from previous page

NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)

Budget for the National Coordination Office

NNI's NCO provides operational support and technical expertise to the NNI program by planning, coordinating and assisting R&D activities. It is funded through a distributed cost budget, a process involving an assessment based on how much each agency has identified in the initiative's budget. Each agency's contribution is in proportion to its share of the total budget for NNI. Participating agencies contributed $2.9 million to support the office in FY 2020, of which 58 percent was provided by NIH ($840,000) and NSF ($840,000). NNI had two employees on detail from participating agencies within its NCO and 12 contractor staff, as of September 2022. The NNI NCO is supported by funding and services contracts through NSF.



Source: GAO review of OSTP's Annual *Interagency Funding for Activities of the NSTC* reports. | GAO-23-105396

Note: Percentages may not add to 100 because of rounding.

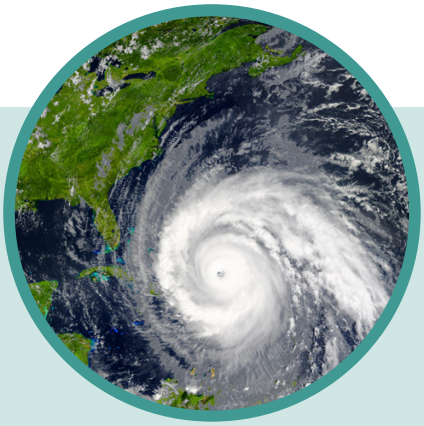
continued from previous page

Agencies that participate and/or report allocating funding to the NNI

✓ Participates in the initiative (44 total)

$ Reports funding to support the initative (28 total)

Executive Office of the President	
Office of the Director of National Intelligence	✓
Office of Management and Budget	✓
Office of Science and Technology Policy	✓
National Aeronautics and Space Administration	✓ $
National Science Foundation	✓ $
Nuclear Regulatory Commission	✓
United States International Trade Commission	✓



Source: Mike Mareen/stock.adobe.com. | GAO-23-105396

AT A GLANCE

U.S. GLOBAL CHANGE RESEARCH PROGRAM (USGCRP)

The program began as a presidential initiative in 1989 and was codified by the Global Change Research Act of 1990. USGCRP coordinates and integrates federal science research on climate change and assesses scientific literature on changes in the global environment and their implications for society. The initiative is required to develop a global research plan to be renewed every three years with recommendations for further research by federal agencies. Also, the program is required to submit an annual report to the President and Congress describing its scientific findings and reporting agency budget investments in this area. The program is also required to produce a quadrennial assessment of observed and projected global change, as well as the impacts of those on the Nation. Thus far, four of these National Climate Assessments have been published, and the fifth is expected to be published by the end of 2023.

Program Areas

The research projects and activities undertaken by the participating agencies are regularly organized and coordinated as "focus areas" evolve over time with agency funding initiatives and administration priorities. According to Office of Science and Technology Policy (OSTP) officials, these areas are not as formal or as long-lived as the program areas for the other R&D initiatives.

In Fiscal Year 2022, USGCRP had 11 interagency working groups. USGCRP efforts are coordinated by the National Science and Technology Council (NSTC) Subcommittee on Global Change Research.

Agencies that participate and/or report funding to the USGCRP

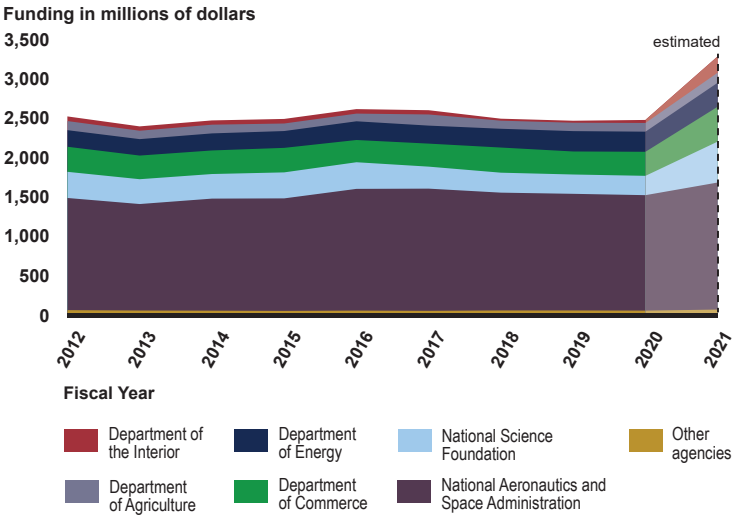
✓ Participates in the initiative (15 total)

$ Reports funding to support the initative (10 total)

Department of Agriculture	✓ $
Department of Commerce	✓ $
Department of Defense	✓
Department of Energy	✓ $
Department of Health and Human Services	✓ $
Department of the Interior	✓ $
Department of State	✓
Department of Transportation	✓ $
Environmental Protection Agency	✓ $
Executive Office of the President	
Office of Management and Budget	✓
Office of Science and Technology Policy	✓
National Aeronautics and Space Administration	✓ $
National Science Foundation	✓ $
Smithsonian Institution	✓ $
United States Agency for International Development	✓

Program Funding

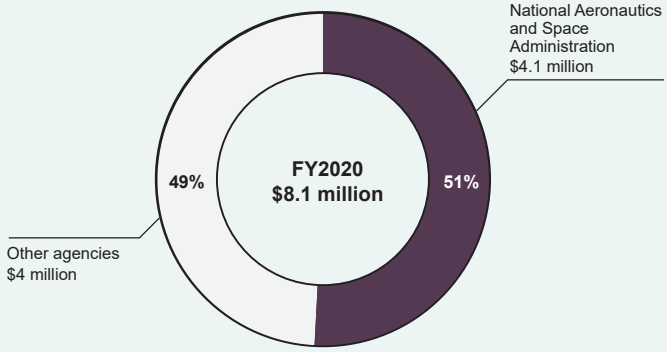
Funding for the initiative was flat from FY 2012 to FY 2020 but is projected to increase.



Source: GAO analysis of the U.S. Global Change Research Program's (USGCRP) annual *Supplement to the President's Budget* for fiscal years 2014 through 2022. | GAO-23-105396

Budget for the National Coordination Office

USGCRP's NCO provides operational support and technical expertise to the program by planning, coordinating and assisting USGCRP activities. It is funded through a distributed cost budget, a process involving an assessment based on how much each agency has identified in the initiative's budget. Each agency's contribution is in proportion to its share of the total budget for the initiative. NASA contributed $4.1 million (51 percent) of the $8.1 million that participating agencies provided in FY 2020 for the support of the office and related activities. USGCRP had three employees on detail from participating agencies within its NCO and 25 contractor staff, as of August 2022. The USGCRP NCO is managed by a consultancy contract with NASA.



Source: GAO review of OSTP's Annual *Interagency Funding for Activities of the NSTC* reports. | GAO-23-105396

Note: Percentages may not add to 100 because of rounding.

Agency Comments

We provided a draft of this report to DOD, DOE, HHS, NASA, NSF, OMB, and OSTP for review and comment. We received a written response from DOD, which is reproduced in appendix II. DOD stated it did not have any substantive comments to the draft report, but provided technical comments, which we incorporated. In addition, we received technical comments from DOE, HHS, and OSTP, which we incorporated as appropriate. NASA and NSF informed us they had no comments on the draft report. OMB did not provide a response.

We are sending copies of this report to appropriate congressional committees, the Departments of Defense, Energy, and Health and Human Services, NASA, NSF, OMB, OSTP, and other interested parties. In addition, this report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-6888 or wrightc@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 major contributions to this report are listed in appendix III.

Candice N. Wright
Director, Science, Technology Assessment, and Analytics

Appendix I: Department of Defense Research, Development, Test, and Evaluation Budget Activities

The Department of Defense (DOD) funds technology and product development activities under its research, development, test, and evaluation (RDT&E) budget, which DOD groups into seven budget activity categories for its annual budget estimates. The categories follow a mostly sequential path for developing technologies from basic research to operational system development. The first three budget activity categories generally represent activities undertaken by DOD to advance research and develop technology, while the remaining budget activity categories are typically associated with product development for acquisition programs. Table 7 provides a description of each budget activity.

Table 6: Department of Defense (DOD) Research, Development, Test, and Evaluation (RDT&E) Budget Activities

	DOD RDT&E Budget Activity	Description
Science and technology (S&T) funding	Basic research (6.1)	Scientific study and experimentation focusing on increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences, which may address long-term national security needs.
	Applied research (6.2)	Research focuses on the expansion and application of knowledge and is directed toward general military needs to determine the initial feasibility and practicality of proposed solutions to technology challenges.
	Advanced technology development (6.3)	Concept and technology demonstrations that assess the technological feasibility, operability, and producibility of components, subsystems, or system models. Demonstrations evaluate general military utility or cost reduction potential of the technology. Projects in this category should have the goal of moving out of S&T and into the acquisition process within the Future Years Defense Program.
Acquisition-based funding	Advanced component development & prototypes (6.4)	System specific evaluations of integrated technologies, representative models, or prototype systems in a realistic operating environment. Focuses on proving component and subsystem maturity prior to integration into major systems.
	System development & demonstration (6.5)	Engineering and manufacturing development tasks aimed at meeting requirements prior to full-rate production. Prototype performance is near or at planned operational system levels. Conduct live fire and initial operational test and evaluation.
	RDT&E management support (6.6)	Efforts to sustain and/or modernize installations or operations required for RDT&E such as test ranges, military construction, and studies and analyses in support of RDT&E.
	Operational system development (6.7)	Efforts to upgrade systems that have been fielded or will soon enter full rate production.

Source: GAO summary of Department of Defense regulations. | GAO-23-105396

Note: Technology Readiness Levels are a tool that DOD, among others, uses to assess technology maturity. They are measured on a scale from 1 to 9, beginning with paper studies of a technology's feasibility and culminating with a technology fully integrated into a completed product.

Appendix II: Comments from the Department of Defense

DEPUTY UNDER SECRETARY OF DEFENSE
3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3030

RESEARCH
AND ENGINEERING

Ms. Candice Wright
Director, Science Technical Assessment and Analytics
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Ms. Wright:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-22-105396 "Federal Research and Development: Funding Has Grown Since 2012 and Is Concentrated within a few Agencies," dated October 21, 2022 (GAO Code 105396). The GAO makes no recommendations to the Department in the draft report. The Department has no substantive comments to consider for inclusion in the GAO final report; however, we propose the following technical edits to page 54 for your consideration:

- Basic research (6.1). Change from: "Scientific study and experimentation focusing on increasing fundamental knowledge, which may address long-term national security needs." Change to: "Scientific study and experimentation focusing on increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences, which may address long-term national security needs."

- Applied research (6.2). Change from: "Research focuses on the expansion and application of knowledge and is directed toward general military needs to determine the initial feasibility and practicality of proposed solutions." Change to: "Research focuses on the expansion and application of knowledge and is directed toward general military needs to determine the initial feasibility and practicality of proposed solutions to technology challenges."

- Advanced technology development (6.3). Change from: "Concept and technology demonstrations that assess the technological feasibility, operability, and producibility of components, subsystems, or system models. Demonstrations evaluate general military utility or cost reduction potential of the technology. Projects in this category should have the goal of moving out of Science and Technology (S&T) and into the acquisition process within five years." Change to: "Concept and technology demonstrations that assess the technological feasibility, operability, and producibility of components, subsystems, or system models. Demonstrations evaluate general military utility or cost reduction potential of the technology. Projects in this category should have the goal of moving out of S&T and into the acquisition process within the Future Years Defense Program."

If you have any questions, please contact Dr. James Petro, Director, DoD Laboratories, Federally Funded Research and Development Centers, and University Affiliated Research Centers, at 571-372-6435 or james.b.petro.civ@mail.mil.

Sincerely,

HONEY.DAVID.A.1044947591 Digitally signed by HONEY.DAVID.A.1044947591 Date: 2022.11.21 13:01:20 -05'00'

David A. Honey, PhD

2

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Candice N. Wright, (202) 512-6888 or wrightc@gao.gov

Staff Acknowledgments

In addition to the individual named above, Richard Hung (Assistant Director), Eric Bachhuber (Analyst in Charge), Eric Charles, Minda Nicolas, and Arvin Wu made key contributions to this report. Also contributing to this report were Sada Aksartova, Sue Bernstein, Jehan Chase, Jenny Chanley, Ryan Han, John Mingus, Leah Nash, Fardusi Uddin, Seyda Wentworth, Rachel Wexler, and Gregory Wong.

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