R&D

Academic Research and Development

NSB-2023-26

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This publication is part of the 2024 edition of the *Science and Engineering Indicators (Indicators)* suite of reports. *Indicators* is prepared under the guidance of the National Science Board by the National Science Foundation's National Center for Science and Engineering Statistics. The *Indicators* suite consists of a summary report called *The State of U.S. Science and Engineering*, more-detailed thematic reports with supporting data, and a data tool that provides state-level indicators.

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Executive Summary

Key takeaways:

- Institutions of higher education in the United States spent nearly $90 billion on R&D in FY 2021, the highest amount reported to date. Most of that spending (55%) was financed by federal government sources.
- Higher education institutions perform a significant amount of the basic research conducted in the United States. In calendar year 2021, academic institutions represented 44% of U.S. basic research performed that year. However, that share has declined since 2012, when academia performed 54% of basic research. Overall, academic research and development (R&D) represented 11% of total U.S. R&D performed in 2021, compared with 14% in 2012.
- In 2021, the United States ranked highest among 32 leading countries or regions in total funding of academic R&D, but it ranked 23rd when academic R&D spending is expressed as a percentage of gross domestic product.
- Academic institutions perform R&D using specialized facilities and equipment. In 2021, U.S. universities and colleges reported that facilities devoted to research occupied 236.1 million net assignable square feet (NASF), compared with 202.2 million in 2011. These institutions reported that they expect to invest $12.8 billion in new research facilities in 2022 and 2023, providing an additional 10.6 million NASF of research space.
- The number of women in the science and engineering (S&E) research doctoral academic workforce trained in the United States increased from about 78,700 to about 140,800 between 2003 and 2021, while the number of men grew from about 180,700 to about 206,400. In 2021, 41% of S&E doctorate holders employed in academia were women.
- In 2021, 10% of S&E doctorate holders employed in academia and 9% of full-time faculty were individuals who identified as underrepresented minorities—Black or African American, Hispanic or Latino, and American Indian or Alaska Native—compared with 7% and 7%, respectively, in 2006.
- Students pursuing S&E doctorates and postdoctoral researchers (postdocs) are engaged in academic R&D, and they are concentrated in institutions with very high research activity. In 2021, these institutions enrolled about 80% of S&E doctoral students and employed over 80% of S&E postdocs.

R&D conducted at U.S. universities contributes to fundamental discoveries, problem-solving, and the creation of new technologies. Engagement in academic R&D constitutes a key element of the education and training of the nation's advanced scientific and technical workforce. Funds provided by federal agencies, universities and colleges, businesses, nonprofit organizations, and state and local governments cover much of the costs of academic R&D. These funds also provide financial support for graduate students and postdocs, many of whom then join the U.S. R&D workforce.

The federal government is the main funder of U.S. academic R&D spending, financing nearly 55% of academic R&D expenditures in FY 2021—down from 61% in FY 2012. Concurrently, the share of R&D spending by U.S. higher education institutions from those institutions' own funds rose from 21% to 25%. Six agencies provided more than 90% of federal support for academic R&D—the Department of Health and Human Services, the Department of Defense, the National Science Foundation, the Department of Energy, the National Aeronautics and Space Administration, and the Department of Agriculture.

Academic R&D spending is concentrated in a relatively small share of all U.S. higher education institutions. In FY 2021, the 131 institutions with very high research activity accounted for nearly 75% of U.S. academic R&D spending, out of 3,733 total institutions granting 4-year degrees. Those 131 institutions also enrolled about 80% of the nation's S&E doctoral students and employed over 80% of the nation's S&E postdocs. The 30 institutions ranked highest in R&D spending in FY 2021 accounted for 42% of all academic R&D expenditures that year.

The scale and share of academic R&D at U.S. institutions of higher education vary by institutional characteristics. In FY 2021, public universities accounted for more of the academic R&D spending (65%) than did private universities (35%). However, private universities constituted 14 of the 30 universities with the highest R&D spending that year. R&D at universities with medical schools represented a considerable share of academic R&D spending, accounting for 75% of all federally supported academic R&D spending in FY 2021.

Graduates from minority-serving institutions contribute to the diversity of the U.S. S&E workforce. In FY 2021, 56 historically Black colleges and universities (HBCUs) reported R&D expenditures in the Higher Education Research and Development Survey, and their federally supported R&D spending totaled $402 million. However, in constant 2012 dollars, that total was $339 million—35% lower than federal funding of R&D spending reported by HBCUs in FY 2012, in constant dollars. The 97 institutions identified as high-Hispanic-enrollment institutions reported around $8.8 billion dollars in academic R&D spending in FY 2021; about 46% of that spending came from federal government funds.

Graduate students and postdocs are essential to the U.S. academic R&D labor force and often receive financial support for their studies. Sources of support for S&E graduate students vary by the level of study. Master's students are largely self-supporting, and doctoral students are primarily supported by their academic institutions and the federal government. Patterns of support vary by field, type of institution attended, and students' demographic characteristics. In 2021, the federal government funded about half of S&E postdocs, mainly through research grants, whereas institutions funded over one-fifth of postdocs. S&E postdoctoral appointments were concentrated in the biological and biomedical sciences and health sciences.

Introduction

This report presents an overview of research and development (R&D) in science and engineering (S&E) fields performed at institutions of higher education in the United States, including historical trends and recent patterns.[1] The report first examines the financing and performance of R&D at universities based on patterns in funding and spending, then discusses the physical infrastructure required to enable and sustain academic R&D. The final section addresses the human resources engaged in academic R&D, particularly the graduate students and postdoctoral researchers (postdocs) who perform academic R&D under the supervision of faculty and full-time research personnel.

The primary sources of data presented in this report are surveys conducted by the National Center for Science and Engineering Statistics (NCSES) at the National Science Foundation (NSF). International data come from the Organisation for Economic Co-operation and Development (OECD), with supplemental data from other statistical agencies and from peer-reviewed research articles. Financial data on academic R&D spending are drawn primarily from the NCSES Higher Education Research and Development (HERD) Survey (2010 onward) and its predecessor, the Survey of Research and Development Expenditures at Universities and Colleges (1972–2009). The HERD Survey collects data on universities' annual R&D spending; the sources of funds supporting that spending; and how the spending is distributed across types of R&D, fields of research, and institutions with specific features. HERD Survey data report spending based on the academic fiscal year from July through June. Throughout this report, data from the 2021 HERD Survey are expressed in *current* dollars, whereas *constant* dollars (inflation adjusted, with 2012 as the index year) are used to compare financial data over multiple years. To calculate academic R&D as a share of U.S. R&D performance, this report uses data reported in the NCSES data series *National Patterns of R&D Resources* (NCSES ***NP 2021***). That data source follows different conventions for reporting financial data on academic R&D.[2]

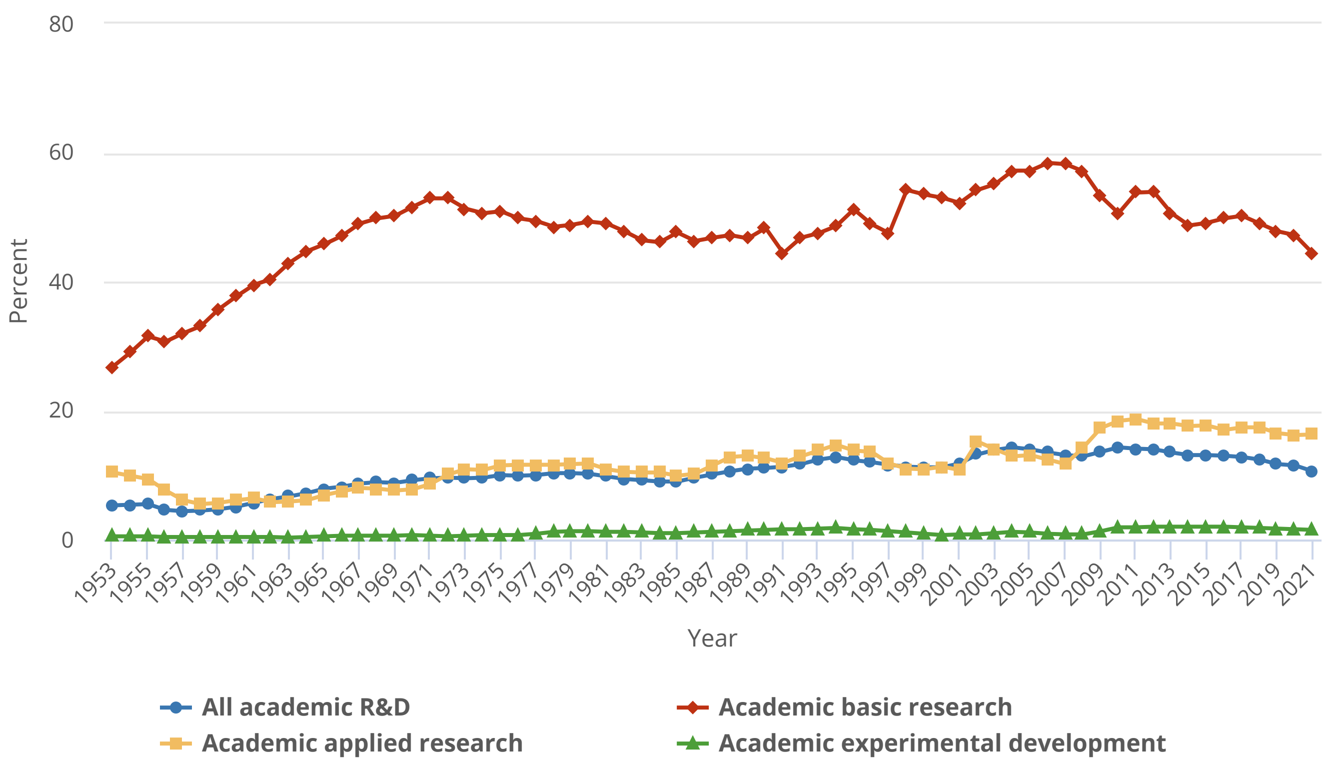
This is one of a series of reports that make up the biennial *Science and Engineering Indicators* report of the National Science Board (NSB). Other reports in the *Indicators* series contain information relevant to S&E in higher education, including the forthcoming *Indicators 2024* reports "Research and Development: U.S. Trends and International Comparisons," "Higher Education in Science and Engineering," "The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers," "Publications Output: U.S. Trends and International Comparisons," and "Invention, Knowledge Transfer, and Innovation."

Academic R&D in the U.S. R&D Enterprise

In the years during and after World War II, the federal government recognized that university-based research contributed directly to societal priorities such as defense and health and devoted more resources to support that work (Nichols 1993). Federal investments in academic R&D contributed to a rapid growth in the share of U.S. R&D performed in higher education, which nearly doubled between 1953 and 1979. Academia's share of U.S. R&D began trending upward again in 1986, exceeding 14% in 2004 (NCSES ***NP 2021***: **Table 2**). Although the amount of academic R&D rose after 2004, it represented 11% of national R&D spending in 2021, continuing a decline in share that began in 2010 (Figure URD-1).

Figure URD-1

Academic R&D as a percentage of U.S. R&D, by type of R&D: 1953–2021



Note(s):
The absolute numbers on which the percentages in this figure are based can be found in the original data source. Before 2003, higher education R&D covered only S&E fields; in 2003 and later years, R&D in non-S&E fields is also included. In 1998 and later years, the higher education R&D data have been adjusted to eliminate double counting of R&D funds passed through from academic institutions to other academic and nonacademic (business, nonprofit, other) subrecipients.

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources.

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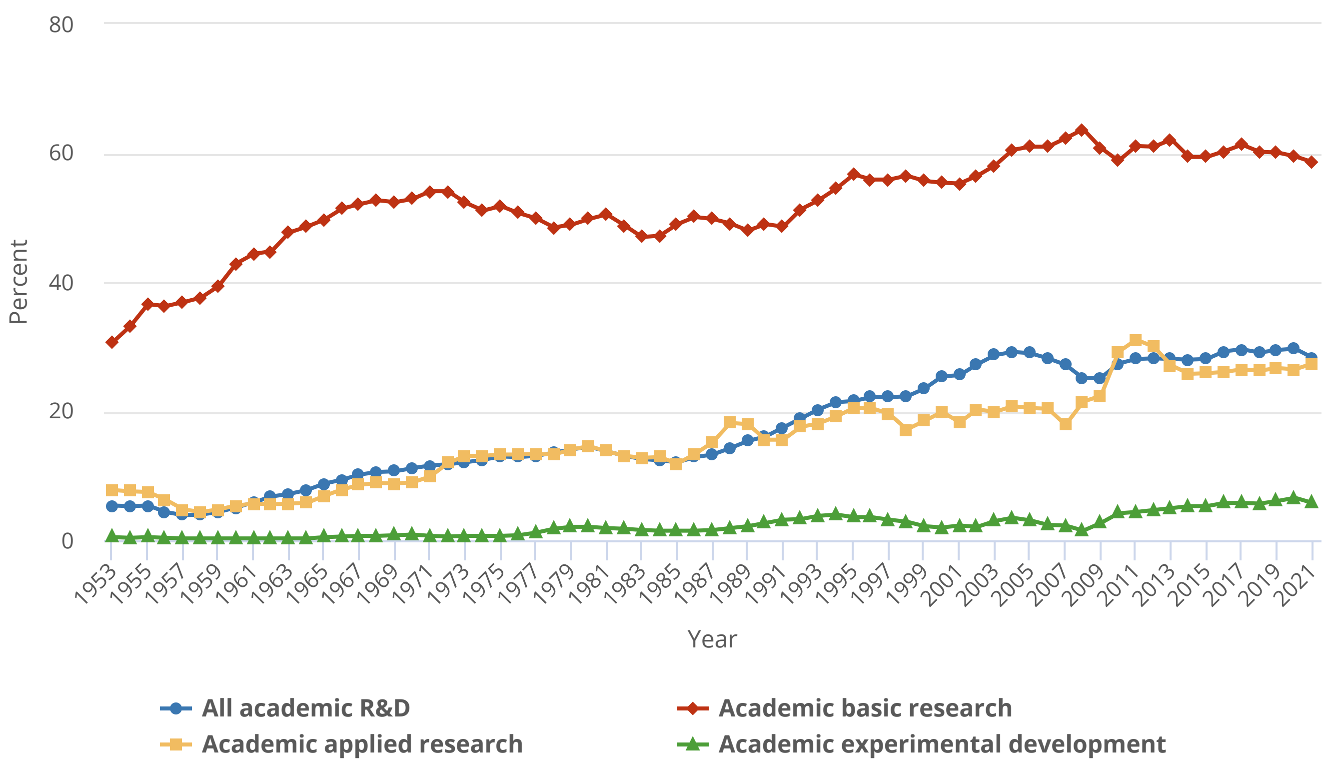
R&D conducted in academia is concentrated on *basic research* (experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view) rather than on *applied research* (original investigation undertaken to acquire new knowledge but directed primarily toward a specific, practical aim or objective) or *experimental development* (systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes).[3] Consequently, R&D at higher education institutions contributes primarily to total U.S. basic research. From 1972 to 2011, the share of U.S. basic research performed by academia fluctuated between 44% and 58%. This share has declined in recent years, from 54% in 2012 to 44% in 2021. In contrast, academic R&D accounted for 16% of U.S. applied research performed in 2021, down from a peak of 19% in 2011. Historically, academia has accounted for 2% or less of U.S. experimental development (Figure URD-1).

In 2021, U.S. academic R&D constituted a greater share of U.S. R&D funded by the federal government—about 28%—than its 11% share of overall national R&D (Figure URD-1 and Figure URD-2). In 2021, academia accounted for nearly 60% of federal funding for basic research, 27% for applied research, and nearly 6% for experimental development (NCSES ***NP 2021***: **Table 7**, **Table 8**, and **Table 9**).

Figure URD-2

Federally funded academic R&D as a share of U.S. federally funded R&D, by type of R&D: 1953–2021



Note(s):
The absolute numbers on which the percentages in this figure are based can be found in the original data source. Before 2003, higher education R&D covered only S&E fields; in 2003 and later years, R&D in non-S&E fields is also included. In 1998 and later years, the higher education R&D data have been adjusted to eliminate double counting of R&D funds passed through from academic institutions to other academic and nonacademic (business, nonprofit, other) subrecipients.

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources.

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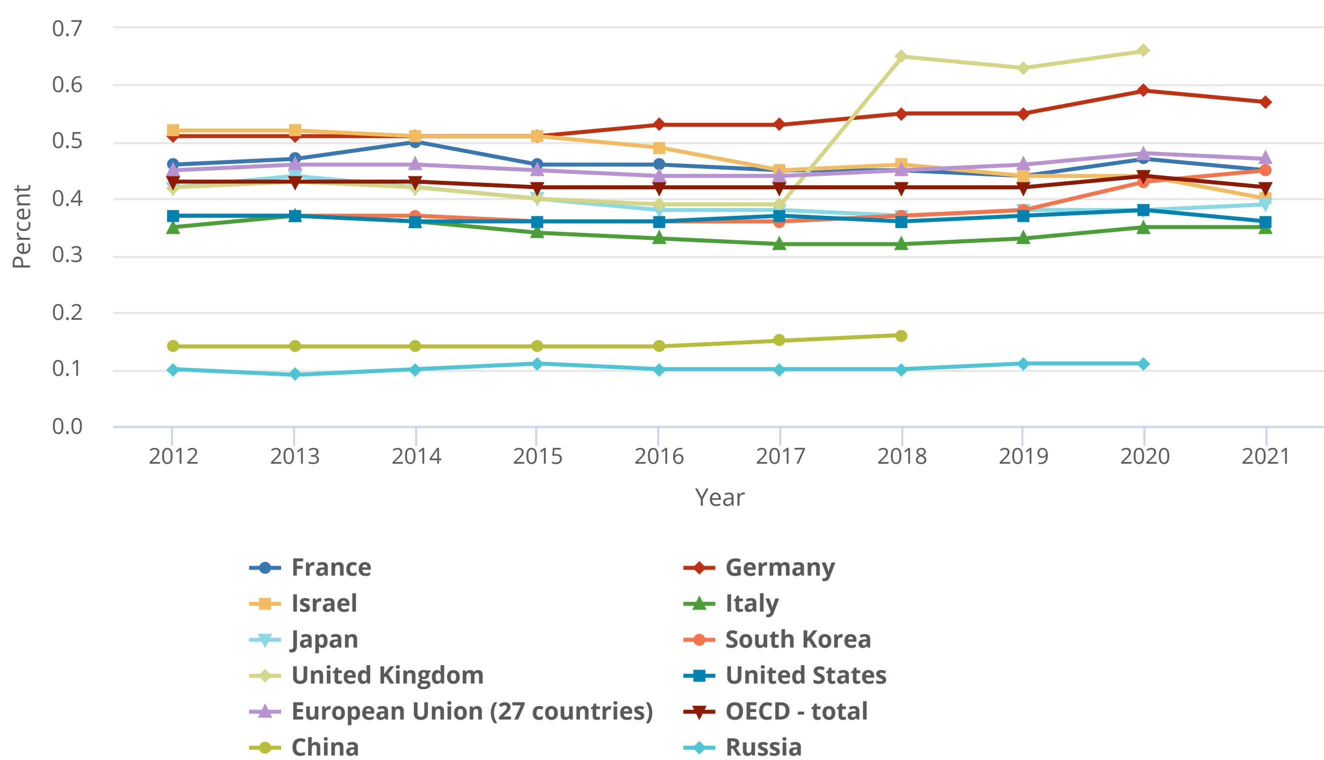
Academic R&D: International Comparisons

The United States spends more in support of academic R&D than any other country. According to data compiled by OECD, the top five countries for such spending in 2020 were the United States ($81 billion), Germany ($28 billion), the United Kingdom ($20 billion), Japan ($20 billion), and France ($15 billion). The 27 European Union nations (EU-27), including Germany and France, spent $100 billion (OECD 2023a, Table 68).

An indicator of the intensity of academic R&D spending by countries is the ratio of such spending to the gross domestic product (GDP) of each country (Figure URD-3). The United States has maintained a ratio ranging between 0.36% and 0.38% since 2012; its ratio of 0.36% in 2021 placed it 23rd among the 32 nations reporting data in that year (OECD 2023a, Table 70). By comparison, Germany has increased its intensity of academic R&D spending from 0.51% to 0.57% over the same time frame. South Korea and the EU-27 have also increased their intensity of academic R&D investments. Other countries, notably Israel and Japan, have reduced their academic R&D intensity over this period. China has rapidly expanded its academic R&D spending, but its GDP has also risen rapidly, so its ratio of academic R&D spending to GDP increased gradually from 0.12% in 2008 to 0.16% in 2018.[4] Russia's ratio of academic R&D to GDP has increased at a slightly higher pace than China's, growing from 0.07% in 2008 to 0.11% in 2020, but it lags behind the ratios of other nations that have significant annual investment in R&D (OECD 2023a).[5]

Figure URD-3

Higher education R&D expenditures as a percentage of gross domestic product for selected regions, countries, or economies: 2012–21



OECD = Organisation for Economic Co-operation and Development.

Note(s):
Higher education R&D expenditures represent the component of gross domestic expenditure on R&D incurred by units belonging to the higher education sector. It is the measure of intramural R&D expenditures within the higher education sector during a specific period. OECD is currently reviewing China's estimates for 2019, 2020, and 2021, so updated data are not available at the time of this publication. OECD has stopped collecting data from Russia at this time. The United Kingdom submitted revised data in 2023, resulting in a break in the data series starting in 2018.

Source(s):
Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (May 2023).

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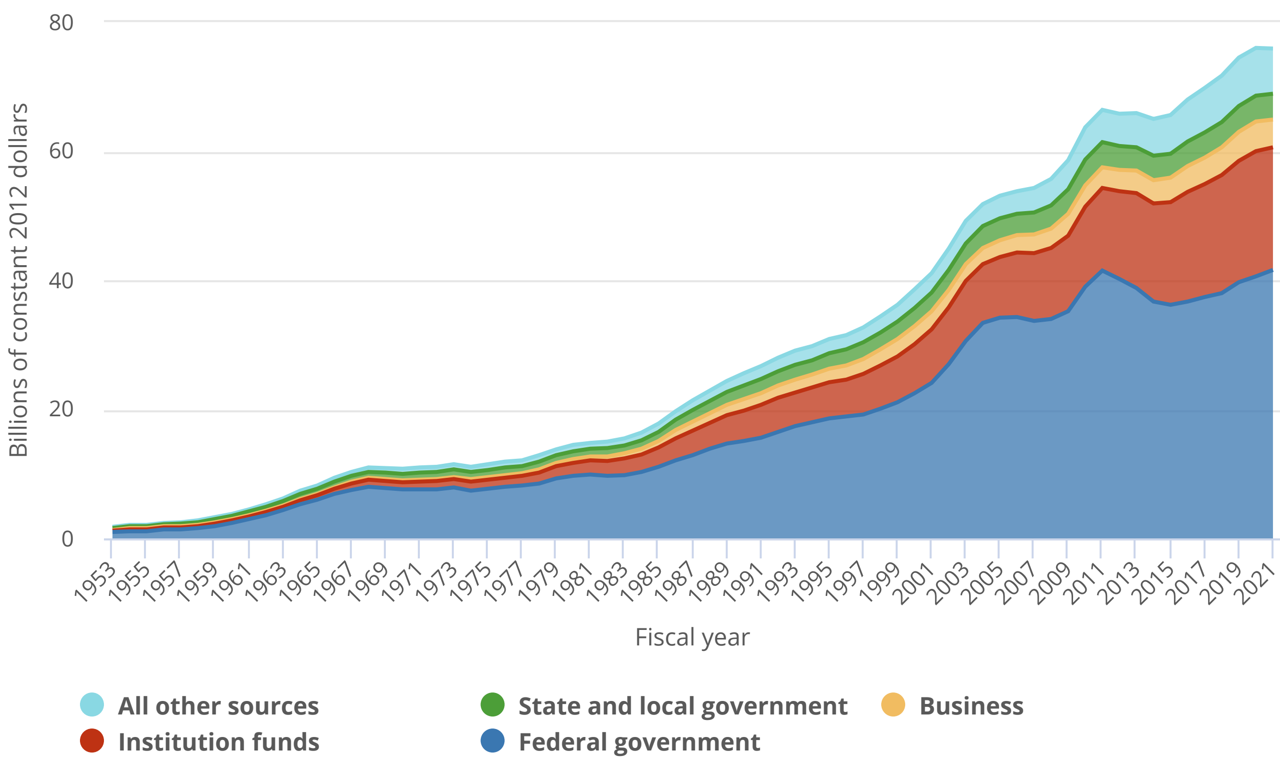
Funding Sources of Academic R&D

Academic R&D spending has grown significantly over the past half century, reaching nearly $90 billion in 2021 compared with $255 million in 1953 (not adjusting for inflation) (NCSES ***HERD 2021***: **Table 1**).[6] The federal government has been the largest funder of academic R&D since 1953; in 2021, federal funding supported 55% of academic R&D spending. Academic institutions were the second largest source of funding for academic R&D, contributing 25% of the funds. The remainder was funded by businesses, nonprofit organizations, state and local governments, and other sources, such as overseas funding (Figure URD-4). The shares of funding provided by different sources have shifted gradually over time. The share contributed by the federal government has declined from 61% in 2012 to 55% in 2021 (Figure URD-5). The federal government's emergency funding for academic R&D during the COVID-19 pandemic in 2020 and 2021 did not reverse this trend. Although the federal government overall contributes the greatest share of funds spent on academic R&D each year, in 2021, six agencies provided more than 90% of the federal funds spent in academic R&D (Table URD-1). The Department of Health and Human Services (HHS), largely through the National Institutes of Health (NIH), has provided more than half of federal support over that period.

Figure URD-4

Academic R&D expenditures, by source of funds: FYs 1953–2021



Note(s):
Federal data include funds from the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA was an important source of federal expenditures for academic R&D during the economic downturn and recovery from 2010 through 2012 and continued to contribute to such spending, although in smaller amounts, in 2013 and 2014. By 2015, all ARRA funds had been spent. Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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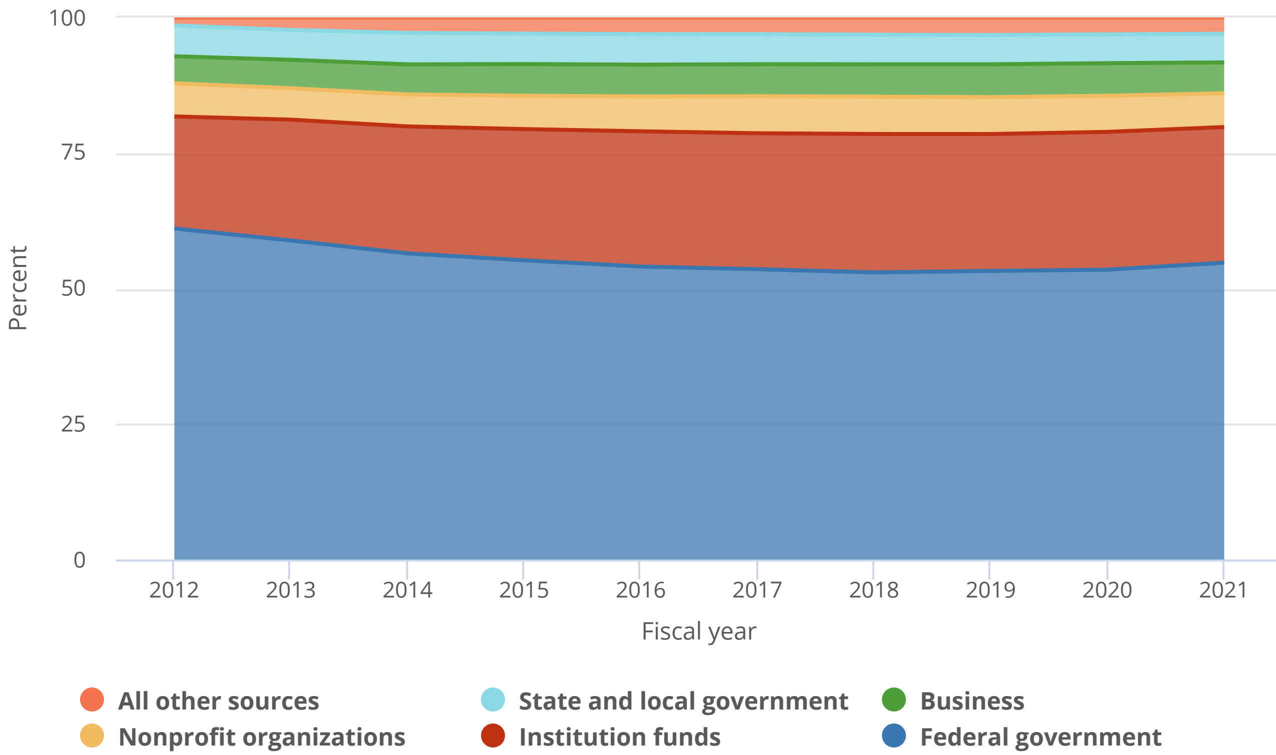
Figure URD-5

Share of academic R&D expenditures, by source of funds: FYs 2012–21



Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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Table URD-1

Federal agency support of academic R&D spending: FYs 2012, 2017, and 2021

(Billions of constant 2012 dollars and percent)

Agency	Billions of constant 2012 dollars			Percentage of federal agency support of academic R&D spending		
	FY 2012	FY 2017	FY 2021	FY 2012	FY 2017	FY 2021
HHS	21.92	20.07	23.26	54.60	53.73	56.02
DOD	4.91	5.23	6.22	12.23	14.00	14.98
NSF	5.28	4.83	4.57	13.14	12.94	11.01
DOE	1.95	1.69	1.87	4.87	4.52	4.51
NASA	1.33	1.30	1.49	3.32	3.49	3.60
USDA	1.09	1.14	1.10	2.72	3.04	2.65
Other agencies	3.66	3.09	3.00	9.12	8.27	7.22
Total	40.14	37.35	41.52	100.00	100.00	100.00

DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s):
Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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The share of R&D spending funded by the academic institutions themselves rose concurrently with the decrease in the share funded by the federal government, increasing from 21% in 2012 to 25% in 2021 (Figure URD-5).[7] Between 2012 and 2021, spending funded by institutional support increased by nearly 40% (Figure URD-4). Nonprofit organizations funded about 6% of academic R&D spending in 2021, representing an increase of about 17% between 2012 and 2021 in constant dollars (NCSES ***HERD 2021***: **Table 2**). Business also funded around 6% of academic R&D spending in 2021 (Figure URD-5), increasing by about 30% between 2012 and 2021 in constant 2012 dollars (Figure URD-4), reflecting in part industry's growing reliance on research results flowing from academia. State and local governments funded around 5% of academic R&D spending in 2021 (Figure URD-5), which, in constant dollars, reflected an increase of approximately 8% since 2012 (Figure URD-4).

All other sources of support for academic R&D—such as foreign governments, other universities, or gifts from individual donors directed to research funding—provided a relatively small share of funding for U.S. academic R&D. In 2021, those sources supported 3% of academic R&D spending (Figure URD-5), compared with 1.5% of all academic R&D spending in 2012. Overall, support from foreign sources (firms, universities, governments, nonprofits, and others) amounted to approximately 1.5% of academic R&D spending in 2021 (NCSES ***HERD 2021***: **Table 1** and **Table 15**).

Patterns of Academic R&D Spending

This section presents data on the distribution of academic R&D expenditures along several key dimensions, including the type of R&D, the characteristics of receiving institutions, and fields of S&E.

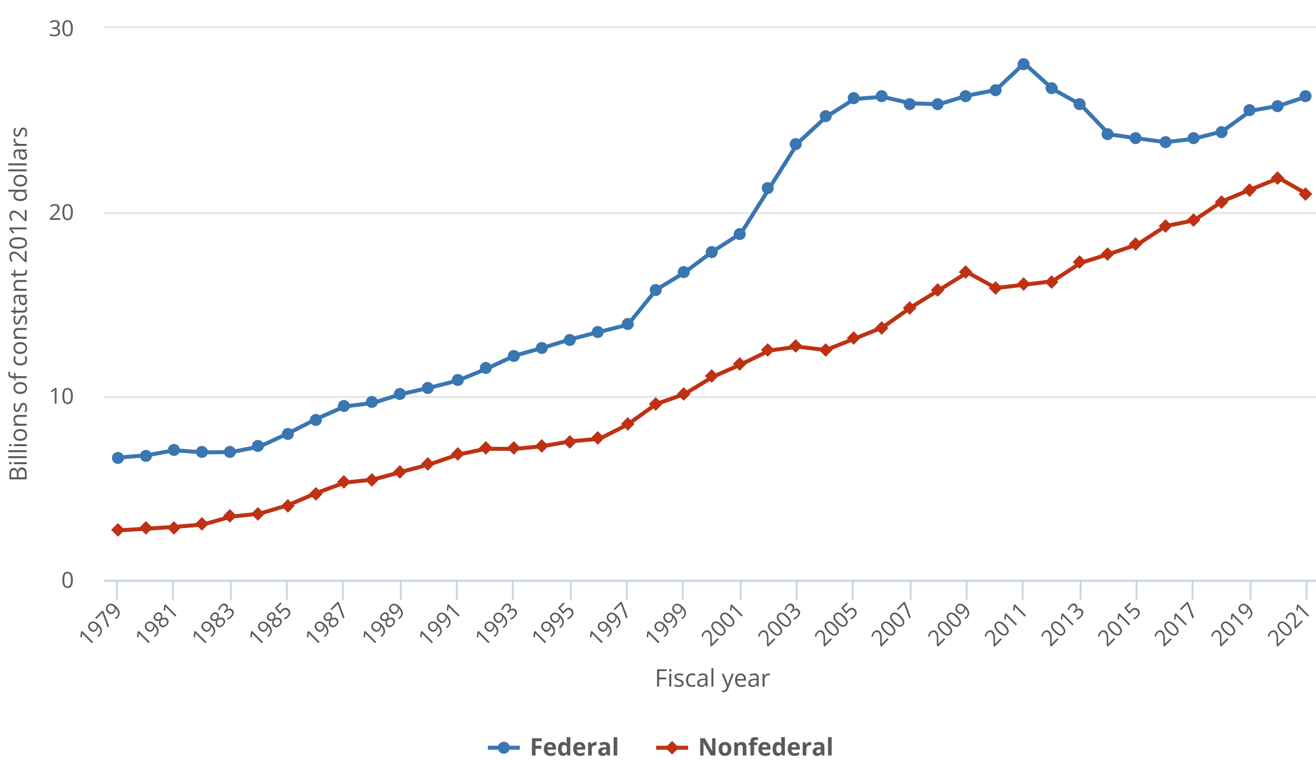
Spending, by Type of R&D

In the collection of statistical data, R&D is composed of three types: basic research, applied research, and experimental development. Of the nearly $90 billion spent on academic R&D in 2021, 62% of this amount ($56 billion) went to the performance of basic research, down from 65% in 2012. About 28% was spent on applied research and 10% on experimental development. These proportions have remained roughly stable since 2012, when 26% of academic R&D was spent on applied research and 9% on experimental development (NCSES ***HERD 2021***: **Table 9**).

Federal support for basic research at academic institutions increased more rapidly between 1997 and 2005 than in any earlier period, spurred in particular by the effort to double the research budget at NIH (Kaiser 2002). That support began declining in 2011 (in constant dollar terms) but started to increase again in 2016. In 2021, federal support for basic research at academic institutions was 11% higher than in 2016, after adjusting for inflation (Figure URD-6) but remained below its level in 2011. In contrast, basic research support from nonfederal sources has increased fairly consistently in constant dollars since 1983. Federal and nonfederal support for applied research and experimental development were higher in 2021 than in 2011 (Figure URD-7).

Figure URD-6

Federal and nonfederal funding of academic basic research: FYs 1979–2021



Note(s):
The type-of-R&D estimation procedure was revised for FY 1998 and later years; hence, these data are not directly comparable with data for FY 1997 and earlier years. Before FY 2010, R&D expenditures by type of R&D were based on percentage estimates of basic research provided by universities and colleges. Beginning in FY 2010, institutions were asked for dollar amounts of federally funded and nonfederally funded R&D expenditures for basic research, applied research, and experimental development. Federal data include funds from the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA was an important source of federal expenditures for academic R&D during the economic downturn and recovery from 2010 through 2012 and continued to contribute to such spending, although in smaller amounts, in 2013 and 2014. By 2015, all ARRA funds had been spent. Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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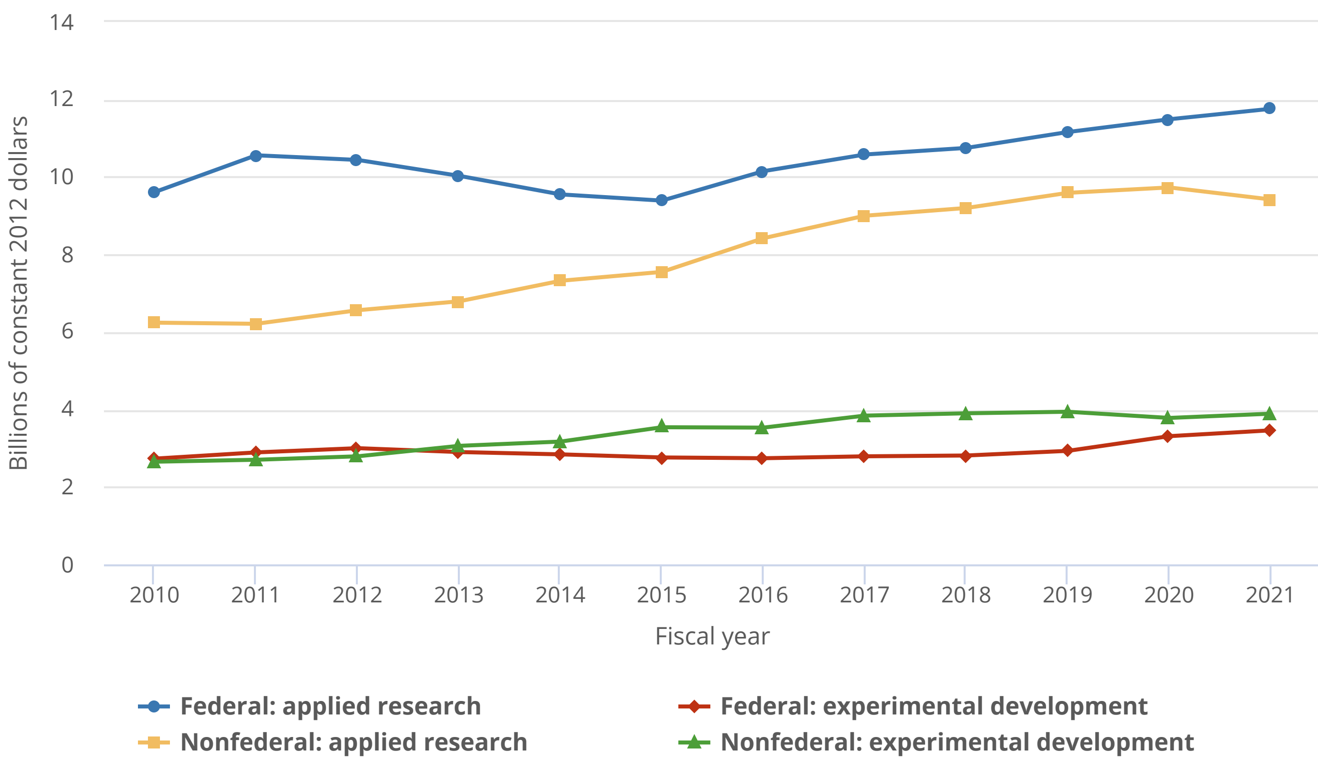
Figure URD-7

Federal and nonfederal funding of academic experimental development and applied research: FYs 2010–21



Note(s):
Federal data include funds from the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA was an important source of federal expenditures for academic R&D during the economic downturn and recovery from 2010 through 2012 and continued to contribute to such spending, although in smaller amounts, in 2013 and 2014. By 2015, all ARRA funds had been spent. Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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Spending, by Type of Institution

The level and distribution of spending on academic R&D vary across institutions.[8] Out of 3,733 postsecondary degree–granting institutions in the United States in 2020, 620 reported more than $1 million in R&D expenditures in that year (NCSES ***HERD 2021***: **Table A-5**).[9] The 131 doctoral universities with very high research activity, based on the Carnegie Classification as of 2018, spent nearly 75% of all reported academic R&D funds in 2021.[10] These institutions also awarded approximately 80% of U.S. doctoral degrees in S&E in 2021 (NCSES ***SED 2021***: **Table 1-2**) and enrolled more than 81% of doctoral students in those fields (NCSES ***GSS 2021***: **Table 5-3**).[11]

In 2021, the top 30 institutions, ranked by total R&D spending, accounted for over 42% of all U.S. academic R&D (NCSES ***HERD 2021***: **Table 21**). This concentration of R&D spending in a relatively small number of institutions is a long-standing characteristic of U.S. academic R&D spending (see [NSB ***Indicators 2018***: **Figure 5-5**]). Furthermore, the composition of the top-ranked institutions, as measured by academic R&D expenditures, has not shifted significantly over the past two decades (Table URD-2). Of the 10 top-ranked institutions in 2001, 9 institutions remained among the top 10 in 2021, although they were in a different order. Of the 30 top-ranked institutions in 2001, 24 institutions remained among the top 30 in 2021.

Table URD-2

Top 30 institutions, ranked by R&D expenditures: FYs 2001, 2011, and 2021

(Rank)

Rank	Top institutions in FY 2001	Top institutions in FY 2011	Top institutions in FY 2021
1	Johns Hopkins U.	Johns Hopkins U.	Johns Hopkins U.
2	U. California, Los Angeles	U. Michigan, Ann Arbor	U. California, San Francisco
3	U. Wisconsin-Madison	U. Washington, Seattle	U. Michigan, Ann Arbor
4	U. Michigan, Ann Arbor	U. Wisconsin-Madison	U. Pennsylvania
5	U. Washington, Seattle	Duke U.	U. Washington, Seattle
6	U. California, San Diego	U. California, San Diego	U. California, Los Angeles
7	U. California, San Francisco	U. California, San Francisco	U. California, San Diego
8	Stanford U.	U. California, Los Angeles	U. Wisconsin-Madison
9	U. Pennsylvania	Stanford U.	Stanford U.
10	U. Minnesota	U. Pittsburgh	Harvard U.
11	Pennsylvania State U.	U. Pennsylvania	Duke U.
12	U. California, Berkeley[a]	Columbia U. City of New York	Ohio State U.
13	Cornell U.	U. North Carolina, Chapel Hill	U. North Carolina, Chapel Hill
14	Massachusetts Institute of Technology[a]	U. Minnesota, Twin Cities	Cornell U.
15	U. California, Davis	Ohio State U.	Yale U.
16	Texas A&M U., College Station	Pennsylvania State U.-University Park and Hershey Medical Center	Texas A&M U., College Station
17	Washington U., Saint Louis	Cornell U.	U. Maryland
18	U. Illinois at Urbana-Champaign	U. Florida	U. Pittsburgh
19	Ohio State U.	Washington U., Saint Louis	U. Texas M. D. Anderson Cancer Center
20	Baylor C. Medicine	Massachusetts Institute of Technology[a]	Georgia Institute of Technology[a]
21	Duke U.	U. California, Berkeley[a]	Columbia U. City of New York
22	Harvard U.	U. California, Davis	U. Minnesota, Twin Cities
23	U. Arizona	Texas A&M U., College Station	New York U.
24	Columbia U. City of New York	U Texas M. D. Anderson Cancer Center	Vanderbilt U. Medical Center
25	U. Pittsburgh	Yale U.	Washington U., Saint Louis
26	U. Florida	Georgia Institute of Technology[a]	Pennsylvania State U.
27	U. Southern California	Harvard U.	U. Florida
28	Yale U.	U. Texas, Austin	U. Southern California

Table URD-2

Top 30 institutions, ranked by R&D expenditures: FYs 2001, 2011, and 2021

(Rank)

Rank	Top institutions in FY 2001	Top institutions in FY 2011	Top institutions in FY 2021
29	Georgia Institute of Technology[a]	Northwestern U.	Massachusetts Institute of Technology[a]
30	U. North Carolina, Chapel Hill	U. Arizona	Northwestern U.

[a] Institution does not have a medical school.

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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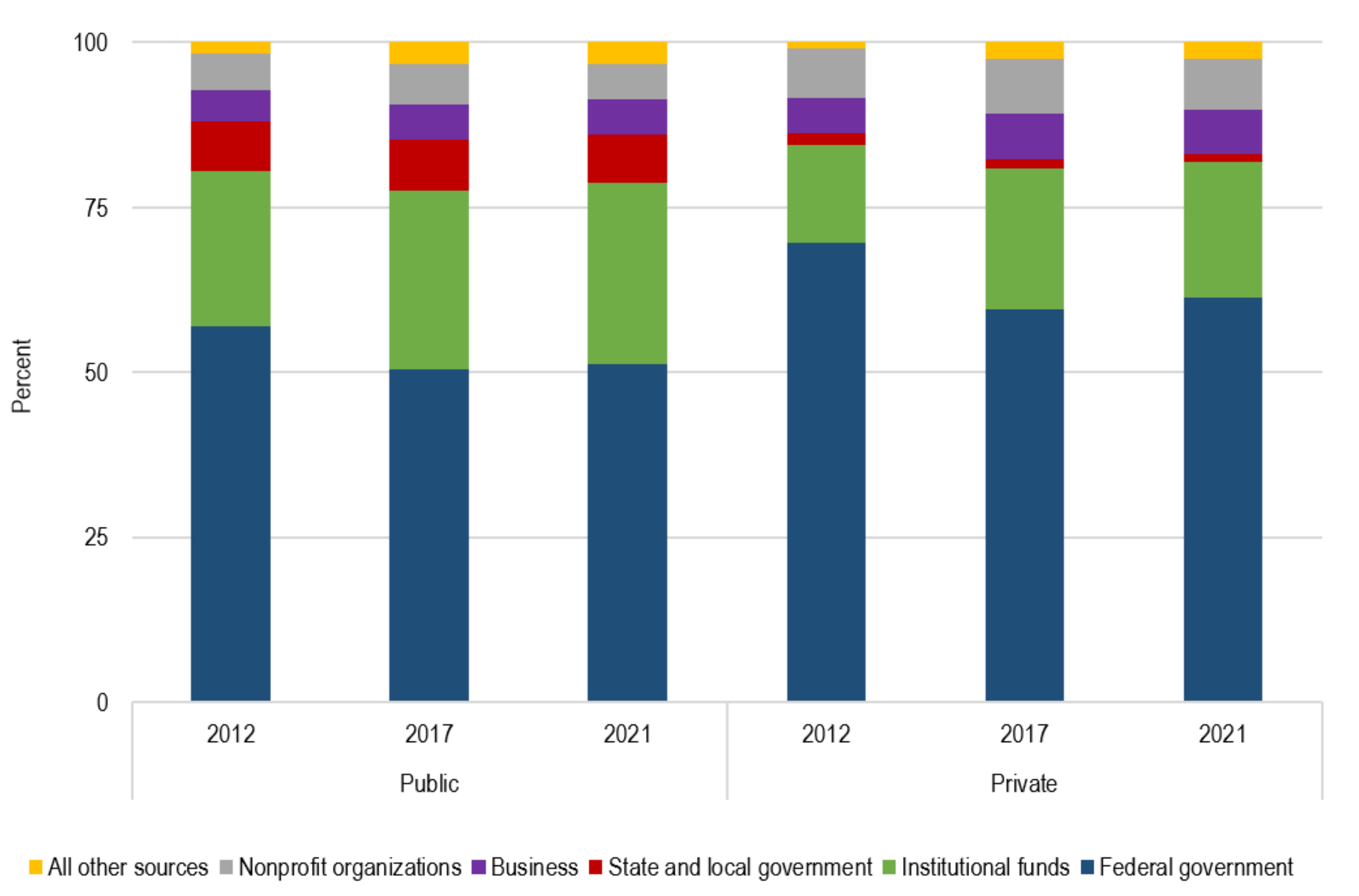
Spending at Public and Private Institutions

In 2021, public universities were responsible for 65% of academic R&D spending, and private universities spent the remainder; this proportion has remained roughly stable for more than a decade (NCSES ***HERD 2021***: **Table 17**). R&D spending is more concentrated among private institutions. In 2021, the top 25 private universities spent more than 75% of the private academic R&D total, whereas the top 25 public universities spent around 46% of the public total (NCSES ***HERD 2021***: **Table 37** and **Table 38**).

Sources of funding for academic R&D in public and private universities differ (Figure URD-8). Since at least 2012, private universities have received a greater share of their R&D spending from federal support, whereas institutional funds and funding from state and local government have been more prevalent sources for public universities. Within the share funded by federal sources, HHS contributed to R&D spending at private universities to a greater degree than at public universities, and the Department of Agriculture (USDA) contributed relatively more to spending at public universities (Figure URD-9).

Figure URD-8

Sources of funding for academic R&D in private and public institutions: FYs 2012, 2017, and 2021



Note(s):
Institutional control is a classification of whether an institution is operated by publicly elected or appointed officials (public control) or by privately elected or appointed officials and derives its major source of funds from private sources (private control).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

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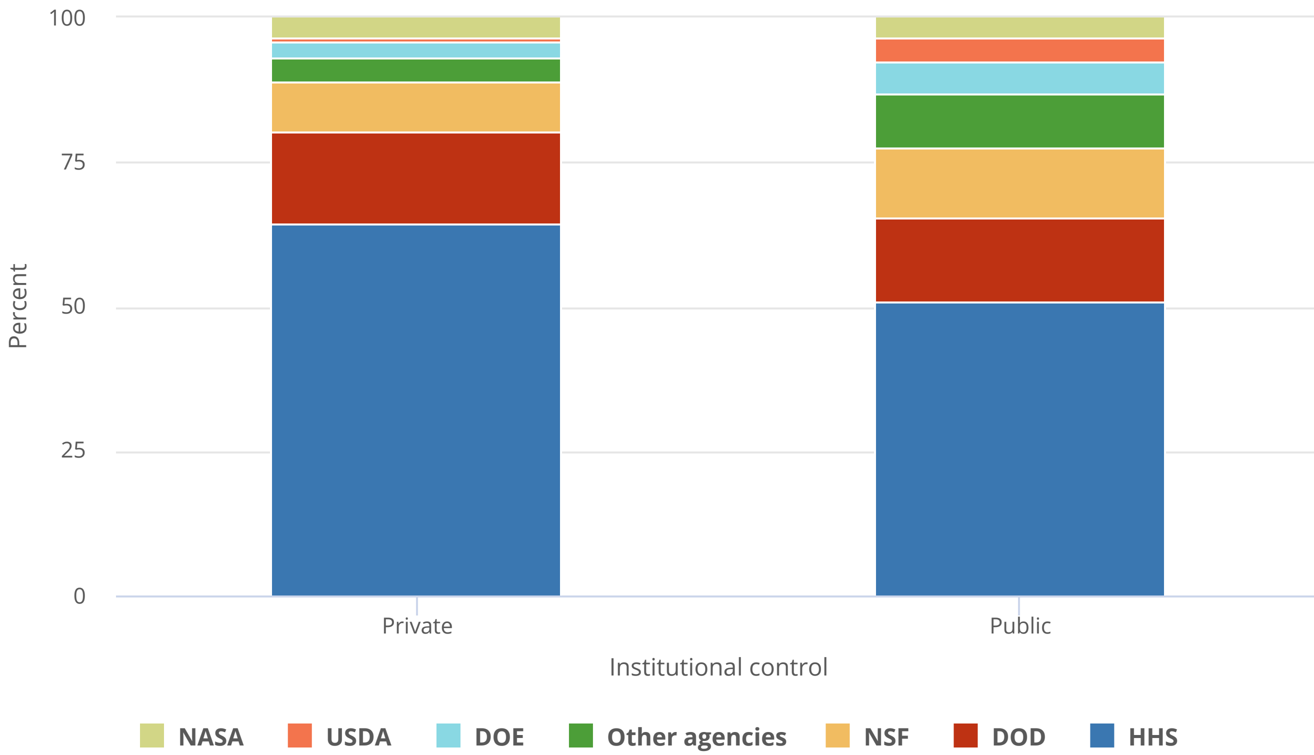
Figure URD-9

Shares of federal agency funding for public and private institutions: FY 2021



DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s):
Institutional control is a classification of whether an institution is operated by publicly elected or appointed officials (public control) or by privately elected or appointed officials and derives its major source of funds from private sources (private control).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

Science and Engineering Indicators

Spending at Institutions with and without Medical Schools

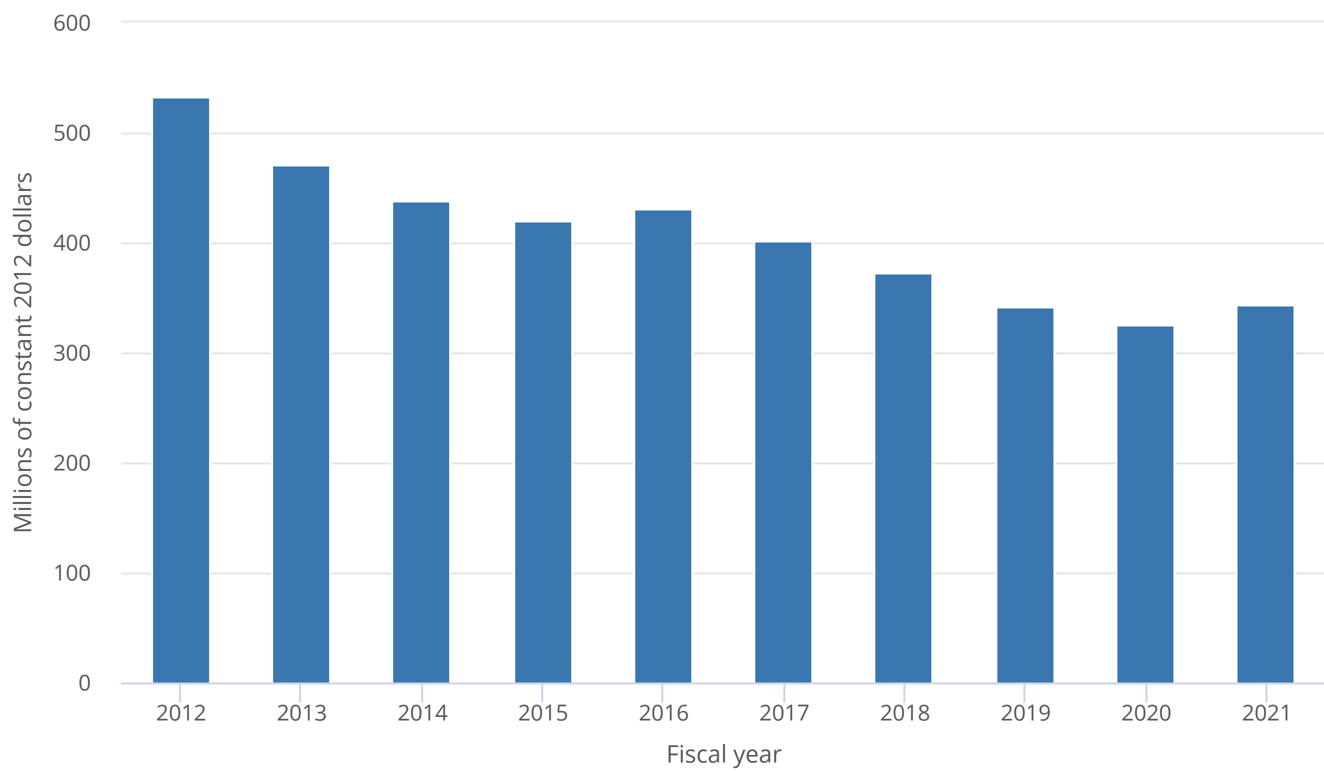
Spending on biomedical R&D exerts considerable influence on overall patterns in academic R&D spending, such that more R&D support is concentrated in academic institutions that have medical schools. In 2021, 75% of all federally sourced spending for academic R&D went to institutions that also house a medical school, totaling $37 billion. Of the federally supported R&D at institutions with a medical school, $24.4 billion was provided by HHS, or about 89% of all HHS funds for academic R&D in that year (NCSES ***HERD 2021***: **Table 26** and **Table 72**). Institutions with medical schools accounted for more than half of the R&D spending supported by funds from each federal agency except USDA, although few agencies beyond NIH directly supported R&D at the medical schools themselves (NCSES ***HERD 2021***: **Table 26** and **Table 72**). These institutions also received 65% of nonfederal support for R&D spending in 2021, amounting to $28 billion (NCSES ***HERD 2021***: **Table 26**, **Table 69**, and **Table 72**).

Spending at Minority-Serving Institutions

Minority-serving institutions (MSIs) include a diverse array of more than 800 federally designated institutions including, but not limited to, historically Black colleges and universities (HBCUs), high-Hispanic-enrollment (HHE) institutions, and tribal colleges and universities (TCUs).[12] The HBCUs are institutions that are defined under the Higher Education Act of 1965 as those that were established to serve Black or African American (hereafter referred to as Black) students in the years before desegregation; according to the U.S. Department of Education, 103 HBCUs are operating as of 2022 (NCES 2023). In 2021, 56 HBCUs reported R&D expenditures in the HERD Survey, and their federally supported R&D spending totaled $339 million in constant 2012 dollars (Figure URD-10; NCSES ***HERD 2021***: **Table 32** and **Table 84**).[13] These expenditures constitute less than 1% of total federally financed for U.S. academic R&D in 2021 (Figure URD-4). In 2012, 60 HBCUs responding to the survey reported $516 million in federally funded R&D expenditures, indicating that federal funding of R&D spending at HBCUs declined by 34% in constant dollars over this period. The federally funded expenditures reported in 2021 were 2% higher than the total reported in 2020, but it is not clear if this increase indicates a reversal of the long-term trend (Figure URD-10).

Figure URD-10

Federally funded R&D expenditures at historically Black colleges and universities: FYs 2012–21



Note(s):
These estimates include academic institutions from the short- and long-form survey populations. Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey, and Institute of Education Sciences, National Center for Education Statistics.

Science and Engineering Indicators

HHE institutions are universities in which Hispanic or Latino (hereafter referred to as Hispanic) students constitute at least 25% of full-time equivalent (FTE) student enrollment.[14] In 2021, the 130 HHE institutions reporting expenditures in the HERD Survey spent a total of around $8.8 billion on academic R&D (NCSES ***HERD 2021***: **Table 34**). The federal government provided around $4 billion (about 46%) of this spending, a lower percentage than its share of support for academic R&D at all institutions. The distribution of academic R&D spending across fields at HHE institutions did not differ substantially from the distribution by field for all U.S. universities (NCSES ***HERD 2021***: **Table 13** and **Table 34**).

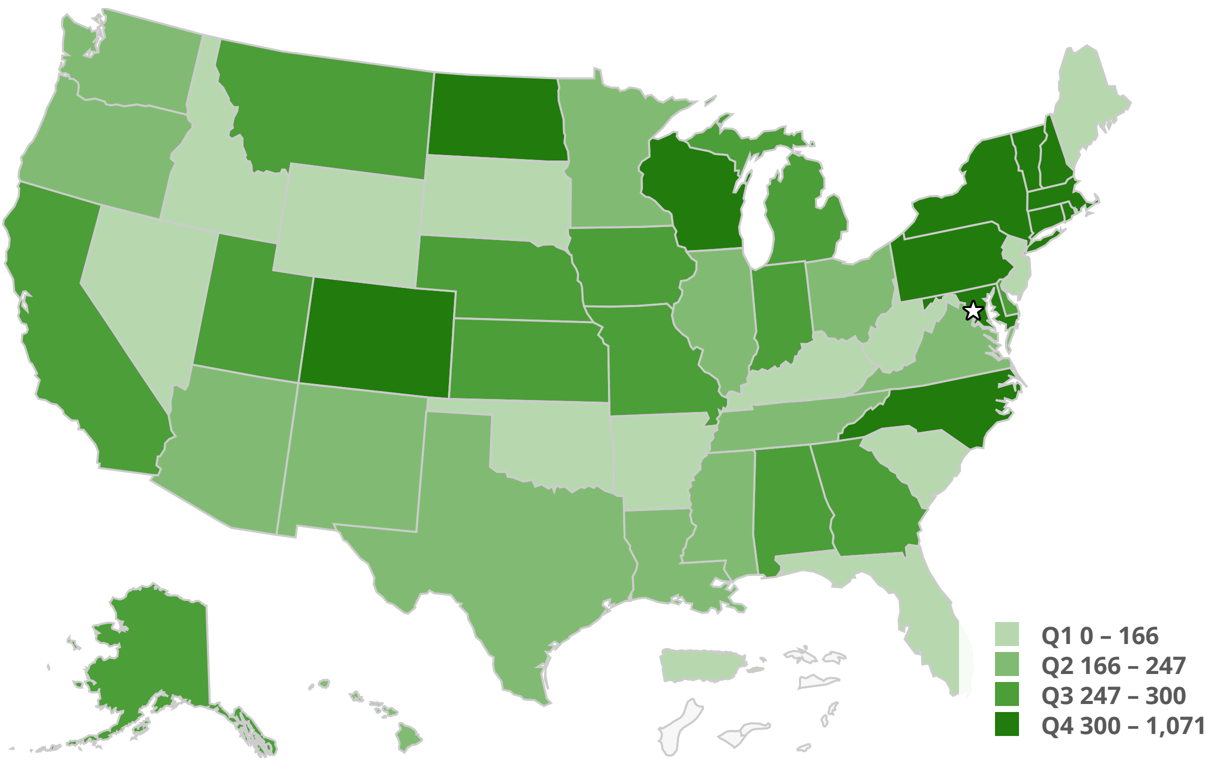
Several 4-year TCUs reported R&D expenditures above the $150,000 reporting threshold in recent years; in some years, a few reported over $1 million in R&D spending.[15] Four TCUs were represented in the population of reporting institutions for the HERD Survey in 2021, with R&D spending totaling approximately $3.1 million (NCSES ***HERD 2021***: **Table 82**).

Geographic Distribution of Academic R&D Spending, by State

In 2021, academic R&D spending at institutions located in individual states ranged from about $93.0 million in Wyoming to about $11.2 billion in California (NCSES ***HERD 2021***: **Table 67**). Differences in the level of academic R&D across states stem from the size of the states' populations, the number and size of the academic research institutions in each state, and the interest and success of those institutions in attracting external research funding. Among the top 30 institutions ranked by R&D expenditures, most were public universities in states with large populations (e.g., California, Texas, Florida, Ohio) or prominent private universities (Table URD-2). Normalizing for the populations of the states (i.e., dividing total academic R&D spending in each state by that state's population) provides an alternative perspective on geographical distribution of academic R&D spending. Some states with small populations, such as Maryland and Massachusetts, ranked highly, whereas some states with large populations, such as Texas and Florida, ranked much lower when viewed this way (Figure URD-11). More details on R&D spending in specific states can be found at the *Indicators* website (**https://ncses.nsf.gov/indicators/states/**).

Figure URD-11

Ratio of academic R&D expenditures to population, by U.S. states: FY 2021



Note(s):
State population totals are based on 2020 Decennial Census figures retrieved from the U.S. Census Bureau, Census Data Explorer Portal, at https://data.census.gov/.

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

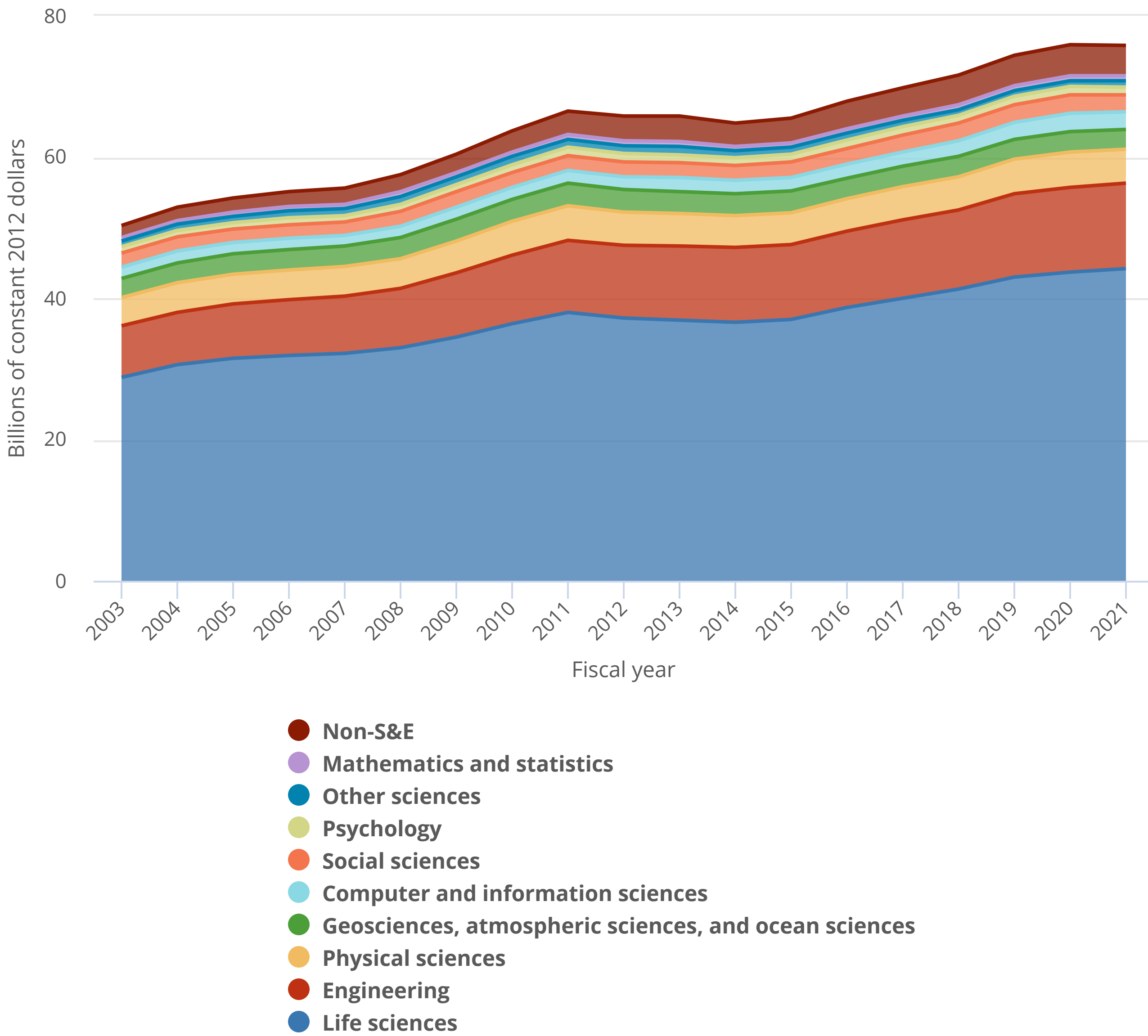
Science and Engineering Indicators

Academic R&D Spending, by Field

The distribution of academic R&D spending across research fields has changed little over the past decade (Figure URD-12). The life sciences have long accounted for the bulk of academic R&D spending, reaching 58% of the total in 2021. Research funded by federal and nonfederal sources showed similar distribution patterns across fields (Figure URD-13 and Figure URD-14). In contrast, the contributions of the various federal departments and agencies to academic research spending differed widely by S&E field (Figure URD-15). For example, HHS supported most academic R&D in life sciences, psychology, and social sciences, whereas the Department of Defense (DOD) was one of the top two agencies funding research in computer and information sciences, engineering, and mathematics and statistics. NSF was the leading funder among all federal agencies of academic R&D in mathematics and statistics; geosciences, atmospheric sciences, and ocean sciences; and physical sciences. NSF also provided a considerable share of funding for computing and information sciences research.

Figure URD-12

Academic R&D spending, by field: FYs 2003–21



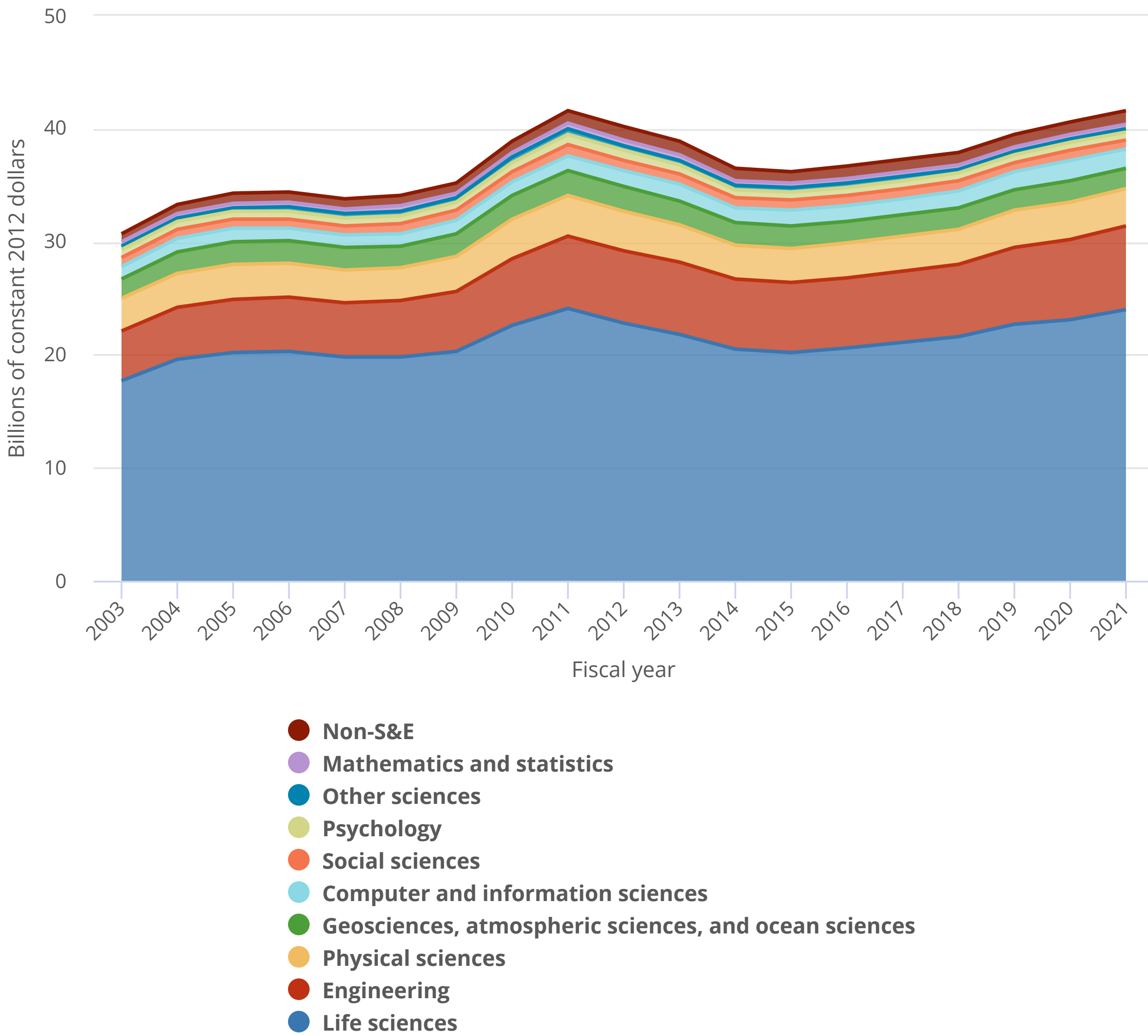
Note(s):
Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

Science and Engineering Indicators

Figure URD-13

Federally funded academic R&D spending, by field: FYs 2003–21



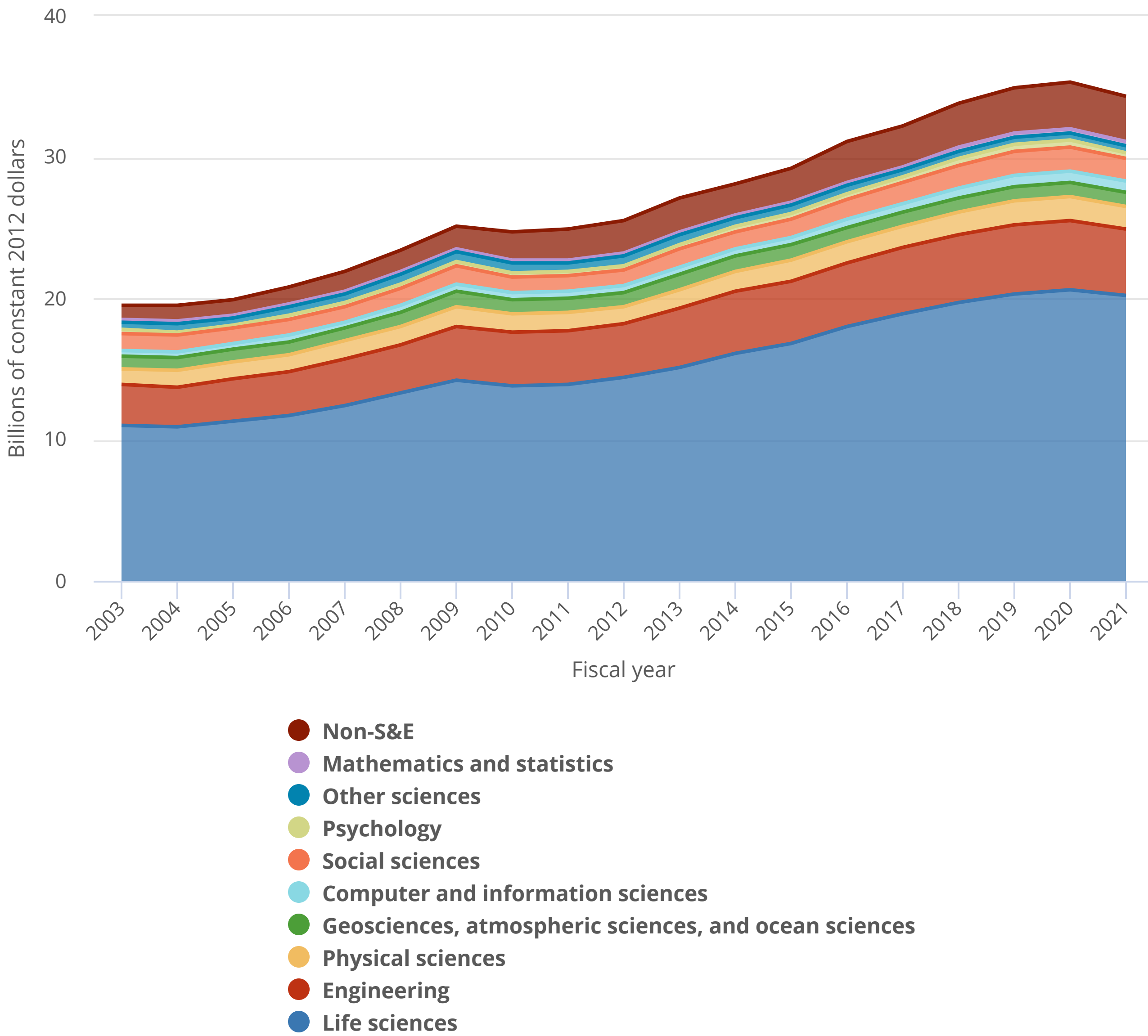
Note(s):
Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

Science and Engineering Indicators

Figure URD-14

Nonfederally funded academic R&D spending, by field: FYs 2003–21



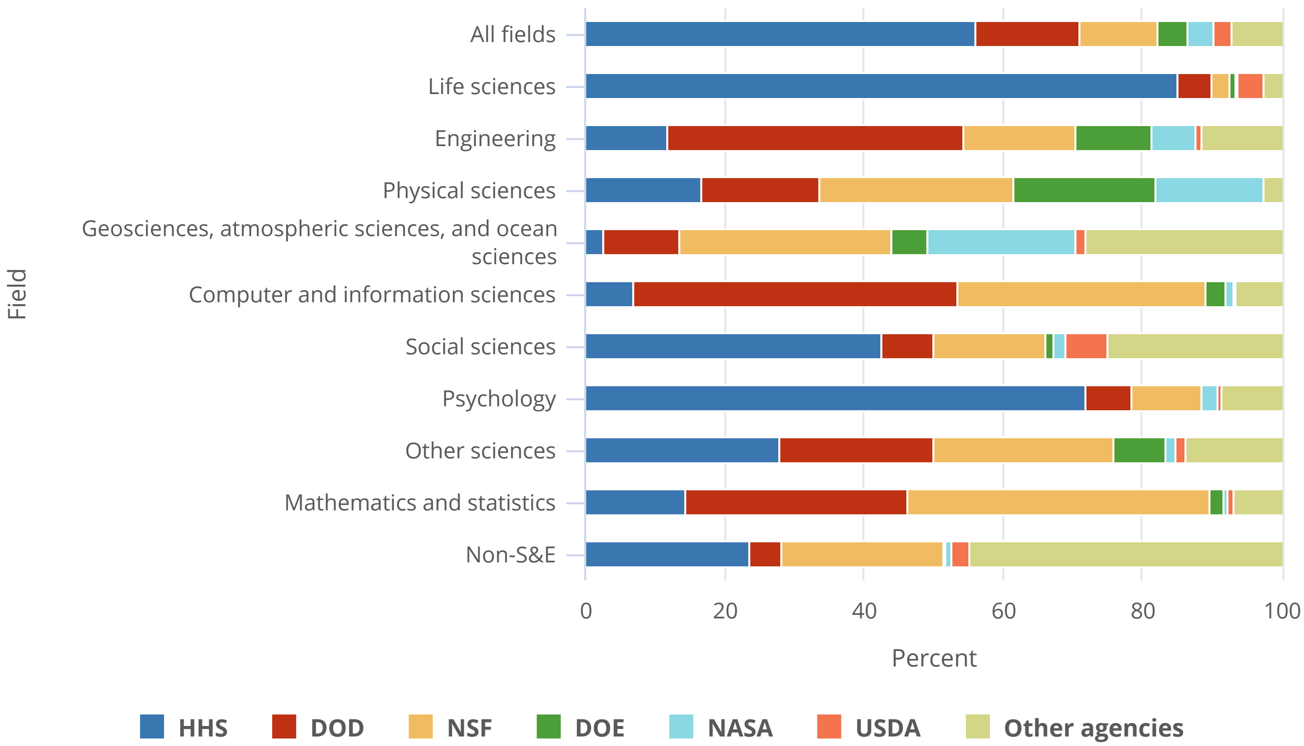
Note(s):
Gross domestic product deflators come from the Bureau of Economic Analysis and are available at https://www.bea.gov/data/gdp/gross-domestic-product (accessed September 2022).

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

Science and Engineering Indicators

Figure URD-15

Federally financed academic R&D expenditures, by agency and field: FY 2021



DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture.

Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey.

Science and Engineering Indicators

Infrastructure for Academic R&D

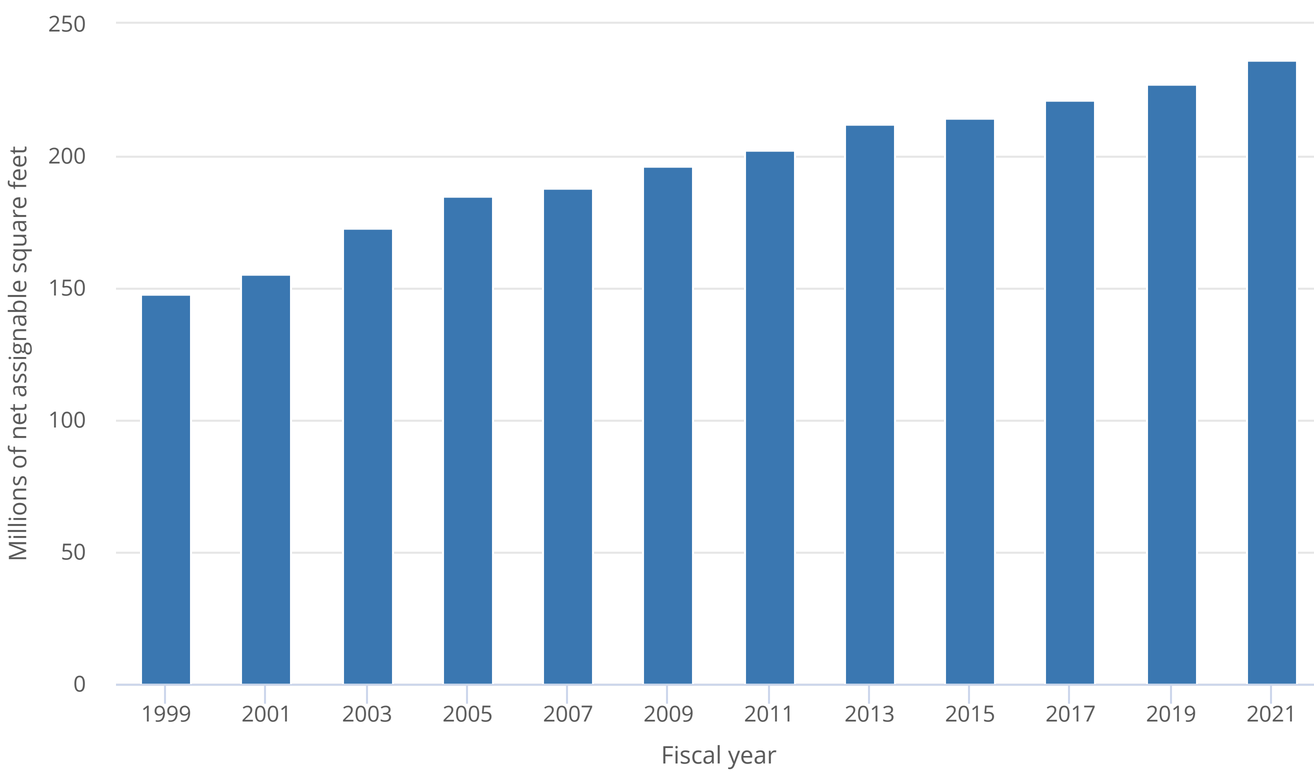
The conduct of academic R&D requires a variety of physical and institutional infrastructures, including laboratories, offices, and other spaces; research equipment; information, communications, and library resources; and diverse organizational elements. In addition to these infrastructures, which are typically owned and controlled by the researchers' academic institutions, academic R&D also makes increasingly heavy use of external infrastructures not under the institution's direct ownership and control, such as federal user facilities, shared research databases, computational and communications cyberinfrastructures, astronomical and terrestrial observatories, oceanographic networks and ships, and so on.[16] For more than three decades, NCSES has surveyed academic research institutions regarding their use of and investments in internal research infrastructures: facilities and capitalized research equipment. These two key elements of physical infrastructure are the focus of the remainder of this section.

Research Facilities

In 2021, U.S. universities and colleges reported devoting 236.1 million net assignable square feet (NASF) of space to S&E research, an increase of 9.2 million NASF over 2019 (Figure URD-16). The space devoted to research varies widely across the fields of S&E, reflecting the different levels of funding and the physical equipment and resources required for research in diverse fields. The life sciences fields of health sciences and biological and biomedical sciences together used 100.3 million NASF in 2021, or more than 40% of all academic research space (NCSES ***Facilities 2021***: **Table 1**).

Figure URD-16

S&E research space at academic institutions: FYs 1999–2021



Note(s):
The biennial survey cycle for the Survey of Science and Engineering Research Facilities ran on odd years for FYs 1999–2021.

Source(s):
National Center for Science and Engineering Statistics, Survey of Science and Engineering Research Facilities.

Science and Engineering Indicators

In 2021, academic research institutions reported plans to invest over $12.8 billion in current dollars to build new academic research space during 2022 and 2023, which would add over 10.6 million NASF in research space to the nation's inventory (NCSES ***Facilities 2021***: **Table 8** and **Table 12**). These same institutions spent some $4.5 billion on building new facilities that began construction in 2020 or 2021. Of that amount, federal sources provided $40.9 million, or 1% of the total; state and local governments provided $990.7 million, or 22% of the total; and institutions' own funds and other institutional funding sources provided 77% of the total (NCSES ***Facilities 2021***: **Table 24**).

Research space must be maintained and revitalized to continue to deliver necessary services to researchers. In 2020 and 2021, research universities invested about $4.9 billion in current dollars on new projects to repair or renovate research space (NCSES ***Facilities 2021***: **Table 18**). Institutions reported that they plan to invest an additional $6.1 billion in such projects during FYs 2022 and 2023. Additional information on this topic is available from the NCSES analyses of the **Survey of Science and Engineering Research Facilities**.[17]

Research Equipment

In 2021, universities spent about $2.7 billion in current dollars on capitalized equipment used to conduct academic research (NCSES ***HERD 2021***: **Table 18**). This spending reflected an increase of 2.8% from 2020 in current dollars; when adjusted for inflation, this represented a slight decrease year over year. Annual equipment spending has ranged between $1.9 billion and $2.3 billion in constant dollars over the last 10 years. As in prior years, research equipment expenditures were concentrated in three fields: life sciences (39%), engineering (30%), and physical sciences (17%) (NCSES ***HERD 2021***: **Table 18**).

The federal government typically plays a major role in funding academic research equipment. The share of research equipment expenditures funded by federal sources remained above 50% from 1981, when these data were first collected, through 2013. Since 2014, the federal share of funding has ranged from 44% to 48% (NCSES ***HERD 2014***: **Table 14**; NCSES ***HERD 2015***: **Table 13**; NCSES ***HERD 2016***: **Table 17**; NCSES ***HERD 2017***: **Table 17**; NCSES ***HERD 2018***: **Table 17**; NCSES ***HERD 2019***: **Table 17**; NCSES ***HERD 2020***: **Table 17**; NCSES ***HERD 2021***: **Table 18**). The federal share of research equipment funding differed significantly across fields and subfields. In 2021, the federal share was highest (above 70%) in atmospheric sciences and meteorology, ocean sciences and marine sciences, electrical and electronics engineering, and metallurgical and materials engineering. Among S&E fields, the federal share of funding for equipment in 2021 was lowest in the social sciences (31%), particularly political science (5%) and anthropology (4%) (NCSES ***HERD 2021***: **Table 18**).

Human Resources and Academic R&D

Academic R&D activity employs large numbers of people in diverse roles, including faculty researchers, nonfaculty researchers, students at all levels, postdocs, and support staff ranging from custodial workers to senior professionals. In addition to producing new knowledge disseminated through publications, presentations, and various forms of intellectual property, academic R&D activity contributes to the education and training of graduates at all levels, many of whom go on to careers as academic scientists and engineers. In its *Vision 2030*, NSB noted that talent is one of four elements of S&E leadership that the United States must maintain if it is to continue leading the world in innovation in 2030 (NSB 2020).

This section presents an overview of the people engaged in academic R&D in U.S. institutions, with a focus on faculty, graduate students, and postdocs. For graduate students and postdocs, this section also provides detailed data on sources of financial support for their research and education.[18] Ensuring financial support for students, postdocs, and researchers in S&E and S&E-related fields is essential to developing and retaining the talent needed for the nation to lead global innovation.

Academic Employment

The higher education sector is a large employer of individuals holding research doctorates in S&E fields.[19] The doctoral academic workforce trains the next generation of scientists and engineers and advances the nation's R&D enterprise, especially basic research. In 2021, about 347,000 members of the doctoral academic workforce received an S&E doctorate in the United States (Table SURD-1).[20]

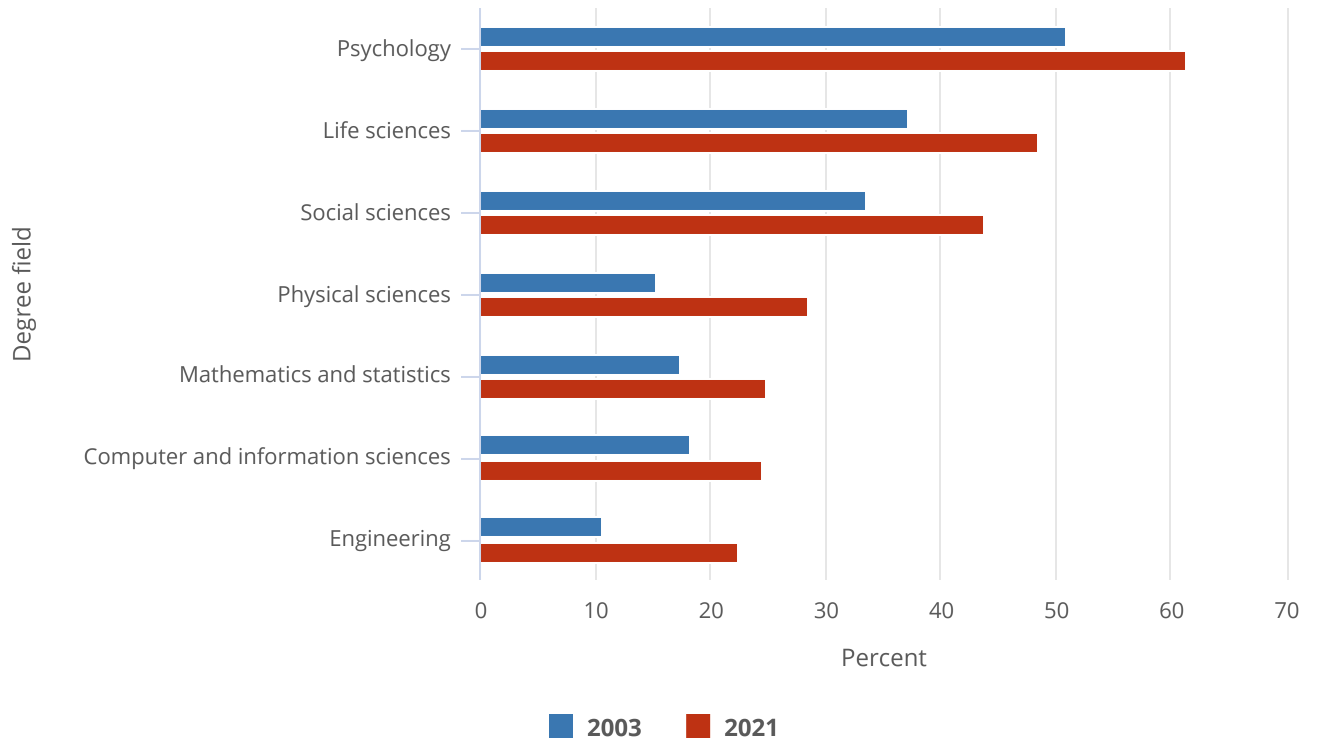
In the last 30 years, S&E doctorate holders made an employment shift from the academic to the for-profit business sector. In 1993, nearly half of S&E doctorate holders (45%) were employed by universities and 4-year colleges, whereas 31% were employed by private, for-profit businesses (NSF 1996: Table 20). By 2021, these percentages shifted, with 39% in 4-year educational institutions and 37% in for-profit businesses (NCSES ***SDR 2021***: **Table 42**). As a proportion of all academically employed S&E doctorate holders, however, the number employed as full-time faculty declined since at least 2003 to about 70% in 2021.[21]

In 2021, 39% of U.S.-trained S&E doctorate holders working in academia reported that research was their primary work activity, and 41% reported being engaged primarily in teaching (Table SURD-2).[22] In 2021, about 40% of academically employed S&E doctorate holders had received federal research support in the previous year (Table SURD-3).

The number of women in the S&E doctoral academic workforce increased from about 78,700 to about 140,800 between 2003 and 2021, while the number of men grew from about 180,700 to about 206,400 (Table SURD-4). In 2021, women accounted for about 41% of S&E doctorate holders employed in academia, up from 30% in 2003, and they accounted for 35% of full-time senior faculty (including full professors and associate professors) in 2021, up from 23% in 2003. During this period, the proportion of female S&E doctorate holders in academic positions increased in all fields (Figure URD-17). The proportion of women in the doctoral academic workforce varied across disciplines (Figure URD-18). In 2021, the proportion of female S&E doctorate holders was larger than that of men in the life sciences, the social sciences, and psychology; in contrast, a smaller proportion of women than men were employed in engineering, physical sciences, mathematics and statistics, and computer and information sciences. (For data on degree awards by sex at the bachelor's, master's, and doctoral levels, see the *Indicators 2024* report "[2024] Higher Education in Science and Engineering.")

Figure URD-17

Female S&E doctorate holders employed in academia, by degree field: 2003 and 2021



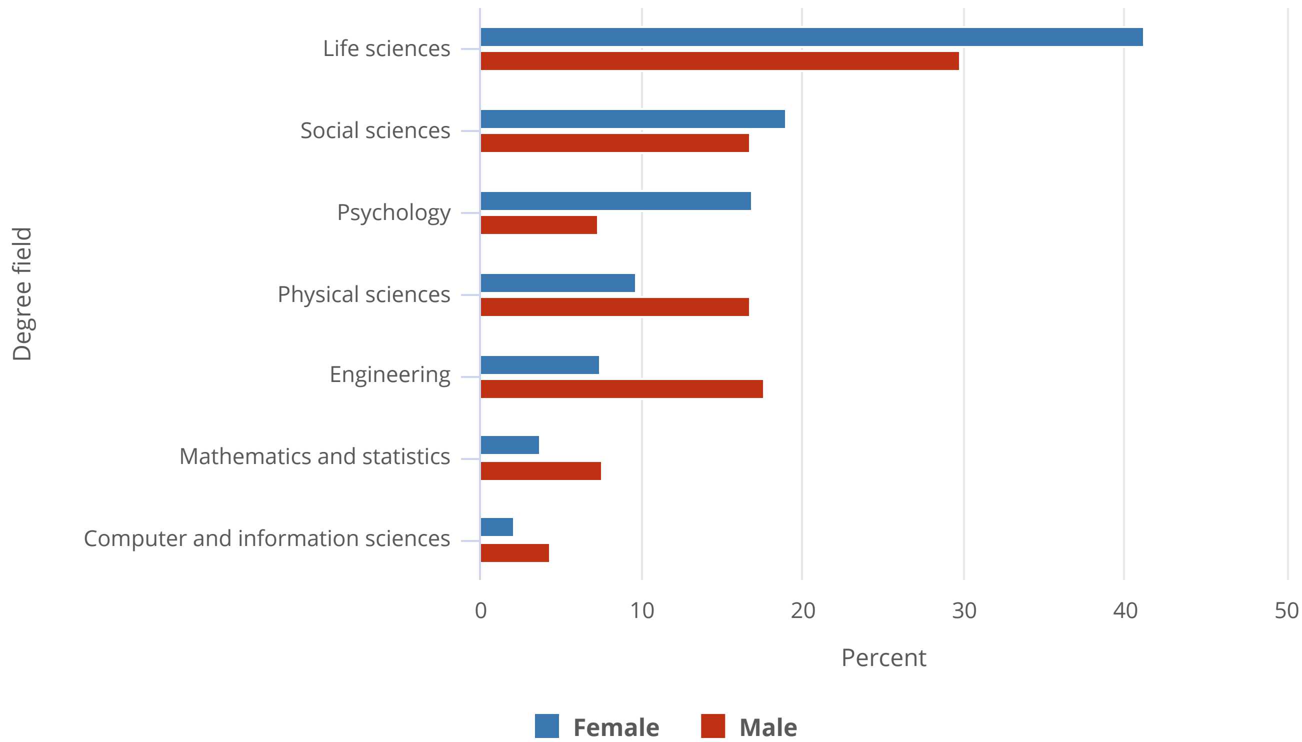
Note(s):
Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, and environmental life and health sciences.

Source(s):
National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Science and Engineering Indicators

Figure URD-18

S&E doctorate holders employed in academia, by sex and degree field: 2021



Note(s):
Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, and environmental life and health sciences.

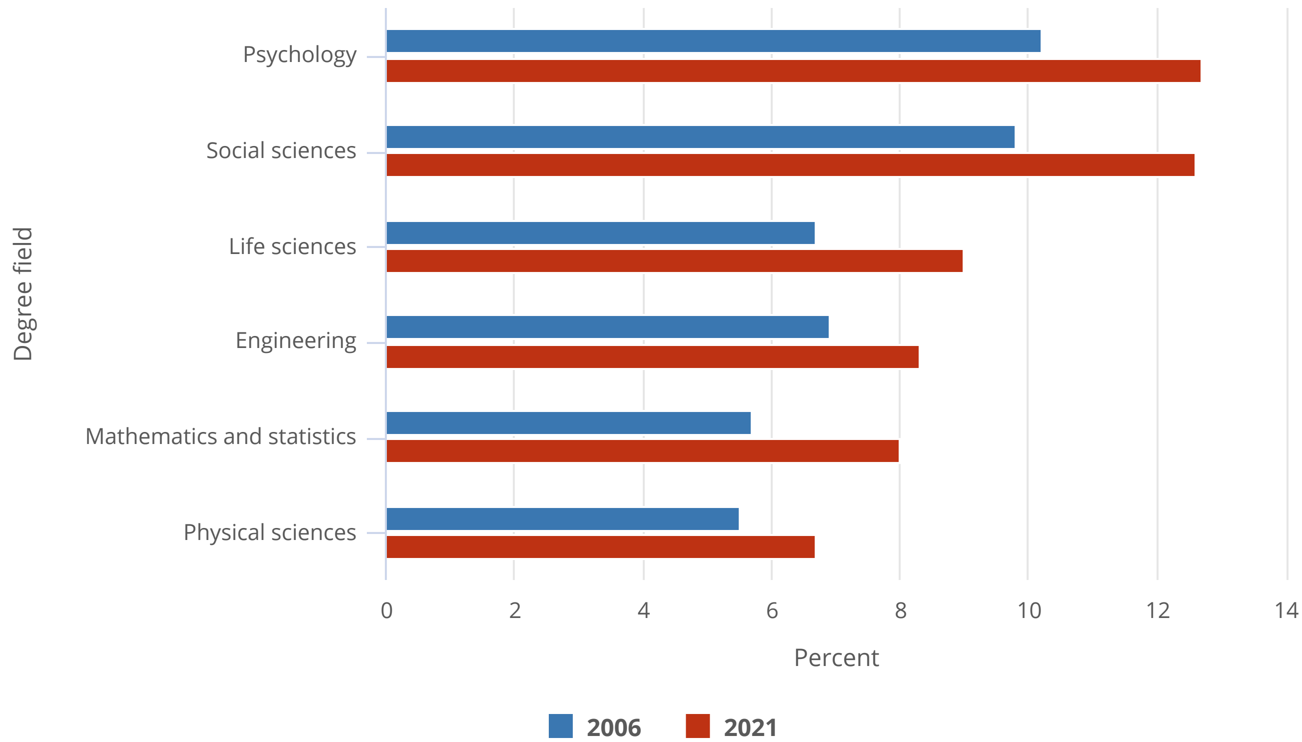
Source(s):
National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Science and Engineering Indicators

The proportion of individuals who identified as Hispanic or Latino, Black or African American, or American Indian or Alaska Native (underrepresented minorities, or URMs) in all academic positions increased from about 7% in 2006 to 10% in 2021 and from 7% to 9% among full-time faculty (Table SURD-5). Among all academic positions in the S&E doctoral workforce (including full-time faculty, postdocs, and other positions) during this period, the proportion of URMs grew in all S&E fields except for computer and information sciences (Figure URD-19).[23] In 2021, the proportions of URM psychology and social sciences doctorate holders employed in academia were larger than those of their White and Asian or Pacific Islander counterparts, and the proportions of URM doctorate holders in mathematics and statistics and the physical sciences employed in academia were lower (Figure URD-20). (For data on degree awards by race and ethnicity at the bachelor's, master's, and doctoral levels, see the *Indicators 2024* report "[2024] Higher Education in Science and Engineering.")

Figure URD-19

Underrepresented minority S&E doctorate holders employed in academia, by selected degree field: 2006 and 2021



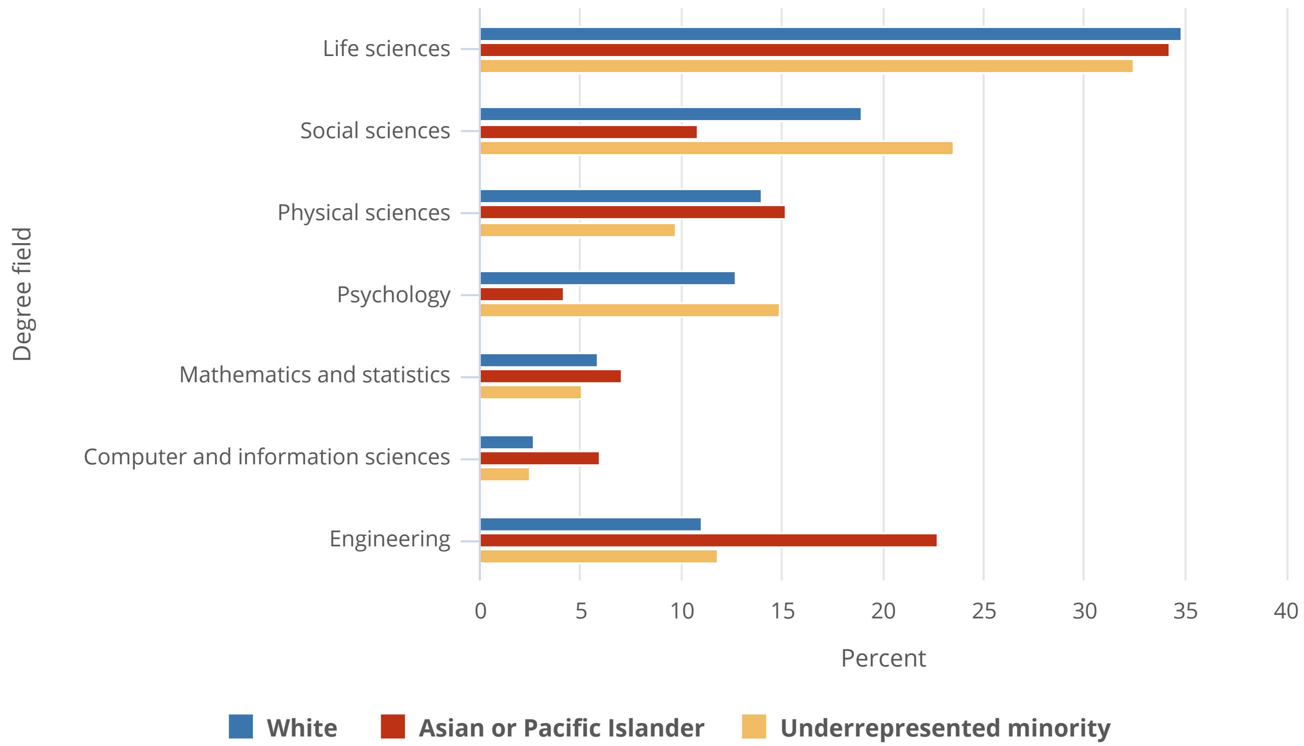
Note(s):
Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Underrepresented minority includes Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, and environmental life and health sciences. Selected fields shown are those where the differences observed were statistically significant.

Source(s):
National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Science and Engineering Indicators

Figure URD-20

S&E doctorate holders employed in academia, by race or ethnicity and degree field: 2021



Note(s):
Academic employment is limited to U.S. doctorate holders employed at 2- or 4-year colleges or universities, medical schools, and university research institutes. Underrepresented minority includes Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives. Physical sciences include earth, atmospheric, and ocean sciences; life sciences include biological, agricultural, and environmental life and health sciences.

Source(s):
National Center for Science and Engineering Statistics, Survey of Doctorate Recipients.

Science and Engineering Indicators

Graduate students and postdocs are also members of the academic research workforce, often running experiments and conducting studies under faculty supervision. In the United States, doctoral universities with the highest research activity enroll the majority of S&E graduate students and appoint most of the postdocs (NCSES ***GSS 2021***: **Table 5-3**). For example, in 2021, 56% of master's students and 81% of doctoral students were enrolled at very high research doctoral universities, and 83% of S&E postdocs had appointments in these institutions.[24]

Financial Support for S&E Graduate Students and Postdocs

Advanced education and research are tightly coupled in academia. This is especially true for graduate students and postdocs in S&E. Engagement in research is a principal mechanism through which students learn how to conduct research and to develop in-depth knowledge of their fields of specialization. To ensure that graduate students or postdocs have the resources to pursue their studies and complete their training, the institutions that enroll or appoint them often provide financial support.[25] This support may take the form of research assistantships (RAs), typically funded by research grants or contracts; teaching assistantships (TAs), typically funded by the institution; and fellowships, paid directly to the individual students by government agencies and other sources. Many full-time graduate RAs, fellowships, and postdoc appointments are supported with funding from research grants and contracts awarded by federal agencies.[26] In addition, some graduate students are self-supported or receive support from family, employers, their home countries, or student loans (or a mix of such sources).

Financial Support for S&E Graduate Students

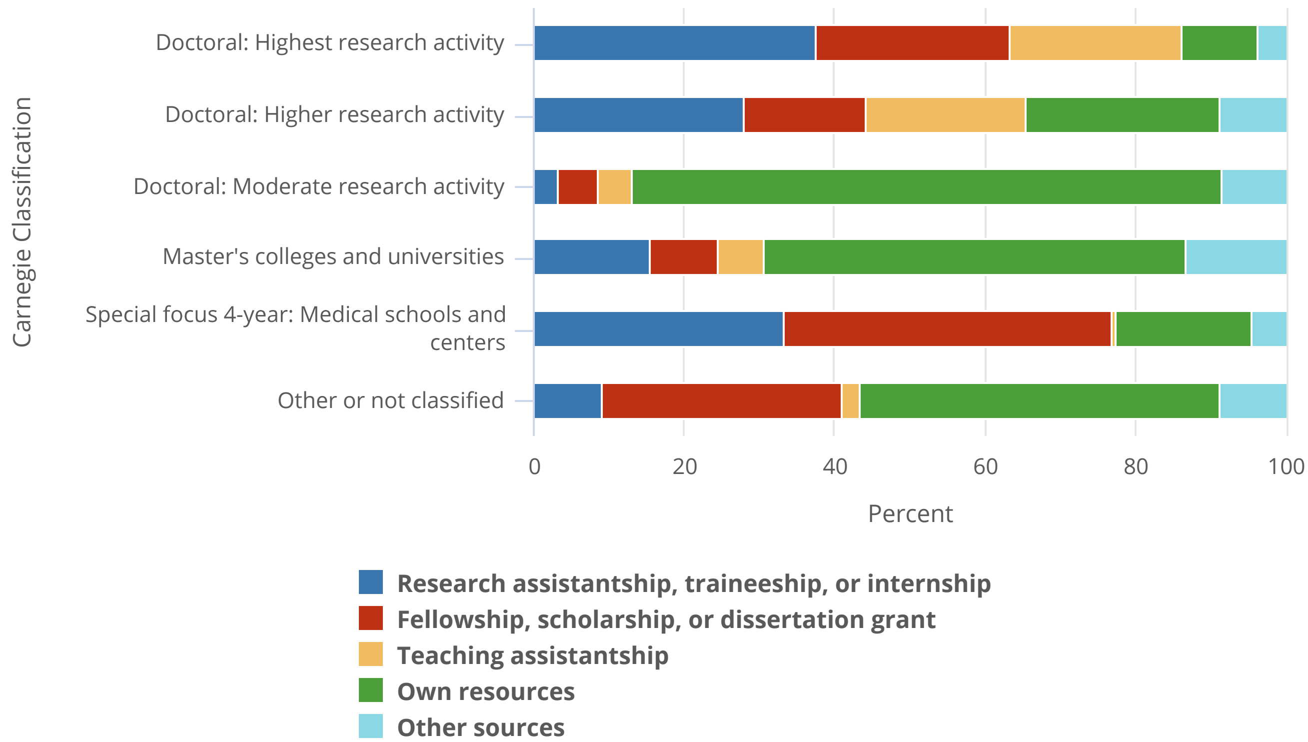
The availability of institutional or federal support for graduate students may affect how much students pay out of pocket and how much education-related debt they incur (NCSES 2019a). Graduate students in S&E fields receive support through various mechanisms, including RAs, TAs, and fellowships.[27] Of the full-time S&E graduate students supported by the federal government in 2021, 69% received RAs funded from research grants. TAs and fellowships were funded most frequently by the student's institution, whereas nearly half of RAs were funded through federal academic research grants (NCSES ***GSS 2021***: Special tabulation).

Graduate students' sources of financial support depend on their level of study.[28] In 2021, around 71% of S&E master's students paid for their graduate program using personal sources (NCSES ***GSS 2021***: **Table 3-1**); by contrast, 9% of doctoral students did so. These differences generally held across all S&E fields. Academic institutions were the primary source of support, including tuition waivers and stipends, for 22% of master's students and 58% of doctoral students. The federal government was the primary source of support for 5% of master's students and 26% of doctoral students. Federal support includes financial support provided by federal agencies but excludes federally guaranteed student loans.

Most doctoral students are supported by multiple sources or mechanisms during graduate school, even in a single academic year. Patterns of support vary by field and the type of institution attended. For example, in 2021, RAs were the most common primary source of financial support for doctorate recipients in engineering, computer and information sciences, physical sciences, and agricultural sciences and natural resources; in mathematics and statistics, TAs were most common (NCSES ***SED 2021***: **Figure 16**). In 2021, the institutions that most frequently supported doctoral students with RAs and TAs, traineeships, fellowships, scholarships, or dissertation grants were doctoral institutions with the highest research activity and those with medical schools and centers (Figure URD-21). In contrast, 79% of doctorate recipients in doctoral institutions with moderate research activity and 56% of those in master's colleges and universities used their own resources as their primary source of financial support. Funding mechanisms also varied by demographic groups (Figure URD-22).

Figure URD-21

Primary source of financial support of doctorate recipients, by 2018 Carnegie Classification of institutions: 2021



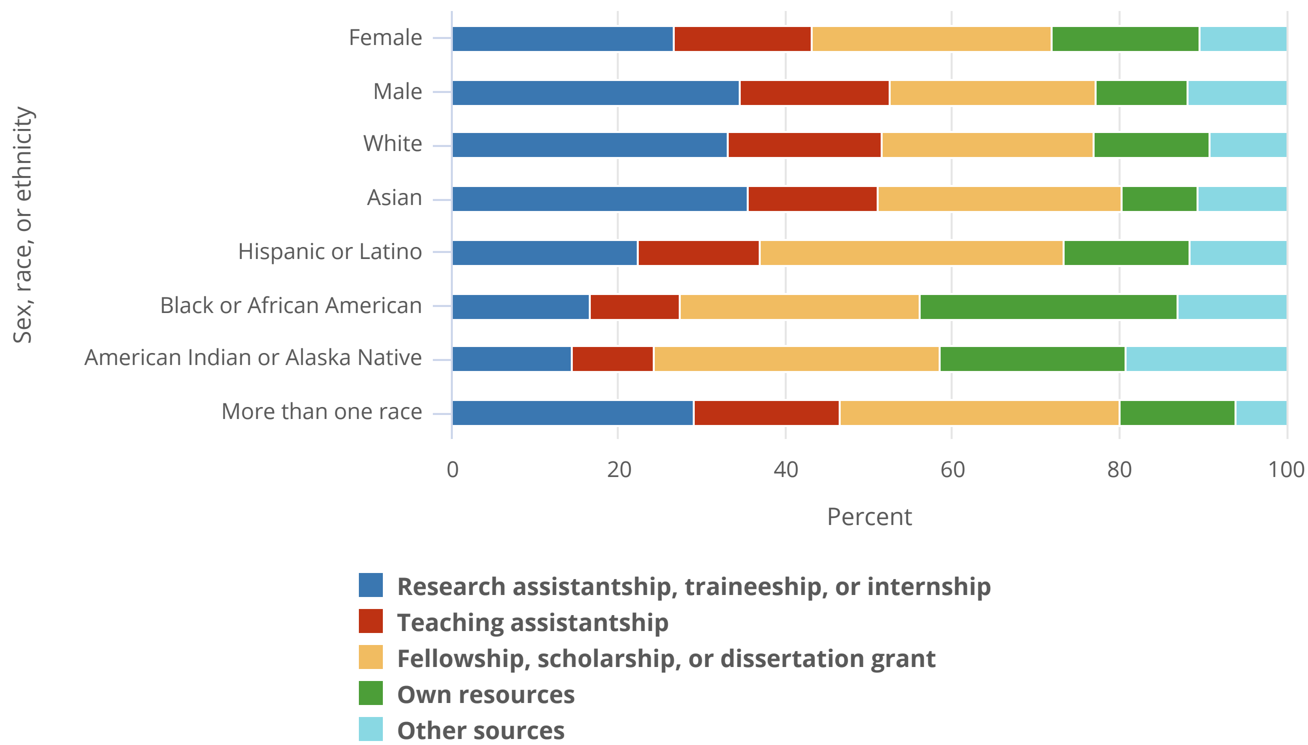
Note(s):
Percentages include only individuals who responded to the financial support questions. Research assistantship or traineeship includes other assistantships and internships or clinical residencies. Own resources includes loans, personal savings, personal earnings outside the institution sources listed, and earnings or savings of spouse, partner, or family. Other sources includes employer reimbursement or assistance and foreign support.

Source(s):
National Center for Science and Engineering Statistics, Survey of Earned Doctorates.

Science and Engineering Indicators

Figure URD-22

Primary source of financial support for U.S. citizen and permanent resident S&E doctorate recipients, by sex, race, or ethnicity: 2017–21



Note(s):
Hispanic may be any race; race categories exclude Hispanic origin. Own resources includes loans, personal savings, personal earnings outside the institution sources listed, and earnings or savings of spouse, partner, or family. Other sources includes employer reimbursement or assistance and foreign support.

Source(s):
National Center for Science and Engineering Statistics, Survey of Earned Doctorates.

Science and Engineering Indicators

Overall, among U.S. citizens and permanent residents who earned S&E doctorates between 2017 and 2021, a larger proportion of men (35%) than women (27%) were supported by RAs, whereas a larger proportion of women (18%) than men (11%) supported themselves through personal or family funds (Table SURD-6). Similar proportions of women and men (16% and 18%, respectively) were supported by TAs. Larger proportions of Asian (36%) and White (33%) doctorate recipients than doctorate recipients from URM groups reported RAs, traineeships, or internships as their primary source of support. Twenty-two percent of Hispanics, 17% of Blacks, and 14% of American Indians or Alaska Natives who earned S&E doctorates between 2017 and 2021 had RAs, traineeships, or internships as their primary source of financial support. To some extent, these differences may reflect differences across demographic groups in doctorate recipients' fields and the types of institutions they attended. However, certain patterns held across fields. For example, larger proportions of Black doctorate recipients than those from other groups used personal sources of funding in almost every S&E field.

The primary sources of financial support of S&E doctorate recipients varied by citizenship status. Overall, a larger proportion of S&E doctorate recipients who were temporary visa holders than those who were U.S. citizens or permanent residents reported RAs or traineeships as their primary source of support (52% vs. 34%) (NCSES ***SED 2021***: **Table 4-1**). In contrast, a larger proportion of S&E doctorate recipients who were U.S. citizens and permanent residents than those who were temporary visa holders reported support from fellowships, scholarships, dissertation grants, and their own sources. Patterns of primary financial support also varied by field of study.

Financial Support for S&E Postdocs

In 2021, most S&E postdocs (61%) were funded through research grants (NCSES ***GSS 2021***: **Table 3-6**). Postdocs were also funded through fellowships (10%), traineeships (6%), and other mechanisms of support (23%). The proportion of postdocs funded through research grants was higher among those who were supported by federal funding (81%).[29] In 2021, the federal government funded 51% of S&E postdocs (down from around 60% in 2009) (NCSES ***GSS 2009***: **Table 70**; ***GSS 2021***: **Table 3-2**). The federal government funded 40% or more of postdocs in all fields except civil, environmental, transportation, and related engineering (38%); industrial, manufacturing, systems engineering, and operations research (32%); mathematics and statistics (30%); and social sciences (21%). In 2021, institutions funded between 17% and 32% of all postdocs in most fields other than mathematics and statistics (49%); social sciences (47%); and industrial, manufacturing, systems engineering, and operations research (41%).[30] Other nonfederal domestic sources funded 15% of postdocs, and foreign sources funded around 2%.

Almost all U.S. academic postdoctoral appointments were located at very high research doctoral universities (83%), high research doctoral universities (5%), and medical schools and centers (10%) (NCSES ***GSS 2021***: **Table 5-3**). Just over half of postdocs (53%) were located at public institutions (NCSES ***GSS 2021***: **Table 5-1**). Postdoctoral appointments were concentrated in the biological and biomedical sciences and in health sciences in 2021 (60% in these two fields combined in 2021; NCSES ***GSS 2021:*** **Table 3-2** and **Table 5-1**).[31] Physical sciences (11%) and engineering (13%) constituted most of the remainder.

Financial Support for S&E Graduate Students and Postdocs, by Source

Federal Support

Federal agencies support S&E graduate students and postdocs in different numbers and proportions because of practices within the disciplines supported by those agencies. For example, in 2021, NIH supported 59% of all postdocs in academic R&D (NCSES ***GSS 2021***: **Table 3-4**). Much of the NIH spending on academic R&D was concentrated in the biological and biomedical sciences, the field with the largest share of postdocs (32% in 2021) (NCSES ***GSS 2021***: **Table 4-1**). NSF, which distributes its academic R&D funding across a broad range of fields, supported a larger share of graduate students (26% of all S&E graduate students) than postdocs (12% of all postdocs) in 2021 (NCSES ***GSS 2021***: **Table 3-3** and **Table 3-4**).

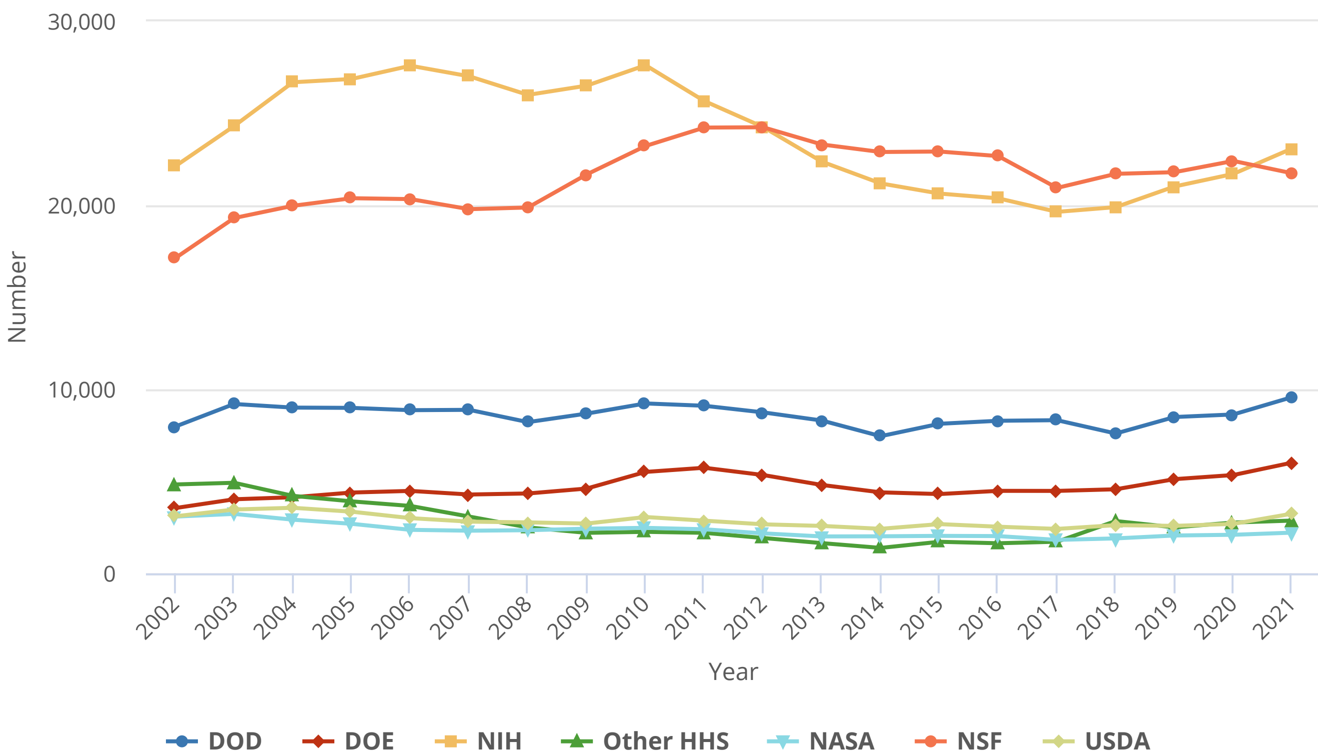
Graduate Students

The federal government supported around 15% of full-time S&E graduate students (82,588 of 543,823) in 2021 (NCSES ***GSS 2021***: **Table 1-6**), down from 21% (83,816 of 402,573) in 2004. The proportion of doctoral students supported by the federal government (26%) was higher than the proportion of the master's students supported (5%).[32] Put another way, in 2021, 82% of S&E graduate students supported by the federal government were doctoral students (NCSES ***GSS 2021***: **Table 1-6**). In all S&E fields, the federal government supported a higher percentage of doctoral students than master's students (NCSES ***GSS 2021***: **Table 3-1**).

NSF (21,743) and NIH (23,088) supported the most graduate students in 2021. Together, these two agencies supported 54% of federally supported graduate students (NCSES ***GSS 2021***: **Table 1-7** and **Table 3-3**). Other agencies supporting significant numbers of S&E graduate students in 2021 were DOD (9,575), the Department of Energy (DOE) (6,016), and USDA (3,244); other agencies were HHS (excluding NIH) (2,866) and the National Aeronautics and Space Administration (NASA) (2,211) (Figure URD-23). RAs were the primary mechanism that the federal government used to fund graduate students. Among full-time S&E graduate students primarily funded by the federal government in 2021, 69% received RAs, followed by fellowships (13%) and traineeships (7%).[33]

Figure URD-23

Full-time graduate students in S&E primarily supported by the federal government, by agency: 2002–21



DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services, excluding NIH; NASA = National Aeronautics and Space Administration; NIH = National Institutes of Health; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s):
In this figure, 2007 data represent data as collected in 2007. In 2014, the survey frame was updated after a comprehensive frame evaluation study. The study identified potentially eligible but not previously surveyed academic institutions in the United States with master's- or doctorate-granting programs in science, engineering, or health. A total of 151 newly eligible institutions were added, and 2 private for-profit institutions offering mostly practitioner-based graduate degrees were determined to be ineligible. In 2017, enrollment and financial support data were collected separately for master's and doctoral students. The list of disciplinary fields eligible for the Survey of Graduate Students and Postdoctorates in Science and Engineering was updated to align with the National Center for Science and Engineering Statistics Taxonomy of Disciplines. Two institutions became newly eligible, and 13 became ineligible. This figure excludes other federal agencies. S&E includes health fields.

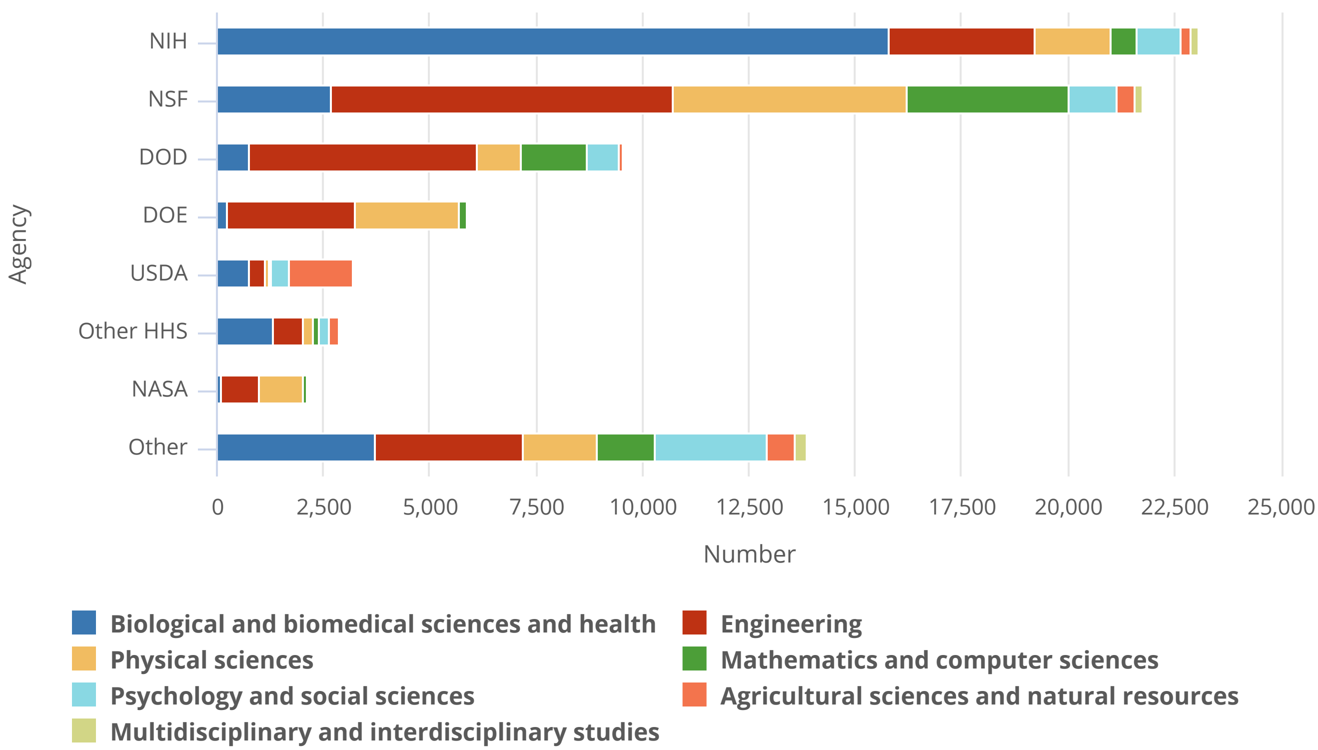
Source(s):
National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

Science and Engineering Indicators

The largest numbers of federally supported S&E graduate students were in engineering (25,302), biological and biomedical sciences (20,832), and physical sciences (11,216). Together, these fields contained around 45% of total S&E graduate students but 69% of federally supported students (NCSES ***GSS 2021***: **Table 3-1**). NSF supported substantial numbers of full-time graduate students across different fields, whereas over 68% of those supported by NIH were in biological and biomedical sciences and health. Of the full-time graduate students funded by DOD, 56% studied engineering, and more than 90% funded by DOE were in physical sciences and engineering (Figure URD-24).

Figure URD-24

Full-time graduate students in S&E primarily supported by the federal government, by degree field and agency: 2021



DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services, excluding NIH; NASA = National Aeronautics and Space Administration; NIH = National Institutes of Health; NSF = National Science Foundation; USDA = Department of Agriculture.

Note(s):
S&E includes health fields. Physical sciences include geosciences, atmospheric sciences, and ocean sciences. Agricultural sciences include veterinary sciences. Natural resources include conservation. Mathematics includes statistics, and computer science includes information sciences.

Source(s):
National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

Science and Engineering Indicators

Postdocs

The federal government supported more than half (51%, or 32,429) of S&E postdocs in 2021 (NCSES ***GSS 2021***: **Table 3-2**). Research grants and contracts continue to be the primary mechanisms the federal government uses to fund postdocs. Among postdocs primarily funded by the federal government in 2021, 81% were funded by research grants, followed by traineeships (8%) and fellowships (7%), with the remainder funded by other mechanisms.[34] The largest numbers of federally supported postdocs were in biological and biomedical sciences (11,372), clinical medicine (7,529), and engineering (4,235). These fields contained around 70% of total postdocs and around the same proportion of those funded by the federal government (NCSES ***GSS 2021***: **Table 3-2**).

NIH supported the most postdocs of any federal agency (19,079) in 2021 (NCSES ***GSS 2021***: **Table 3-4**). Other agencies supporting considerable numbers of postdocs included NSF (3,820), DOD (2,344), and DOE (2,228). In total, these four agencies accounted for 85% of federally supported postdocs. Federal agencies funded postdocs across fields in a manner consistent with their missions (NCSES ***GSS 2021***: **Table 3-4**). NSF supported postdocs across numerous fields. The majority (80%) of postdocs supported by NIH were in biological and biomedical sciences or in clinical medicine. DOD funded postdocs primarily in engineering (40%) and physical sciences (17%), as did DOE (32% in engineering, 49% in physical sciences).

Institutional Support

Graduate Students

In 2021, institutions supported 39% of full-time S&E graduate students (212,869), more than any other source except self-support (NCSES ***GSS 2021***: **Table 3-1**).[35] Institutions supported 22% of master's students (63,468) and 58% of doctoral students (149,401). Thus, around 70% of S&E graduate students supported by institutions were doctoral students. Institutions mainly used TAs to support graduate students; 38% of institutionally funded graduate students in 2021 had TAs. RAs (25%) and fellowships (17%) accounted for most of the rest.[36]

The largest numbers of institutionally supported full-time graduate students were in engineering (44,890), biological and biomedical sciences (36,255), and social sciences (31,570). Across all fields and levels, institutions supported more students than the federal government did. For full-time S&E doctoral students, institutions supported higher numbers than any other source across fields (NCSES ***GSS 2021***: **Table 3-1**). The percentage of full-time doctoral students supported by institutions varied from just under half for engineering to 80% for mathematics and statistics.

Postdocs

Institutions funded 22% of academic postdocs (13,633) in 2021 (NCSES ***GSS 2021***: **Table 3-2**). The largest numbers of institutionally funded postdocs were in biological and biomedical sciences (3,408), clinical medicine (3,210), and engineering (1,923). In all broad fields except mathematics and statistics and social sciences, fewer postdocs received institutional support than federal support. In 2021, 37% of postdocs supported by institutions were funded from research grants, 13% were funded from fellowships, and 50% received support from traineeships and other sources.[37]

Nonfederal Domestic Support

Various nonfederal domestic sources, including businesses and nonprofits, supported around 4% of S&E graduate students in 2021, including about 2% of master's students (4,908) and 6% of doctoral students (14,107) (NCSES ***GSS 2021***: **Table 3-1**). These sources supported the largest numbers of graduate students in engineering (6,841), biological and biomedical sciences (3,519), physical sciences (1,540), and computer and information sciences (1,510). The proportion of graduate students primarily supported by nonfederal domestic sources was largest in agricultural sciences (10%).

Nonfederal domestic sources supported 15% of total S&E postdocs (9,537) and between 10% and 21% of postdocs across fields (NCSES ***GSS 2021***: **Table 3-2**). These sources funded the most postdocs in biological and biomedical sciences (2,925), clinical medicine (2,507), and engineering (1,352).

Foreign Support

In 2021, no more than 1% of S&E graduate students were supported by foreign sources, including around 1,000 master's students (0.3%) and 2,580 doctoral students (1%). Foreign sources supported the most students in engineering (1,483) (NCSES ***GSS 2021***: **Table 3-1**). They also supported around 2% of academic postdocs (1,354). Most of these postdocs were in clinical medicine (420), biological and biomedical sciences (380), and engineering (262) (NCSES ***GSS 2021***: **Table 3-2**).

Conclusion

Higher education institutions are an essential component of the U.S. R&D system, performing almost half of U.S. basic research and training the next generation of scientists and engineers. The federal government, primarily through six agencies, provides more than half of academic R&D funding. Academic institutions themselves are the second largest contributor of funds spent on academic R&D. In recent years, the federal government share of academic R&D support for university-based R&D has declined, while the share of support from higher education institutions themselves increased. Most academic R&D is performed by the same small proportion of U.S. higher education institutions that award the majority of S&E doctoral degrees. Among S&E fields, life sciences and engineering continue to dominate academic R&D.

The United States ranked highest in overall higher education expenditures on R&D, but it ranked 23rd out of 32 countries or regions in academic R&D expenditure as a percentage of GDP.

Investments made by the federal government, academic institutions, and other funders in the education and training of graduate students and postdocs mirror their investments in academic R&D. Master's students are largely self-supporting, and doctoral students are primarily funded by academic institutions and the federal government through funding mechanisms such as fellowships, RAs, and TAs. The federal government funded over one-fifth of S&E postdocs, mainly through research grants. Institutions themselves funded around a quarter of postdocs. S&E postdoctoral appointments were concentrated in the biological and biomedical sciences and health sciences.

Glossary

Definitions

Net assignable square feet (NASF): Unit for measuring research space. NASF is the sum of all areas on all floors of a building assigned to, or available to be assigned to, an occupant for a specific use, such as research or instruction. NASF is measured from the inside face of walls.

Postdoctoral (postdoc) position: A temporary position primarily for gaining additional education and training in research, usually awarded in academia, industry, government, or a nonprofit organization.

Research and development (R&D): Research and experimental development comprise creative and systemic work undertaken to increase the stock of knowledge—including knowledge of humankind, culture, and society—and to devise new applications of available knowledge (OECD 2015).

> **Basic research:** Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.
>
> **Applied research:** Original investigation undertaken to acquire new knowledge; directed primarily toward a specific, practical aim or objective.
>
> **Experimental development:** Systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.

Research space: The budgeted and accounted-for space used for sponsored R&D activities at academic institutions. Research space is the net assignable square feet of space in buildings within which research activities take place. Research facilities are located within buildings. A building is a roofed structure for permanent or temporary shelter of people, animals, plants, materials, or equipment. Structures are included as research space if they are (1) attached to a foundation; (2) roofed; (3) serviced by a utility, exclusive of lighting; and (4) a source of significant maintenance and repair activities.

Underrepresented minorities: Races or ethnicities whose representation in science, technology, engineering, and mathematics employment and S&E education is smaller than their representation in the U.S. population. These include Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives.

Key to Acronyms and Abbreviations

DOD: Department of Defense

DOE: Department of Energy

EU-27: European Union

FTE: full-time equivalent

FY: fiscal year

GDP: gross domestic product

GSS: Survey of Graduate Students and Postdoctorates in Science and Engineering

HBCU: historically Black college or university

HERD: Higher Education Research and Development Survey

HHE: high-Hispanic-enrollment

HHS: Department of Health and Human Services

MSI: minority-serving institution

NASA: National Aeronautics and Space Administration

NASF: net assignable square feet

NCSES: National Center for Science and Engineering Statistics

NIH: National Institutes of Health

NSB: National Science Board

NSF: National Science Foundation

OECD: Organisation for Economic Co-operation and Development

RA: research assistantship

R&D: research and development

S&E: science and engineering

SDR: Survey of Doctorate Recipients

SED: Survey of Earned Doctorates

TA: teaching assistantship

TCU: tribal college or university

URM: underrepresented minority

USDA: Department of Agriculture

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Notes

1 In this report, S&E fields include agricultural sciences; biological and biomedical sciences; health sciences; physical sciences; geosciences, atmospheric sciences, and ocean sciences; mathematics and statistics; computer and information sciences; psychology; social sciences; and engineering.

2 Comparisons over more than 1 year are made in inflation-adjusted constant 2012 dollars using gross domestic product (GDP)-implicit price deflators based on the calendar year. GDP deflators come from the U.S. Bureau of Economic Analysis and are available at **https://www.bea.gov/national**, accessed September 2022. The totals presented from the HERD Survey differ from similar totals reported in NCSES's National Patterns of R&D Resources data and in the forthcoming *Indicators* 2024 report "[2024] Research and Development: U.S. Trends and International Comparisons." In the HERD Survey data, spending from pass-through funds (funding of subawards from one university to another) is reported as spending by the universities initially receiving the money and as spending by the universities to which the funds are passed. The other sources remove such pass-throughs to avoid double-counting, such that academic R&D expenditures reported in National Patterns in 2021 are about $84 billion in current dollars, compared with about $90 billion reported in the HERD Survey data (NCSES ***NP 2021***: **Table 2**; NCSES ***HERD 2021***: **Table 3**). For more details, see the Methodology notes for the National Patterns of R&D Resources data, available at **https://ncses.nsf.gov/pubs/nsf23321#technical-notes_methodology**. These other sources also present calendar year approximations based on fiscal year data, rather than the academic year data reported in the HERD Survey.

3 For definitions of R&D and these categories, see OECD (2015).

4 "In the March 2023 edition of the Main Science and Technology Indicators (MSTI), the OECD decided to put under review data for several R&D indicators for the People's Republic of China (hereafter 'China') for the period 2019 to 2021, suppressing the publication of several headline indicators until questions on the coherence of R&D expenditure and personnel data have been effectively addressed" (OECD 2023c:1).

5 In 2022, in response to Russia's invasion of Ukraine, OECD ended the collection of statistical data from Russia. Therefore, 2020 is the latest year with R&D spending reports for Russia. See "Box 1: Main coverage changes and major revisions to R&D data in the MSTI March 2023 edition" in OECD (2023b:3).

6 Unless otherwise noted, all of the data and indicators in this section are based on the NCSES HERD Survey of spending in 2021 that was published in 2022. For the HERD Survey, NSF asks institutions of higher education that spent at least $150,000 in annual R&D to report the amounts they spent for separately budgeted R&D activities as well as the sources of those funds. Financial data are in constant 2012 dollars and are reported for the respondents' most recent fiscal years.

7 Spending funded from "institutional sources" as reported in the HERD Survey includes institutionally financed research, cost sharing other than unrecovered indirect costs, and unrecovered indirect costs. Institutional sources do not include funding from general state appropriations spent on R&D (which are accounted as state and local government support) or philanthropic grants designated for research (accounted as support from nonprofit organizations). This amount does include funds spent from an institution's own affiliated foundation directed at research activities, encompassing start-up packages, bridge funding, and seed funding for faculty; competitively awarded internal research grants; other departmental grants designated for research; and tuition assistance for students working on organized research. Spending on research administration and similar support services is considered an indirect cost and therefore is reported as part of federal funding support.

8 The HERD Survey asks institutions for data on separately budgeted R&D expenditures, in part to avoid the conceptual and measurement challenges in compiling data on expenditures for research activities carried out as part of the ordinary expectations of faculty members. Separately budgeted R&D generally includes sponsored R&D, the costs of which are paid for by gifts, grants, and contracts, as well as institutions' own support of R&D through budgeted accounts set aside for that purpose.

9 The total number of degree-granting institutions is reported by the National Center for Education Statistics (see De Brey, Zhang, and Duffy [2022:Table 317.40]). The HERD Survey is distributed to two populations: institutions with more than $1 million in R&D expenditures per year and those with at least $150,000 but less than $1 million in R&D expenditures per year. The number of institutions in each population is found in NCSES (***HERD 2021***: **Table A-3**).

10 The Carnegie Classification of Institutions of Higher Education (**https://carnegieclassifications.acenet.edu/**) is widely used to characterize differences in academic institutions. The Basic Classification categorizes academic institutions primarily based on highest degree conferred, level of degree production, and research activity. This report identifies the 131 doctoral institutions with very high research activity based on the Carnegie Classification as of 2018, as reported in the 2018 Data File of Carnegie Classifications for each institution, accessed from the American Council on Education (**https://carnegieclassifications.acenet.edu/wp-content/uploads/2023/03/CCIHE2018-PublicDataFile.xlsx**). This categorization does not include some academic institutions that are top R&D performers but whose training programs are exclusively focused on a small number of fields (e.g., institutions focused exclusively on biomedical research and training). The relative share of academic R&D expenditures represented by these 131 institutions is calculated by summing the institutional responses reported in NCSES (***HERD 2021***: **Table 21**).

11 In this report, S&E fields include the health fields.

12 For the list of institutions qualifying as MSIs, by designation, see the NASA Minority Serving Institutions Exchange (**https://msiexchange.nasa.gov/institutions**).

13 The HERD Survey collects data from two populations. Institutions with at least $1 million in annual R&D spending respond to the standard-form HERD Survey, whereas those with at least $150,000 but less than $1 million in annual R&D spending respond to the short-form HERD Survey. The totals presented here include spending by HBCUs in the standard-form and short-form populations. Because of the $150,000 spending threshold, some HBCUs reported R&D spending for only a subset of the years from 2012 through 2021.

14 HHE institutions are defined by the U.S. Department of Education as nonprofit public and private institutions of higher education whose FTE enrollment of undergraduate students is at least 25% Hispanic, according to data that institutions reported in the Integrated Postsecondary Education Data System, conducted by the National Center for Education Statistics. For more detail on HHE institutions, see the *Indicators 2022* report "[2022] **Higher Education in Science and Engineering**."

15 The list of institutions currently designated as TCUs can be found on the NASA Minority Serving Institutions Exchange (**https://msiexchange.nasa.gov/institutions?i=75&qo[0]=is&qp[0]=categories__name&qv[0]=Tribal%20College%20or%20University**). Those reporting over $150,000 but less than $1 million in R&D expenditures (responding to the HERD Survey short form) can be identified from NCSES ***HERD 2021:*** **Table 82**. Those with R&D expenditures over $1 million in 2021 can be identified from NCSES ***HERD 2021***: **Table 5**.

16 For a contemporary view of the nature and importance of external research infrastructures, see National Science and Technology Council (2021) and the NSB statement in its *Vision 2030* report (NSB 2020).

17 Data releases and the accompanying InfoBriefs for the previous cycles of the Survey of Science and Engineering Research Facilities are available at **https://www.nsf.gov/statistics/srvyfacilities/**.

18 Data on human resources in academic R&D are drawn primarily from three sources: the NCSES Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS), the NCSES Survey of Earned Doctorates (SED), and the NCSES Survey of Doctorate Recipients (SDR).

19 Data on the academic workforce are drawn primarily from the NCSES SDR, which uses a sampling method to measure trends in doctorate holders in science, engineering, and health fields. In this report, these fields are noted collectively as S&E.

20 Data in this section on human resources are based on statistical samples of relevant populations, whereas the R&D spending data in previous sections are based on a census of the full population of relevant academic institutions.

21 Data are from a special tabulation of the 2021 SDR. For longer time trends, see **Figure LBR-18** in the *Indicators 2022* report "[2022] **The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers**."

22 For longer time trends, see the *Indicators 2022* report "[2022] **The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers**."

23 Fields shown in Figure URD-19 are those in which the differences observed were statistically significant.

24 The GSS is an annual census of all U.S. academic institutions granting research-based master's degrees or doctorates in science, engineering, and health fields as of the fall of the survey year. In this report, science, engineering, and health are noted collectively as S&E.

25 Comprehensive data are not available on the number of undergraduate students engaged in research or on the sources or amounts of financial support for those so involved.

26 Additional aspects of graduate study, including degrees by field and debt, are available in the *Indicators 2020* report "[2020] **Higher Education in Science and Engineering**." Likewise, other aspects of the postdoctoral labor force, including salaries and demographics, can be found in the *Indicators 2022* report "[2022] **The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers**."

27 In 2021, these were the most common funding mechanisms for S&E doctoral students: 40% received RAs, 24% TAs, 16% fellowships, 9% self-support, 4% traineeships, and 7% other types of support (NCSES ***GSS 2021***: **Table 3-5**). In 2021, large majorities (73% and above) of doctorate recipients in most S&E fields reported holding no debt related to their graduate education (**NCSES *SED 2021***: **Figure 17**). In social sciences, health sciences, and in non-S&E fields, the proportion of doctorate recipients with no debt ranged between 53% and 63%; in psychology, it was 48%.

28 This report discusses *sources* and *mechanisms* of graduate student funding. Funding sources include federal, institutional, and personal or self-support, among others. Personal sources include loans (including federal loans) or personal or family financial contributions. Funding mechanisms include assistantships, fellowships, and traineeships, among others.

29 Data are from a special tabulation of NCSES (***GSS 2021***).

30 The data tables from 2009 do not separate nonfederal sources of support for postdocs, so a comparison cannot be provided.

31 These calculations exclude appointments in natural resources and conservation and in multidisciplinary and interdisciplinary studies.

32 The GSS began to separate the data by level (master's or doctorate) in 2017.

33 Data are from a special tabulation of NCSES (***GSS 2021***).

34 Data are from a special tabulation of NCSES (***GSS 2021***).

35 For GSS, "institutional" support includes support from academic institutions and from state and local government.

36 Data are from a special tabulation of NCSES (***GSS 2021***).

37 Data are from a special tabulation of NCSES (***GSS 2021***).

Corrections

11 October 2023: In the "**Executive Summary**," the number of historically Black colleges and universities that reported R&D expenditures in the FY 2021 Higher Education Research and Development Survey was incorrectly listed as 57. The number has been corrected to 56.

Acknowledgments and Citation

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