R&D

Academic Research and Development

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This publication is part of the *Science and Engineering Indicators* suite of reports. *Indicators* is a congressionally mandated report on the state of the U.S. science and engineering enterprise. It is policy relevant and policy neutral. *Indicators* is prepared under the guidance of the National Science Board by the National Center for Science and Engineering Statistics, a federal statistical agency within the National Science Foundation. With the 2020 edition, *Indicators* is changing from a single report to a set of disaggregated and streamlined reports published on a rolling basis. Detailed data tables will continue to be available online.

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Executive Summary

Key takeaways:

- Academic institutions in the United States have long been responsible for performing about half of all U.S. basic research and about 10% to 15% of total U.S. research and development (R&D). In 2019, they performed $83.7 billion in R&D. Nearly two of every three academic R&D dollars supported basic research. Applied research and experimental development received smaller but growing shares.
- The federal government was the largest funder of academic R&D, providing more than half of total funds in 2019. Six departments or agencies provided more than 90% of federal support for academic R&D. Institutional funds have grown as a percentage of total funding: in 2019, they constituted more than a quarter of university R&D, up from less than a fifth in 2010.
- The very high research activity doctoral universities performed three-quarters of all academic R&D. These institutions also enrolled or employed more than 80% of science and engineering (S&E) doctoral students and postdocs.
- In 2018, out of 44 countries, the United States ranked highest in overall higher education expenditure on R&D but ranked 23rd in higher education R&D expenditure as a percentage of gross domestic product (GDP).
- Two fields—biological and biomedical sciences and engineering—have primarily driven the continual increases in academic S&E research space. These two fields accounted for 60% of total research space growth from 2007 to 2019. Research equipment expenditures have fluctuated over the last 15 years but stand at levels similar to those a decade ago.
- Salaries, wages, and fringe benefits made up the largest component of academic R&D direct costs (57% in 2019). Investments in the education and training of students and postdocs made by the federal government, academic institutions, and other funders related closely to their investments in academic R&D.

Academic institutions in the United States have a dual mission. They educate and train the next generation of citizens and workers and, at the same time, perform a significant portion of all U.S. basic research. The outputs of academic R&D (e.g., S&E professionals, scientific publications) differ from outputs produced by R&D in other sectors, like the business sector. Thus, academic institutions fill a unique niche in the U.S. S&E enterprise.

Most academic R&D is funded by a few sources. The federal government has long been the largest funder and provided more than half (53%, or around $45 billion) of total funds in 2019. Six agencies—the Department of Health and Human Services (HHS), the Department of Defense (DOD), the National Science Foundation (NSF), the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the Department of Agriculture (USDA)—provided more than 90% of federal support for academic R&D.

The increasing share of academic R&D funds from institutions themselves reflects both increased institutional contributions to R&D and improved measurement of those contributions over time. Additional academic R&D funders included nonprofit organizations, businesses (industry), and state and local governments.

U.S. academic R&D performance was concentrated in a small percentage of higher education institutions. Doctoral universities with very high research activity, as defined by the Carnegie classification, performed more than three-quarters of academic R&D. The concentration of R&D in a few institutions was greater among private universities than public universities.

Institutions with medical schools also performed a large amount of academic R&D, a function of the large proportion of academic R&D devoted to life sciences. The life sciences have long accounted for more than half of total academic R&D, with engineering second at around 16% in 2019. The federal government provided the majority of funding for academic R&D in all broad S&E fields except social sciences. The six main departments or agencies that sponsored academic R&D funded portfolios consistent with their missions. In almost all broad S&E fields, institutions themselves contributed half or more of nonfederal academic R&D.

When comparing nations, the United States in 2018 ranked highest of 44 countries in overall higher education expenditure on R&D. However, it ranked 23rd out of 44 in higher education expenditure as a percentage of GDP. The relative contributions of different sectors to higher education R&D differed greatly between countries.

Physical infrastructure underlies the ability of academic institutions to perform R&D. Academic institutions added 39 million net assignable square feet (NASF) of S&E research space between 2007 and 2019, led by the addition of 14 million NASF in biological and biomedical sciences. Research space in all S&E fields increased over the past decade, except for space devoted to computer and information science research, which declined slightly. Despite some fluctuations, 2019 research equipment expenditures at academic institutions, when compared in constant dollars, were at their highest levels in the past six years. In 2014, the federal share of funding for research equipment fell below 50% for the first time since data were initially collected in 1981 and remained below ever since.

Graduate students and postdocs are essential to U.S. academic R&D. Sources of financial support for S&E graduate students depended on level of study. Master's students largely supported themselves, whereas doctoral students were primarily funded by academic institutions and the federal government. Teaching assistantships (TAs) and fellowships were mainly institutionally funded, whereas nearly half of research assistantships (RAs) were funded through federal academic research grants. Patterns of support varied by field, type of institution attended, and students' demographic characteristics.

The federal government funded around half 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, with earth and physical sciences and engineering making up most of the remainder.

Introduction

This report provides an overview of R&D conducted by higher education institutions (also referred to as university or academic R&D in this report) in the United States. The report focuses mostly on S&E fields, defined in this report to include astronomy, chemistry, physics, atmospheric sciences, earth sciences, ocean sciences, mathematics and statistics, computer sciences, agricultural sciences, biological sciences, psychology, social sciences, and engineering. The report is divided into four main sections: financial resources, international comparisons, infrastructure, and education and training.

The financial resources section offers an overview of academic R&D funding and performance in the United States. It discusses sources of support for academic R&D: primarily the federal government, followed by academic institutions themselves, along with nonprofit organizations, businesses, and state and local governments. This section describes R&D performance across institutions with different characteristics (e.g., public and private, medical schools, minority-serving institutions). It also provides information on funding across S&E fields and discusses the costs associated with academic R&D.

The international comparisons section uses data from the Organisation for Economic Co-operation and Development (OECD) to compare higher education expenditures on R&D, both in absolute terms and as a proportion of gross domestic product (GDP). It also looks at differences between countries or economies in how different sectors fund these expenditures.

The infrastructure section provides information on research facilities at higher education institutions, including how much space is devoted to research in different S&E fields and trends in research space over time. It also looks at trends in funding for research equipment.

The education and training section provides information on sources and mechanisms of support for graduate students and postdocs. Sources include federal, institutional, and self-support, among others. Mechanisms include assistantships, fellowships, and traineeships, among others.

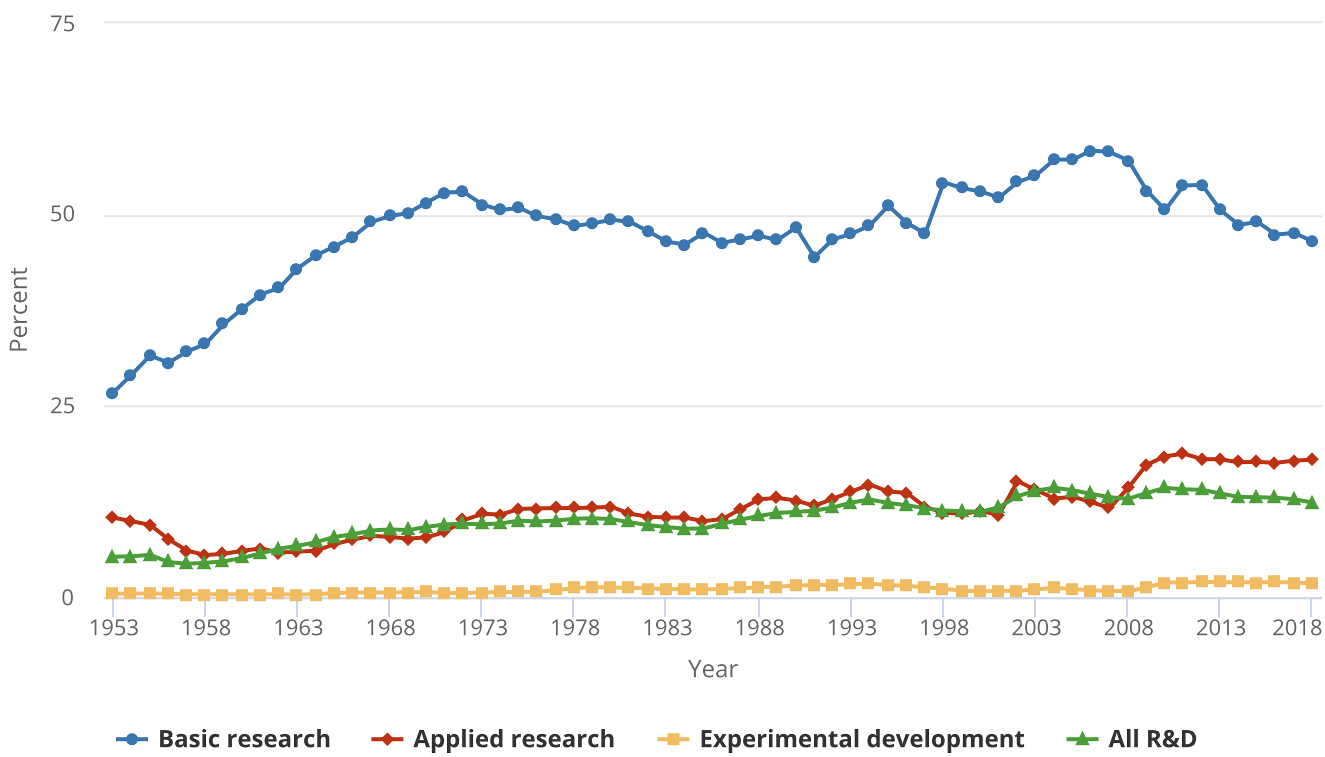
Additional context for the topics covered in this report is available in other *Indicators 2022* reports. See the forthcoming *Indicators 2022* report “Research and Development: U.S. Trends and International Comparisons” for discussion of the overall U.S. R&D system, for more context on how academic R&D fits within that system, and for additional international comparisons of R&D. Graduate students studying S&E will be discussed in the *Indicators 2022* report “Higher Education in Science and Engineering,” and the academic workforce is discussed in the *Indicators 2022* report “The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers.” Academic papers and journal articles, important products of academic R&D, are discussed in the report “Publications Output: U.S. Trends and International Comparisons,” and technology and other knowledge transfer activities are described in the report “Invention, Knowledge Transfer, and Innovation.”

Financial Resources for Academic R&D

R&D conducted by higher education institutions is a key component of the overall U.S. R&D system. In 2018, the higher education sector performed 12% ($74.9 billion) of the overall $606 billion in U.S. R&D, a proportion that has fluctuated within a narrow range for several decades (**Figure URD-1**; NCSES ***NP 2019***: **Table 2**; for more detail on research performance by other sectors, see the forthcoming *Indicators 2022* report "Research and Development: U.S. Trends and International Comparisons").[1] Although universities perform all types of R&D, they have long been the nation's largest performers of basic research (for definitions of basic research, applied research, and experimental development, see the **Glossary** section).[2] In 2018, they performed $47 billion in basic research, or 46% of the national total. After a period of increase beginning in the early 1990s, the proportion of U.S. basic research performed by the higher education sector declined over the last 10 years of available data.[3] Higher education institutions also performed about 18% ($20.9 billion) of all U.S. applied research and less than 2% ($7 billion) of all U.S. experimental development in 2018; these percentages have increased over the last 10 years.

Figure URD-1

Academic R&D as a percentage of U.S. R&D, by type of R&D: 1953–2018



Note(s):

The absolute numbers on which the percentages in this figure are based can be found in the original data source, linked to from the text. 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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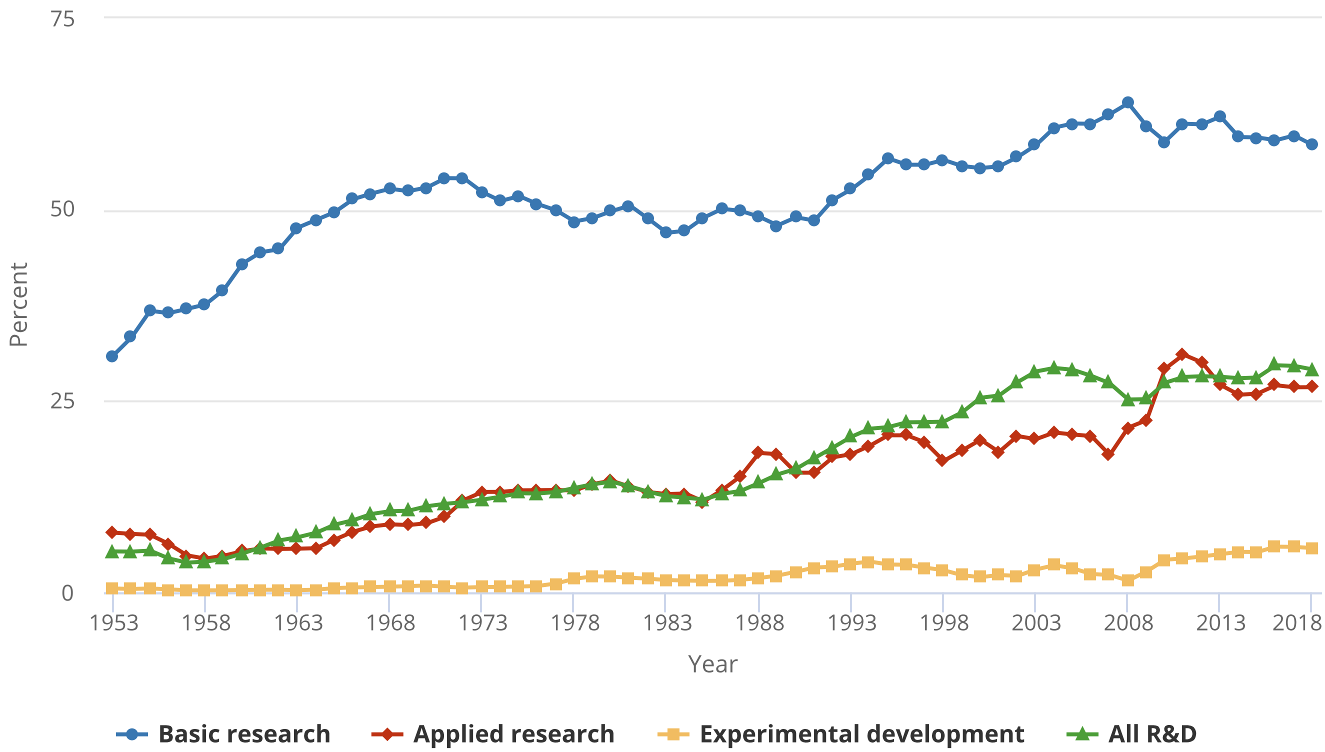
The federal government provided more R&D funding to higher education than to any other sector, including federal intramural R&D (NCSES ***NP 2019***: **Table 6**). In 2018, the higher education sector performed around 29% ($37.7 billion) of all federally funded R&D, a proportion that has generally increased over time (**Figure URD-2**; NCSES ***NP 2019***: **Table 6**). Academic institutions performed around 58% ($24.3 billion) of federally funded basic research, 27% ($10.7 billion) of federally funded applied research, and 6% ($2.8 billion) of federally funded experimental development. The share of federally funded basic research performed by universities has remained relatively flat for the last 10 years, while the shares of applied research and of experimental development have increased.

Figure URD-2

Federally funded academic R&D as a percentage of U.S. federally funded R&D, by type of R&D: 1953–2018



Note(s):

The absolute numbers on which the percentages in this figure are based can be found in the original data source, linked to from the text. 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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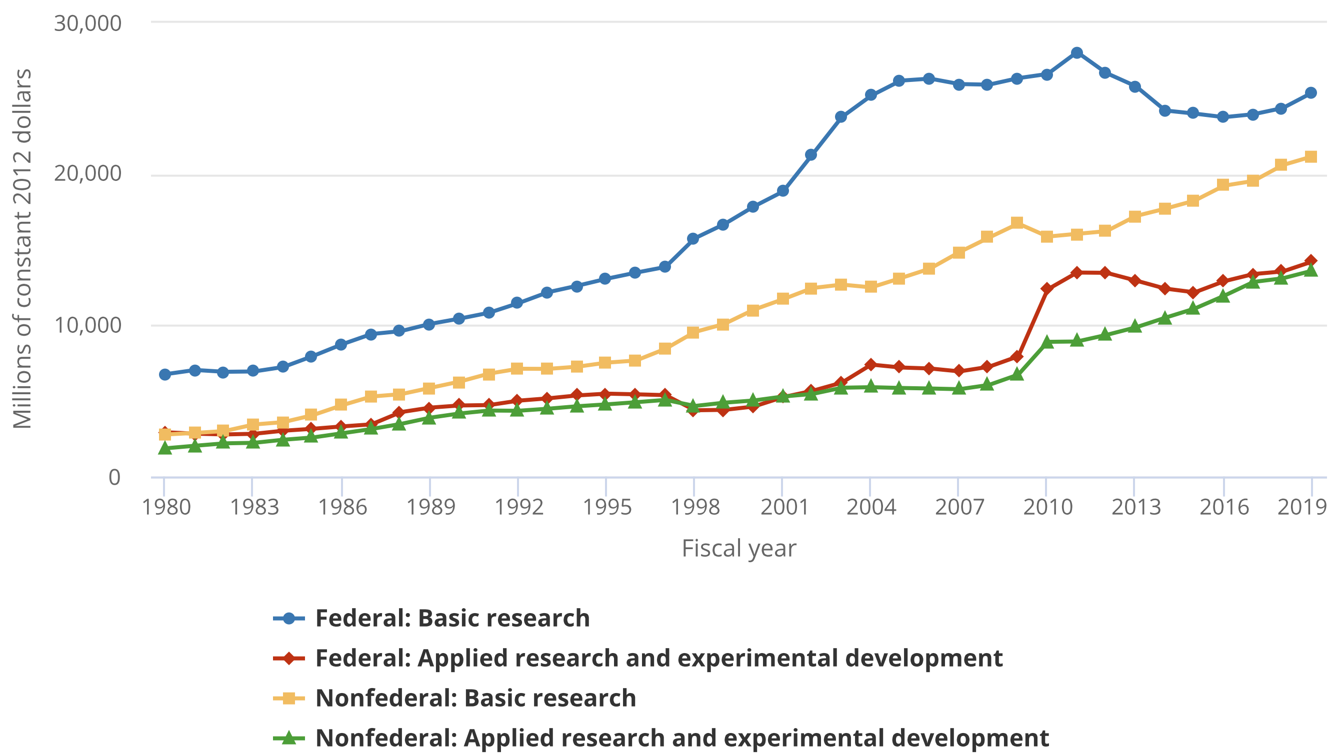
Type of R&D Performed by Academic Institutions

In 2019, academic institutions performed $83.7 billion in R&D (NCSES ***HERD 2019***: **Table 1**).[4] Nearly two-thirds (63% in 2019, or around $52 billion) of the R&D performed by academic institutions was basic research, a percentage that has declined slightly in recent years (NCSES ***HERD 2019***: **Table 7**). After a long period of increase from the 1980s through 2011, federal support for basic research at academic institutions declined over the last decade, although it has made up some of the loss since 2016 (**Figure URD-3**; note that the federal amounts in this figure from 2010 to 2014 include funds from the American Recovery and Reinvestment Act of 2009). Basic research support from nonfederal sources has increased steadily over time.

Figure URD-3

Federally funded and nonfederally funded higher education R&D expenditures, by type of R&D: FY 1980–2019



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. For inflation adjustment, gross domestic product–implicit price deflators based on calendar year were used. Gross domestic product deflators come from the U.S. Bureau of Economic Analysis and are available at https://www.bea.gov/national (accessed August 2020). Federal figures 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.

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

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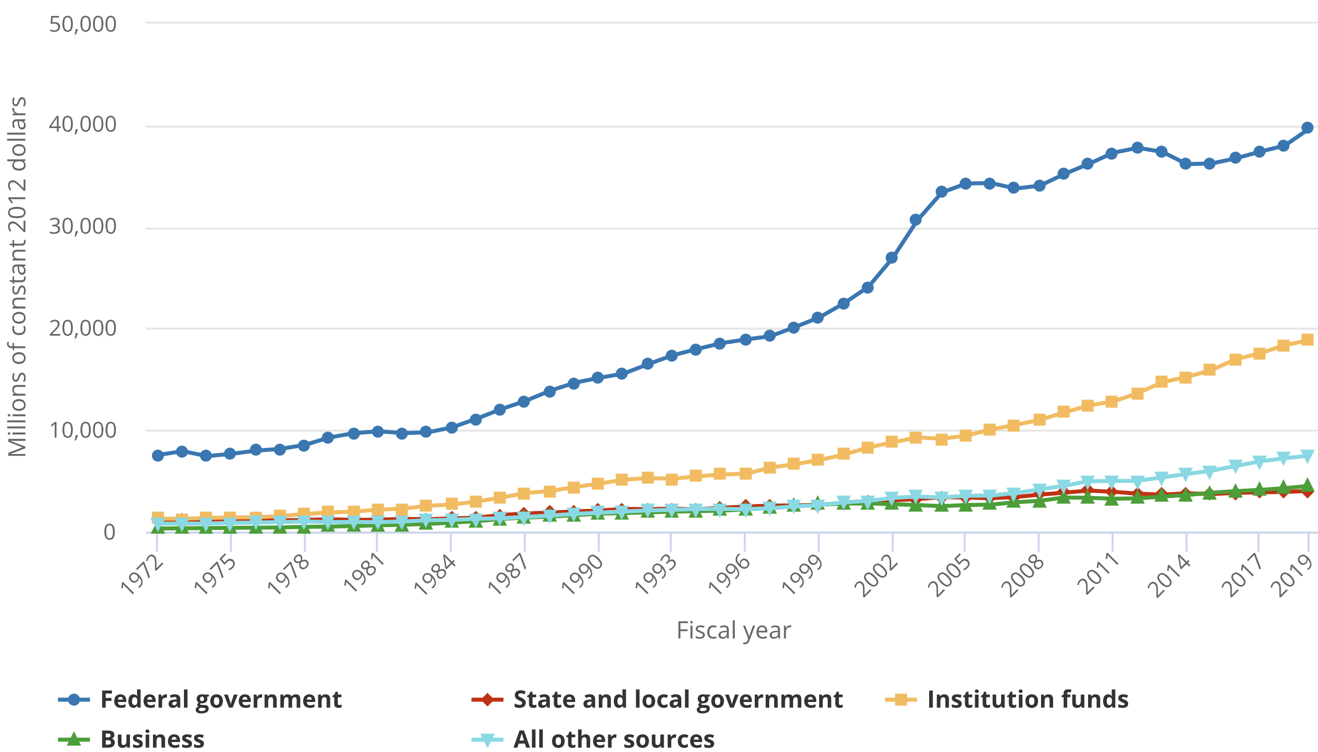
Around a quarter of university R&D ($23.5 billion) was applied research and around a tenth ($7.7 billion) was experimental development (NCSES ***HERD 2019***: **Table 8**). As percentages of overall academic R&D, applied research and experimental development have increased slightly since 2010.[5] Both federal and nonfederal support for applied research and experimental development increased overall since 2010 (**Figure URD-3**).

Support for Academic R&D

Most academic R&D is funded by a few sources (**Figure URD-4** and **Figure URD-5**). The federal government is by far the largest funder of academic R&D, although its share of total academic R&D has declined over time. Academic institutions themselves are the second-largest funder, and their share of total academic R&D has grown. Nonprofit organizations and businesses contribute small but slowly growing shares, while the share from state and local governments has declined.

Figure URD-4

Higher education R&D expenditures, by source of funds: FY 1972–2019



Note(s):
FY 1978 data are estimated based on data collected from doctorate-granting institutions only. Totals for FY 1972–2002 represent R&D expenditures in S&E fields only. From FY 2003 through FY 2009, some institution totals for all R&D expenditures may be lower-bound estimates because the National Center for Science and Engineering Statistics did not attempt to estimate for nonresponse on non-S&E R&D expenditure items before FY 2010. Source of fund detail data do not sum to total for FY 2003–09 because data by source were collected for S&E fields only. Total non-S&E expenditures were collected in a separate item. For inflation adjustment, gross domestic product–implicit price deflators based on calendar year were used. Gross domestic product deflators come from the U.S. Bureau of Economic Analysis and are available at https://www.bea.gov/national (accessed August 2020). Federal figures do not 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. In this figure, the All other sources category includes nonprofits.

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

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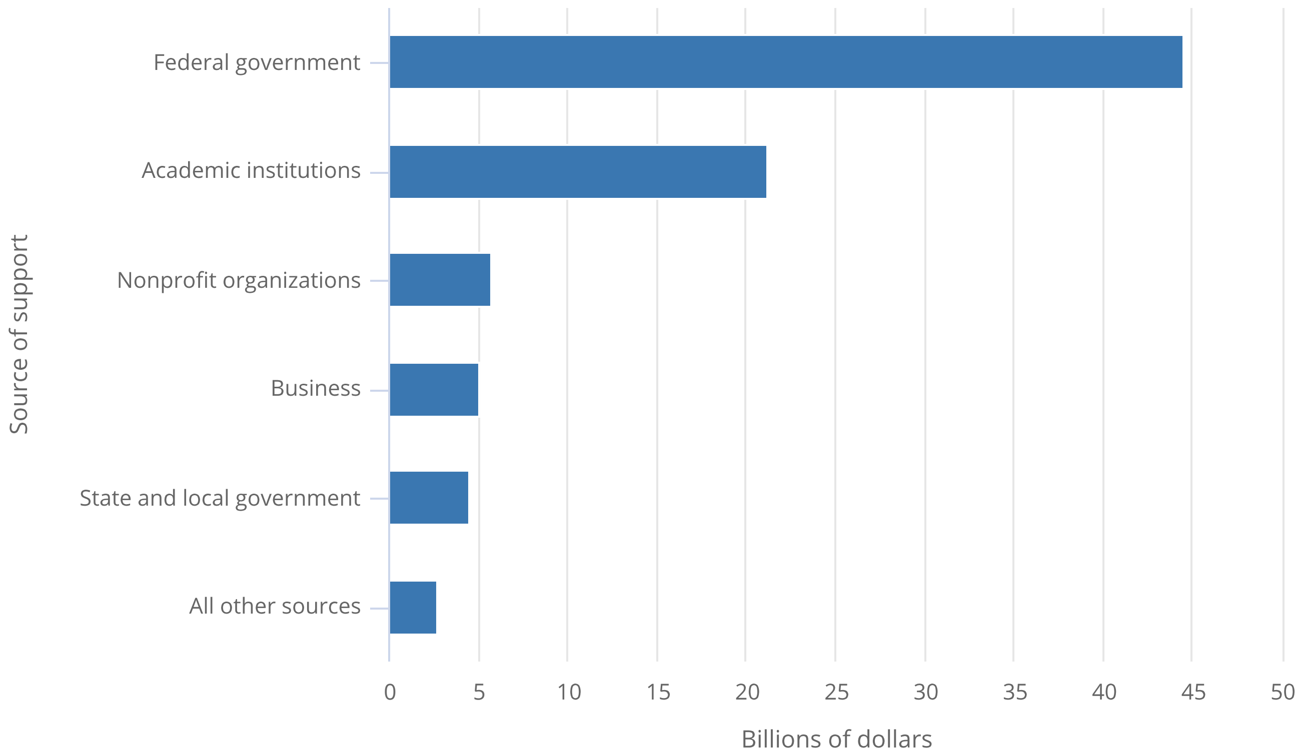
Figure URD-5

Academic R&D expenditures, by source of support: FY 2019



Note(s):
Numbers may not add to totals in other figures because of rounding.

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

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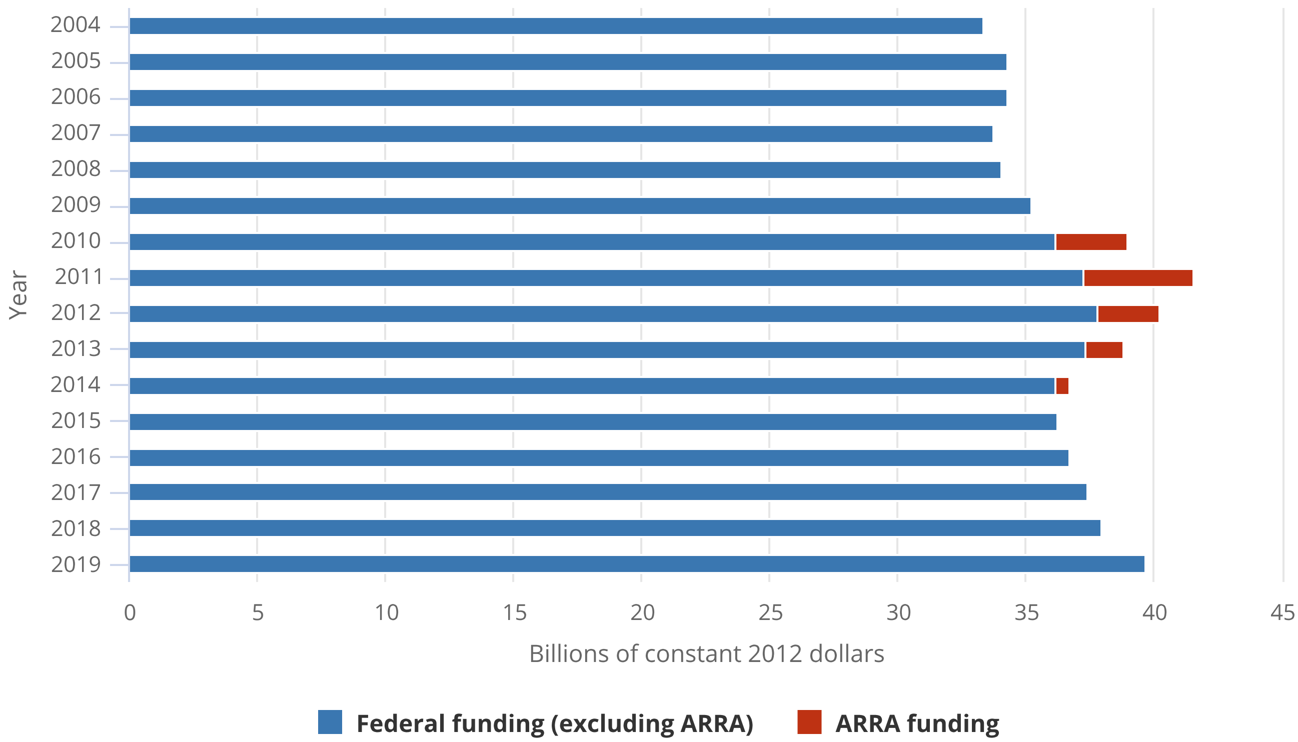
Federal Support

The federal government is the largest funder of academic R&D and provided more than half (53%, or around $45 billion) of total funds in 2019 (**Figure URD-5**). When adjusted for inflation, federal funding for higher education R&D increased by 4.4% between 2018 and 2019 (**Figure URD-6**; NCSES ***HERD 2019***: **Table 1**). After several years of declining funding levels during a period of global recession, federal funding for academic R&D increased by 9.5% between 2015 and 2019.

Figure URD-6

Federal funding for academic R&D expenditures: 2004–19



ARRA = American Recovery and Reinvestment Act of 2009.

Note(s):
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. For inflation adjustment, gross domestic product implicit–price deflators based on calendar year were used. Gross domestic product deflators come from the U.S. Bureau of Economic Analysis and are available at https://www.bea.gov/national (accessed August 2020).

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

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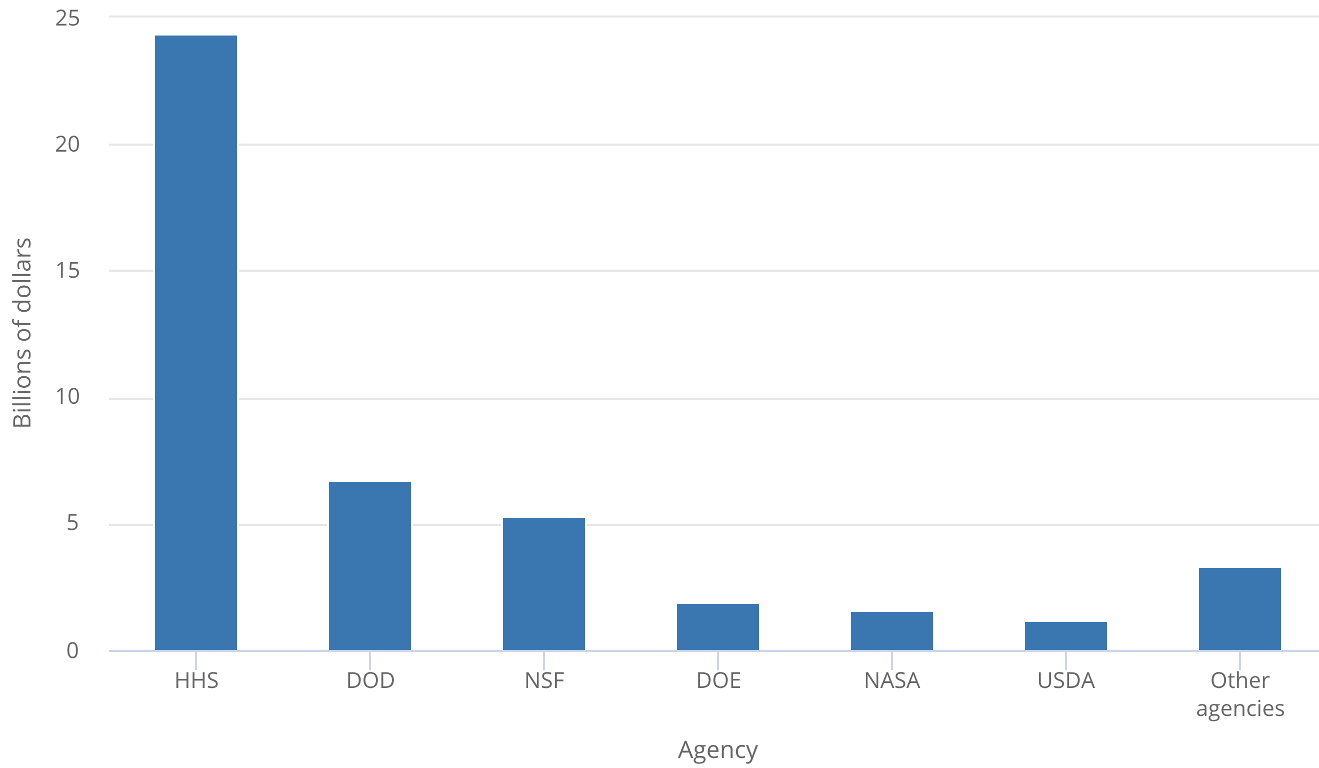
In the federal government, six agencies provided more than 90% of support for academic R&D (**Figure URD-7**; NCSES ***HERD 2019***: **Table 13**). The Department of Health and Human Services (HHS), largely through the National Institutes of Health (NIH), is by far the largest, providing more than half (55%, or $24.4 billion) of federal support in 2019. The Department of Defense (DOD) (15%, or $6.7 billion) and the National Science Foundation (NSF) (12%, or $5.3 billion) are next, followed by the Department of Energy (DOE) (4%, or $1.9 billion), the National Aeronautics and Space Administration (NASA) (4%, or $1.6 billion), and the Department of Agriculture (USDA) (3%, or $1.2 billion).[6] The percentage of total federal academic R&D funding provided by each of these agencies has changed little over the last 10 years.

Figure URD-7

Federally financed academic R&D expenditures, by agency: FY 2019



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 (HERD).

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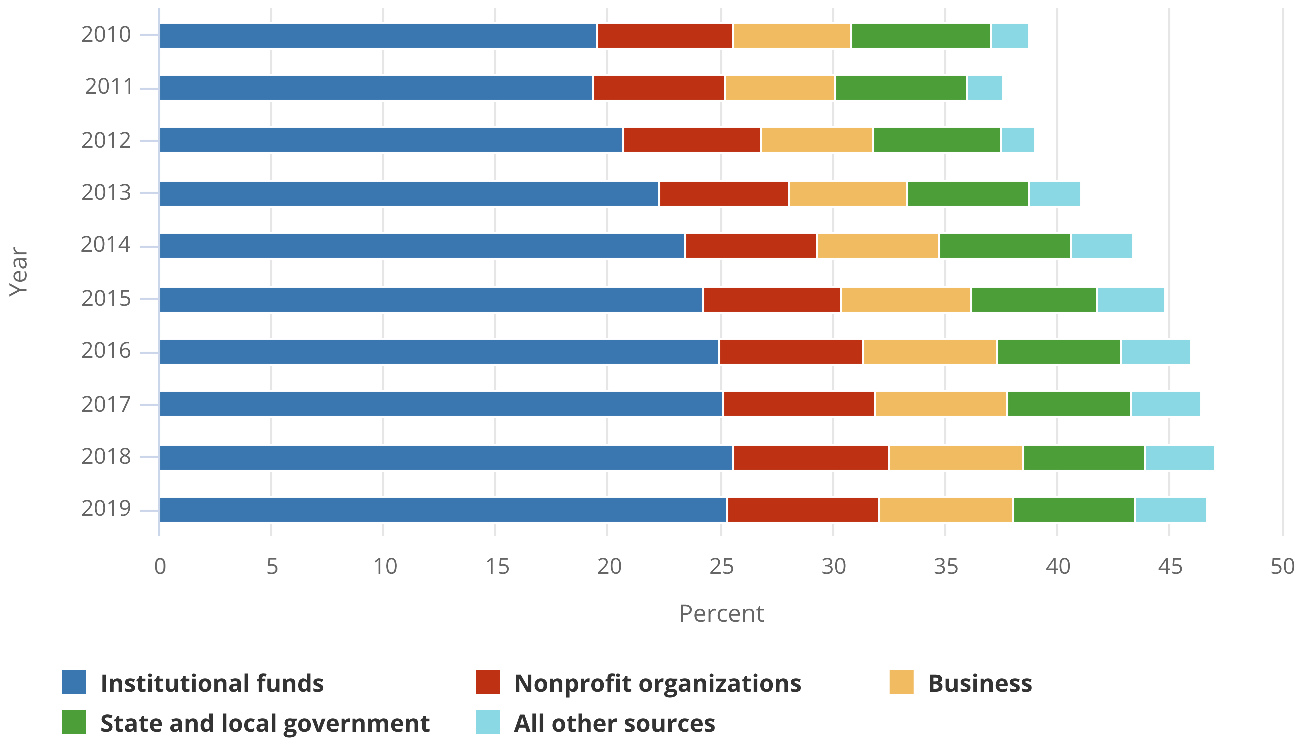
Institutional Support

Institutional support, which is funding provided by academic institutions themselves, has represented an increasingly larger share of total academic R&D over time, although its share has changed little since 2016 (**Figure URD-8**: see NCSES ***HERD 2019***: **Table 2**). Institutions provided more than $21 billion of academic R&D funding in 2019 (**Figure URD-5**), and institutional funds constituted a quarter of university R&D, up from a fifth in 2010. When adjusted for inflation, institutional funding for higher education R&D increased by more than 50% between 2010 and 2019. The increase over this period, while faster than in the past, continues a longer-term trend of a rising share of institutional funding; for comparison, institutions contributed 11%–12% of academic R&D funds in the early to mid-1970s. Precise accounting of institutionally financed R&D is difficult, and the trends described here represent increased institutional contributions to R&D as well as improved measurement of those contributions over time.[7]

Figure URD-8

Nonfederal funding sources as a percentage of total academic R&D expenditures: 2010–19



Note(s):
Percentages are based on total academic R&D expenditures as reported in the Higher Education Research and Development Survey, which for 2010–14 include funds from the American Recovery and Reinvestment Act of 2009.

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

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Institutionally funded R&D expenditures include three main components: direct funding for R&D, cost sharing, and unrecovered indirect costs.[8] Each has increased consistently since 2011, with the largest increase in direct funding for R&D (NCSES ***HERD 2019***: **Table 2**; also see Gibbons 2019: **Figure 2** for details of this trend). These institutional investments may cover many types of costs, including, for example, startup packages for new faculty (see AAMC 2015).

Institutionally financed research includes organized research projects fully supported with internal funding and all other separately accounted-for institutional funds for research. It does not include funds spent on research that are not separately accounted for, such as estimates of faculty time budgeted for instruction that is spent on research. Funds for institutionally financed R&D may derive from sources including general-purpose state or local government appropriations; general-purpose awards from industry, foundations, or other outside sources; endowment income; and gifts. Universities may also use income from patents and licenses or revenue from patient care to support R&D. For more on the topic of institutional funding sources, see Council on Governmental Relations (2019).

Other Sources of Support

Nonprofit Organizations

Nonprofit organizations provided $5.7 billion (about 7%) of academic R&D funding in 2019 (**Figure URD-5**). When adjusted for inflation, nonprofit funding for higher education R&D increased by about 31% between 2010 and 2019, representing a big rise from a small base (NCSES ***HERD 2019***: **Table 2**).

Businesses (Industry)

Businesses provided $5.1 billion (around 6%) of academic R&D funding in 2019 (**Figure URD-5**). When adjusted for inflation, business funding for higher education R&D increased by about 35% between 2010 and 2019.

State and Local Governments

State and local governments provided $4.5 billion (around 5%) of academic R&D funding in 2019 (**Figure URD-5**). When adjusted for inflation, state and local government funding for higher education R&D in 2019 was within 1% of its level in 2010.

Other Sources

In 2019, all other sources of support—such as foreign businesses, other universities, or gifts designated for research—collectively accounted for $2.7 billion (3%) of academic R&D funding (**Figure URD-5**). About half ($1.3 billion) of these funds come from foreign sources. More detail on funding from foreign sources is available in NCSES ***HERD 2019***: **Table 14**.

Performance of Academic R&D

Most academic R&D is performed by a small percentage of U.S. higher education institutions. Out of approximately 4,400 postsecondary degree-granting institutions in the United States (as reported in the forthcoming *Indicators 2022* report "Higher Education in Science and Engineering"), fewer than 1,000 reported R&D expenditures in 2019.[9] An even smaller number of universities, the doctoral universities with very high research activity, performed over three-quarters of all academic R&D. Public and private institutions showed different patterns of support, as did institutions with medical schools.[10] When universities perform R&D and spend research dollars, that spending has an immediate economic impact. Aggregated data from a subset of universities show that research dollars support a wide range of businesses, including minority- or woman-owned and small businesses, in different states and industries (IRIS 2021).

Academic R&D at Research Universities

Academic R&D and doctoral training often occur at the same higher education institutions. The 131 doctoral universities with very high research activity, based on the Carnegie classification, performed 78% ($65.6 billion) of all U.S. academic R&D in 2019.[11] These institutions also awarded around three-quarters of U.S. S&E doctoral degrees in 2019 (NCSES ***SED 2019***: **Table 11**: see also the forthcoming *Indicators 2022* report "Higher Education in Science and Engineering") and enrolled more than 80% of S&E doctoral students (NCSES ***GSS 2019***: **Table 5-3**).

Even within this group of research-intensive universities, R&D activity was concentrated in relatively few institutions: the top 25 R&D performers among the very high research activity doctoral universities were responsible for nearly half ($30.3 billion, or 46%) of total R&D performed by this group of institutions and more than one-third of total academic R&D. The concentration of most R&D activity in a small number of institutions is a long-standing trend (see ***Indicators 2018***: **Figure 5-5** for illustration).

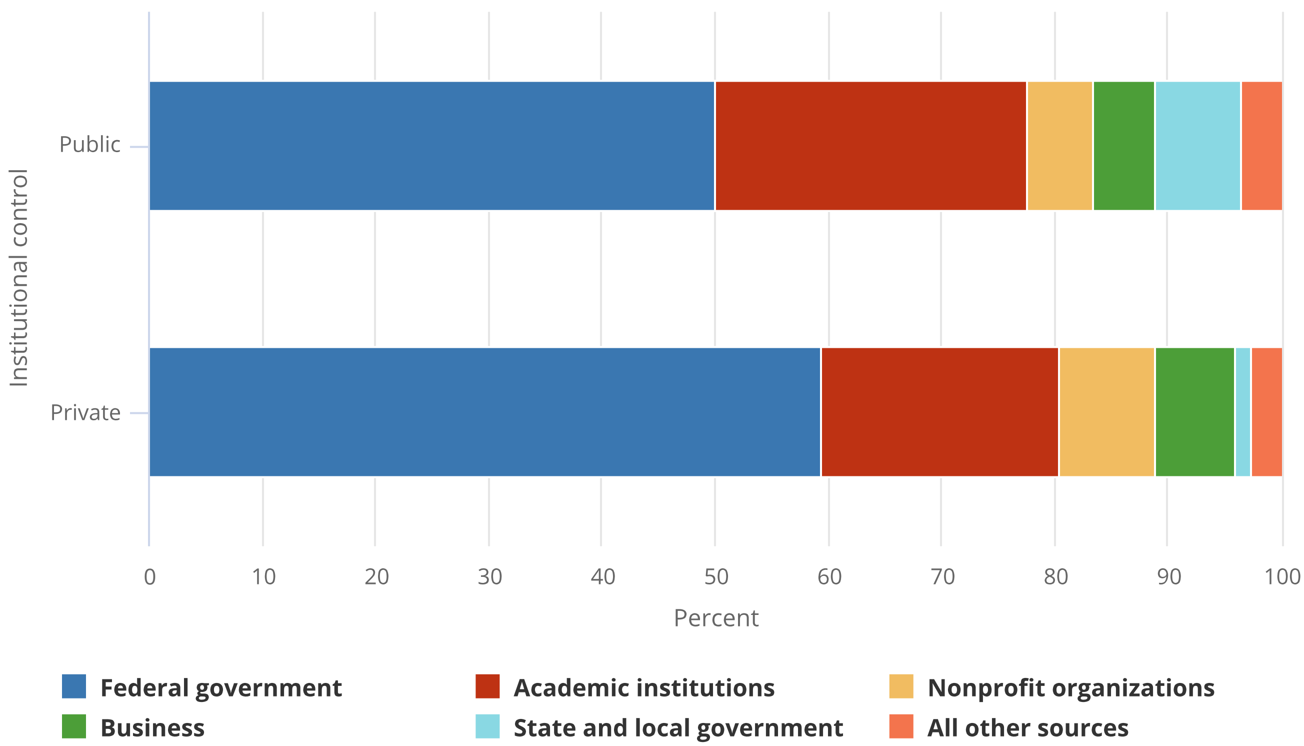
Academic R&D at Public and Private Institutions

Although only about a third of doctoral-granting institutions are public universities (***Indicators 2020*: Table 2-1**), they performed two-thirds ($54.6 billion) of academic R&D in 2019 (NCSES ***HERD 2019*: Table 69**). Additionally, more public universities than private universities reported R&D expenditures.[12] The top 25 public universities performed $25.1 billion in R&D, around 46% of the public university total (NCSES ***HERD 2019*: Table 36**). The concentration of R&D performance in a few institutions was greater in private universities: the top 25 performed $22.3 billion in R&D, more than three-quarters of the total performed by private universities (NCSES ***HERD 2019*: Table 37**).[13]

The relative shares of funding sources differed between public and private institutions (**Figure URD-9**: see also NCSES ***HERD 2019*: Table 69**). Private universities received a higher proportion of their academic R&D funding from the federal government (nearly 60%) compared with public universities (50%). Public universities derived a higher percentage from their own institutional funds and from state and local governments.

Figure URD-9

Academic R&D expenditures, by institutional control and source of support: FY 2019



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 (HERD).

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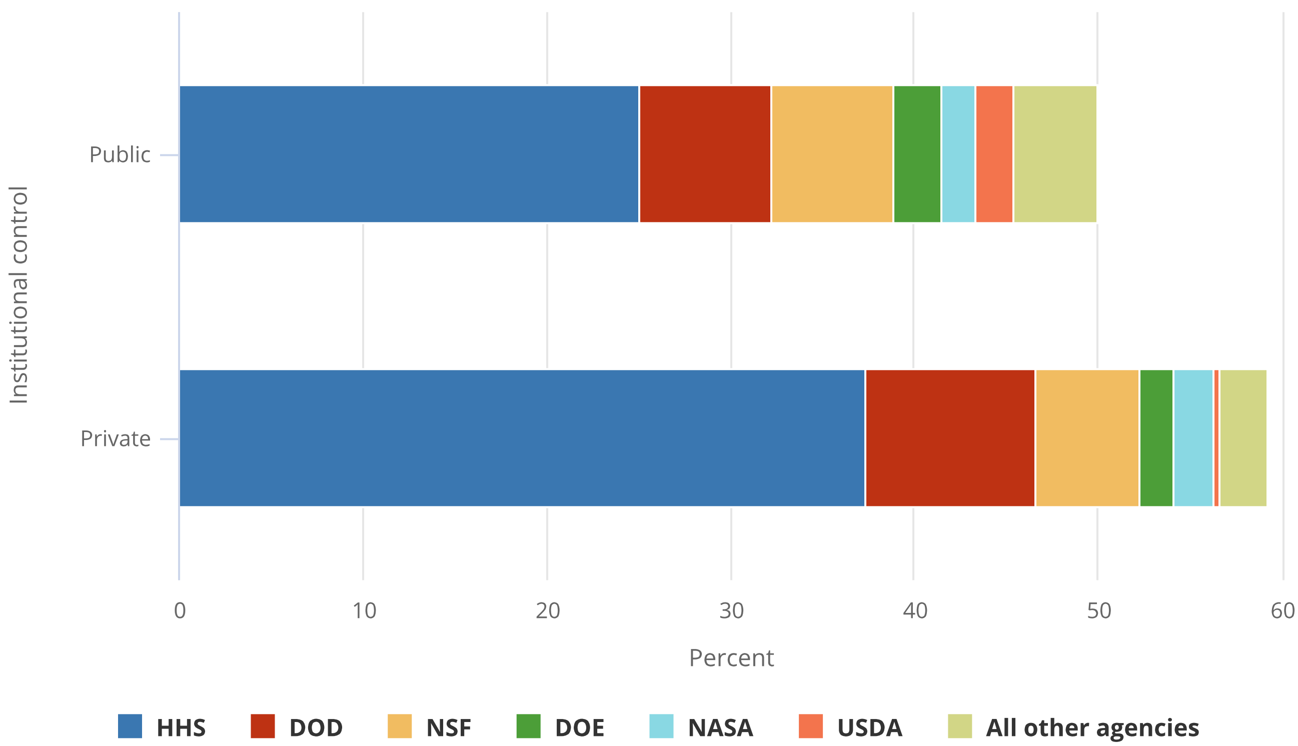
Public and private institutions also differed in the relative importance of particular federal agencies as funding sources (**Figure URD-10**: see also NCSES ***HERD 2019***: **Table 25**). For example, private universities derived more than a third of their R&D funding from HHS, compared with about a quarter for public universities. Although USDA provided a relatively small amount of academic R&D funding, public universities, primarily land-grant universities, derived a much higher proportion of funds from this agency.[14]

Figure URD-10

Federally financed academic R&D expenditures as a percentage of total academic R&D expenditures, by institutional control and agency: FY 2018



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 (HERD).

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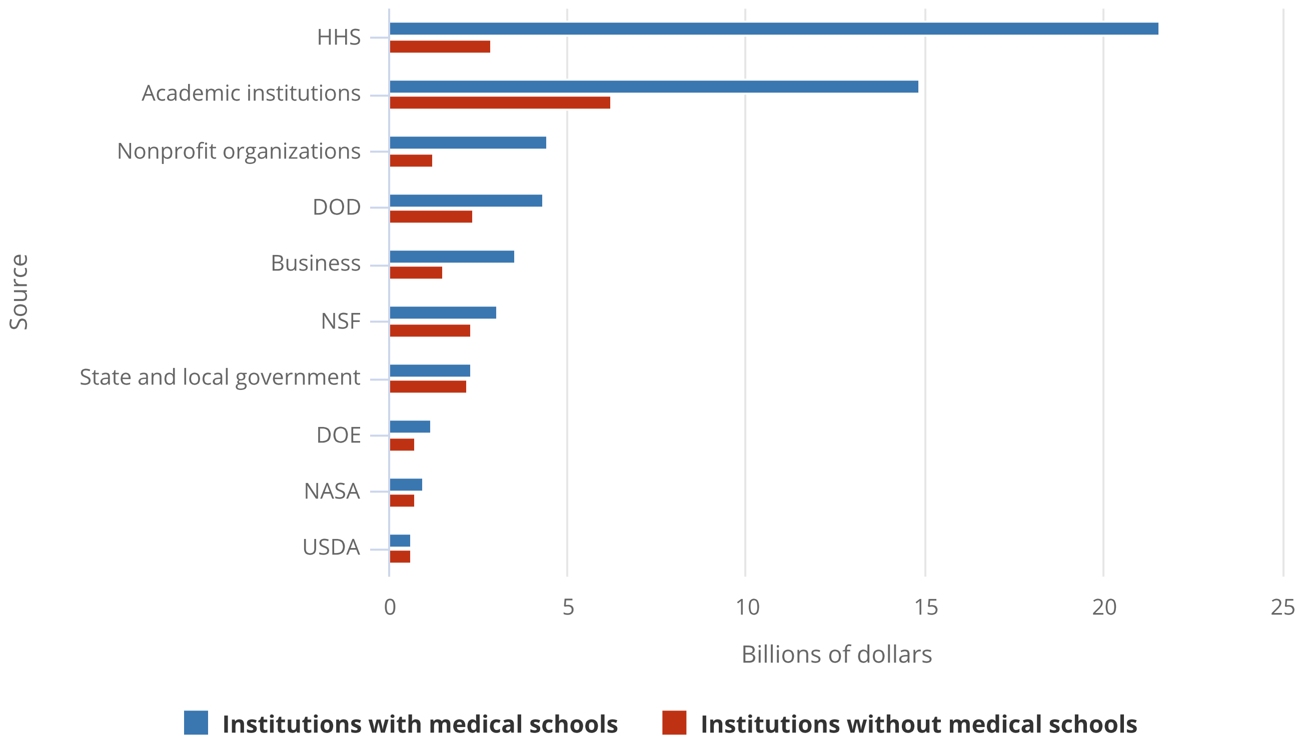
Academic R&D at Institutions with Medical Schools

In 2019, 159 institutions with medical schools reported R&D expenditures (NCSES ***HERD 2019***: **Table 18** and **Table 71**).[15] These institutions performed $60.6 billion of academic R&D, or 72% of total academic R&D. Roughly half of these expenditures ($30 billion) were associated with the medical schools themselves, whereas the other half were associated with other parts of these same institutions.

Institutions with medical schools received nearly $33.5 billion from the federal government (three-quarters of all federal funding for academic R&D), including $21.6 billion from HHS, or about 88% of the HHS total. The remainder of R&D funding for these institutions came from nonfederal sources and constituted more than two-thirds of nonfederal funding for academic R&D. Institutions with medical schools received more than half the funding from each federal agency except USDA and from each main type of nonfederal funding source (**Figure URD-11**).

Figure URD-11

Academic R&D expenditures at institutions with and without medical schools, by source of funding: FY 2019



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):
In FY 2019, HERD included 488 institutions without medical schools and 159 institutions with medical schools with expenditures over $1 million. This figure excludes other federal and nonfederal sources of funding.

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

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Academic R&D at Minority-Serving Institutions

As discussed in the forthcoming *Indicators 2022* report "Higher Education in Science and Engineering," minority-serving institutions (MSIs) include a diverse assemblage of more than 700 federally designated institutions of seven types (see also NASEM 2019). Historically Black colleges and universities (HBCUs) are one type of MSI defined by legislation. In 2019, the 49 HBCUs reporting expenditures in the NCSES Higher Education Research and Development (HERD) survey performed a total of around $500 million in academic R&D (NCSES ***HERD 2019***: **Table 31**).[16] The federal government provided around $370 million (about three-quarters) of this funding, a higher percentage than across institutions overall. The relative amounts of academic R&D performed across fields at HBCUs was very similar to that for all institutions (NCSES ***HERD 2019***: **Table 12** compared to **Table 32**).[17]

High-Hispanic-enrollment institutions (HHE) are defined by the percentage of enrolled Hispanic or Latino students.[18] In 2019, the 78 HHEs reporting expenditures in the HERD survey performed a total of around $6.4 billion in academic R&D (NCSES ***HERD 2019***: **Table 33**). The federal government provided around $1.8 billion (about 40%) of this funding, a lower percentage than across institutions overall. The relative amounts of academic R&D performed across fields at HHEs was also similar to that for all institutions (NCSES ***HERD 2019***: **Table 12** compared to **Table 34**).

Academic R&D, by Field

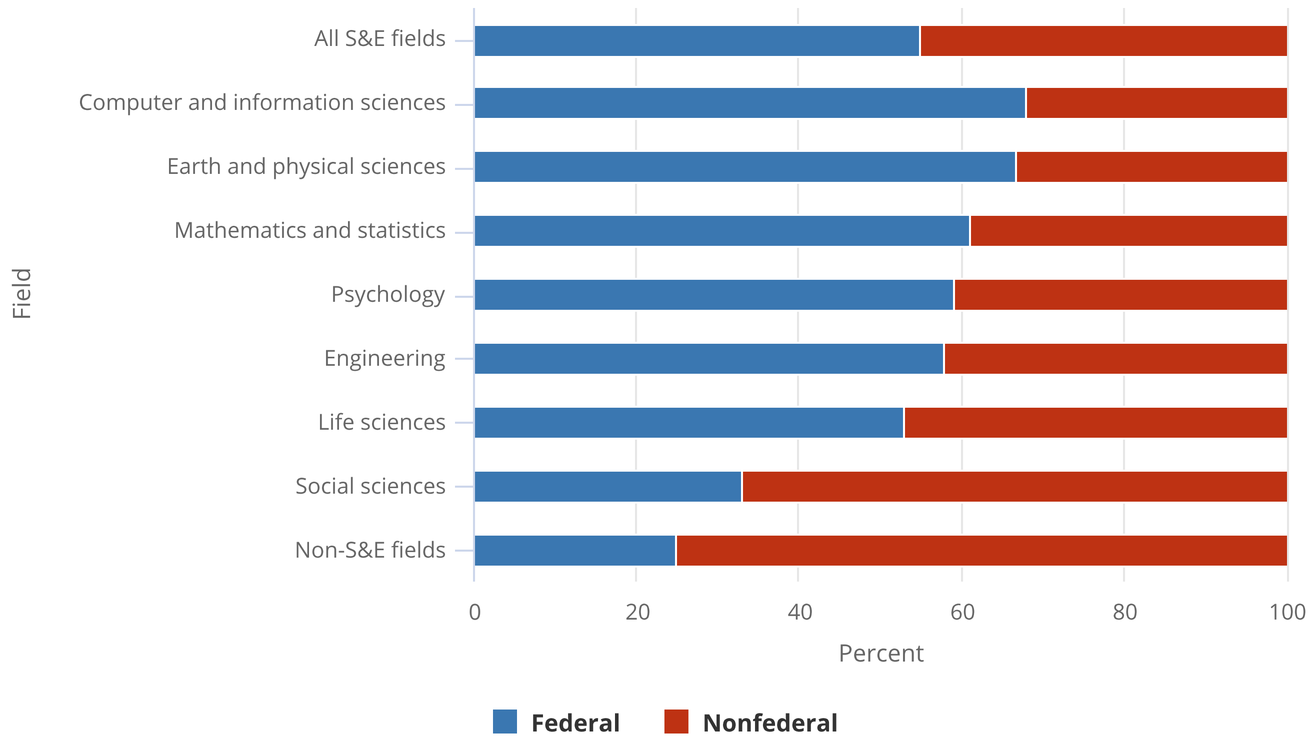
The relative amount of resources provided to different fields has changed little since 2010 (NCSES ***HERD 2019***: **Table 9**). The life sciences—primarily biological and biomedical sciences and health sciences—have long accounted for the bulk of academic R&D: $48.2 billion in 2019, more than half the total (58%). Life sciences plus engineering ($13.2 billion, or 16%) together constituted nearly three-quarters (74%) of academic R&D, with other fields each making up smaller shares of 7% or less. Consistent with the overall pattern, academic R&D funding across broad S&E fields (with the exception of the social sciences) came primarily from the federal government, with academic institutions themselves as the second-largest source (NCSES ***HERD 2019***: **Table 12**). In the federal government, each federal agency funded a portfolio across fields that is consistent with its mission.

Federal Support for Academic R&D, by Field

The percentage of total academic R&D funding provided by the federal government varied across broad S&E fields, from around a third for social sciences (33%) to nearly 70% for computer and information sciences in 2019 (**Figure URD-12**: see also NCSES ***HERD 2019***: **Table 12**).[19] Although life sciences received the most resources, funding for academic R&D in this field was split nearly evenly between federal government and nonfederal sources.

Figure URD-12

Federal and nonfederal support for academic R&D, by field: FY 2019



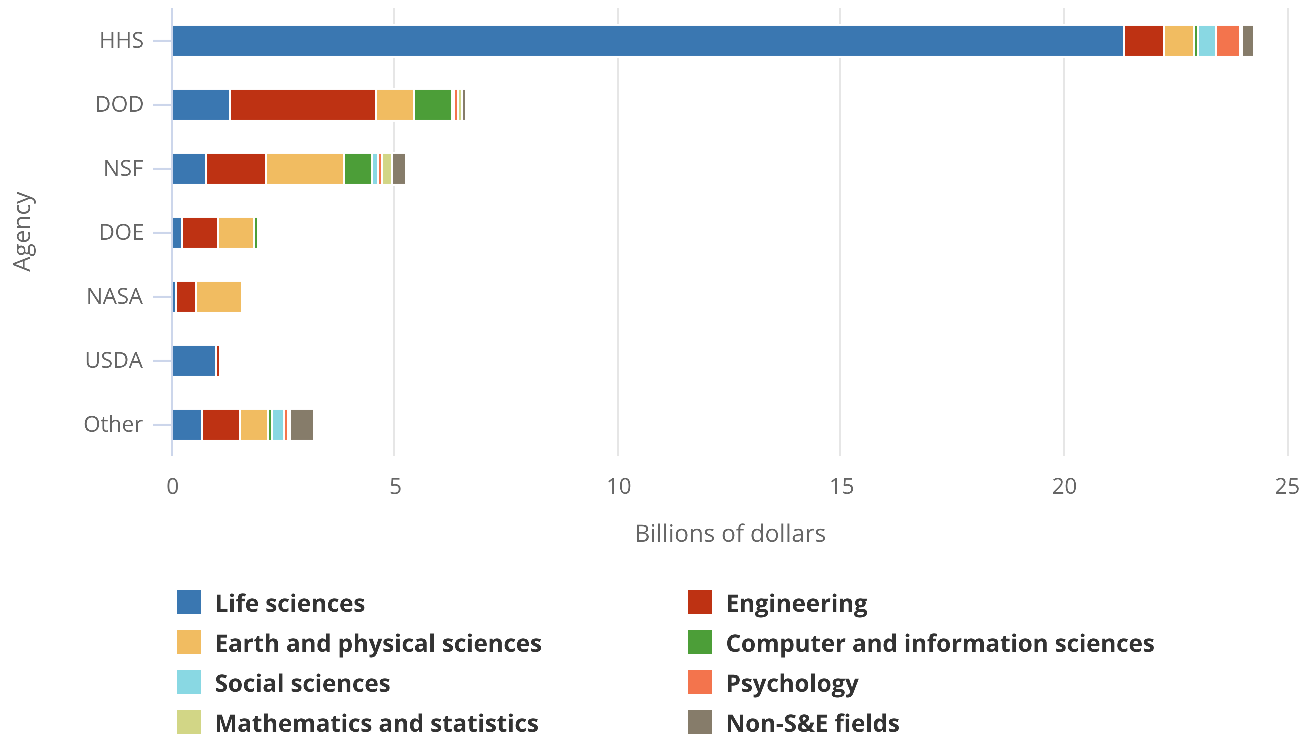
Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey (HERD).

Science and Engineering Indicators

Each of the six primary federal agencies that sponsor academic R&D funded a portfolio across fields consistent with its mission (**Figure URD-13**; NCSES ***HERD 2019***: **Table 13**). For example, the vast majority ($21 billion, or nearly 90%) of the academic R&D funded by HHS was in life sciences. Around 85% ($1.6 billion) of DOE's academic R&D funding was in earth and physical sciences and engineering. NSF supported substantial amounts of academic R&D across a range of S&E fields. Unsurprisingly, agencies' academic R&D support patterns across S&E fields bear many similarities to their support patterns for graduate students and postdocs (see the section **Education, Training, and Academic R&D**).

Figure URD-13

Federally financed academic R&D expenditures, by agency and field: FY 2019



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.

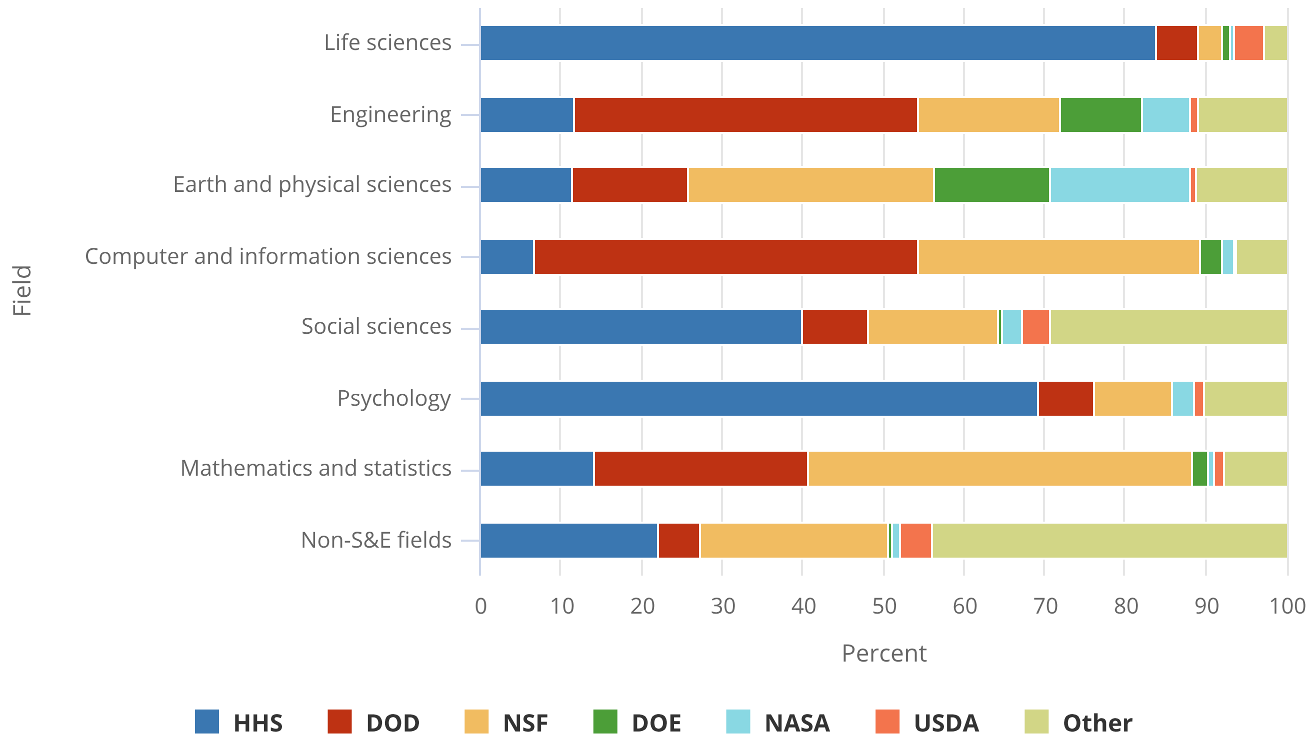
Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey (HERD).

Science and Engineering Indicators

In each S&E field, the portion of R&D supported by specific agencies differed (**Figure URD-14**). For example, HHS provided 84% of total federal support for academic R&D in life sciences and about 70% of such support for psychology. NSF contributed just under half of the total federal academic R&D funding for mathematics and statistics, as well as significant portions of the totals for several other fields. Agencies sometimes targeted funds narrowly to specialized fields (NCSES ***HERD 2019***: **Table 13**). USDA, for example, provided around two-thirds of federal support for academic R&D in agricultural sciences (most of this support was allocated to public land-grant universities). NASA provided around 70% of federal support for academic R&D in astronomy and astrophysics, and NSF provided nearly 45% of federal support for academic R&D in anthropology.

Figure URD-14

Federally financed academic R&D expenditures, by field and agency: FY 2019



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 (HERD).

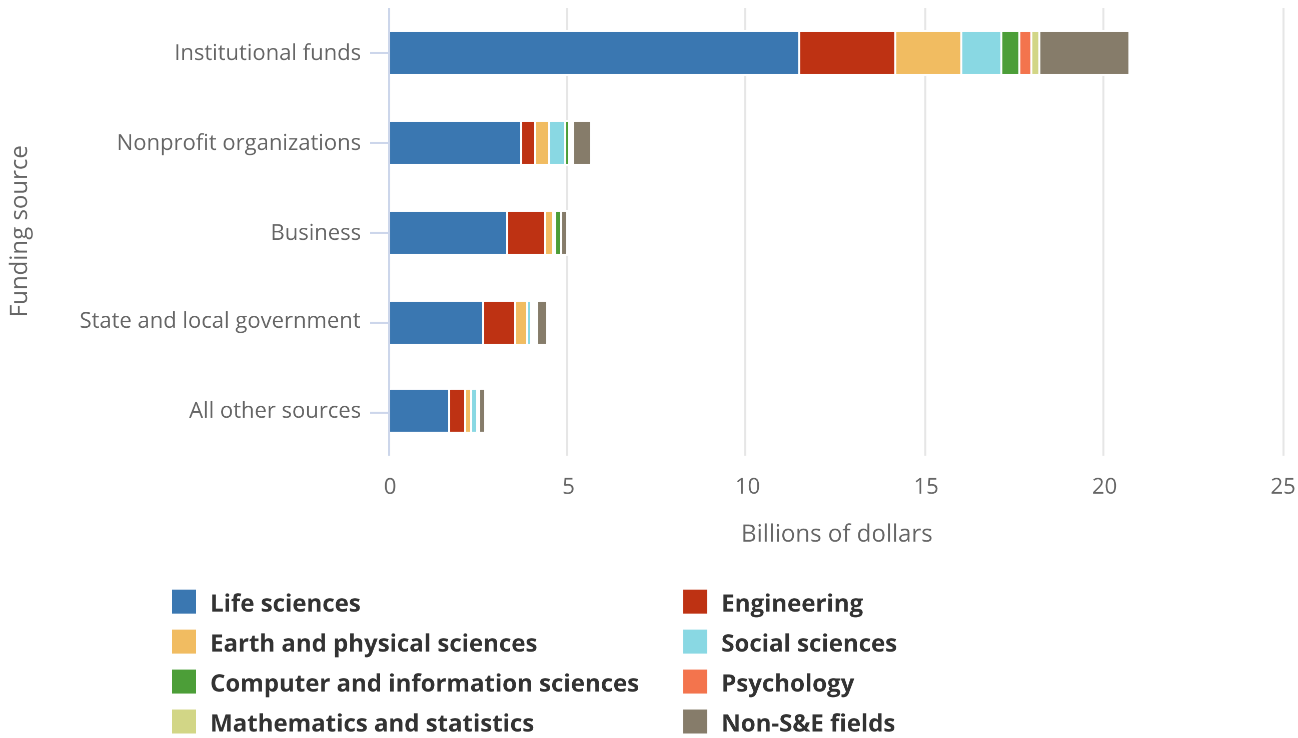
Science and Engineering Indicators

Nonfederal Support for Academic R&D, by Field

Unlike federal agencies, nonfederal academic R&D sources represent aggregations of funders, each of which may have its own funding priorities. However, in 2019, more than half of the total funding from each type of nonfederal academic R&D source—academic institutions themselves, nonprofit organizations, businesses, and state and local governments—was allocated to life sciences (**Figure URD-15**; NCSES ***HERD 2019***: **Table 12**). Engineering was the second-largest recipient for all but nonprofit funding. Underlying this pattern were smaller-scale differences in how these types of sources allocated funds. Businesses, for example, devoted more than 20% of their total academic R&D funding to engineering and around 1% to social sciences. Nonprofit organizations, by contrast, devoted slightly more funds to social sciences (8%) than engineering (7%).

Figure URD-15

Nonfederally financed academic R&D expenditures, by funding source and field: FY 2019



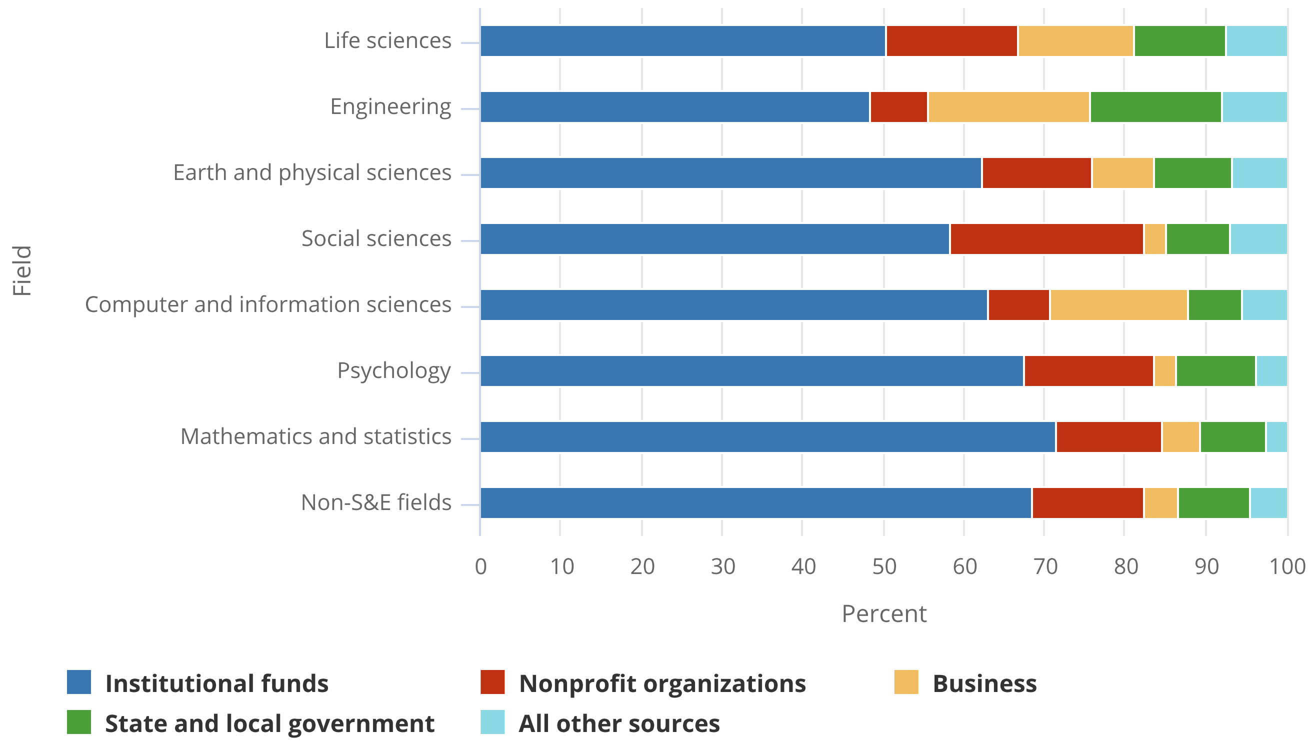
Source(s):
National Center for Science and Engineering Statistics, Higher Education Research and Development Survey (HERD).

Science and Engineering Indicators

Academic institutions contributed half or more of nonfederal academic R&D funding for all broad fields except engineering, to which they contributed just under half (48%) (**Figure URD-16**; NCSES ***HERD 2019***: **Table 12**). Nonprofit organizations contributed nearly a quarter of total nonfederal academic R&D funding for social sciences. Businesses contributed around a fifth of nonfederal academic R&D funding for engineering and nearly that much (17%) for computer and information sciences. State and local governments contributed smaller percentages more uniformly divided among a range of fields.

Figure URD-16

Nonfederally financed academic R&D expenditures, by field and funding source: FY 2019



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

Science and Engineering Indicators

Cost Components of Academic R&D

Academic R&D expenditures are composed of direct and indirect costs (NCSES ***HERD 2019***: **Table 16**; see also COGR 2019). According to a report from the National Research Council, direct costs of research are those components that can be attributed to a specific project, such as researcher salaries, travel, and the costs of laboratory materials. Indirect costs include outlays for facilities and administration, such as library costs and other elements that support multiple projects or an institution's entire research program (NRC 2012).[20] A key distinction between these types of costs is that while funders, including the federal government, *pay* the direct costs of R&D, they may also *reimburse* institutions for all or part of the indirect costs associated with that R&D. When funders do not reimburse all of the associated indirect costs, institutions must rely on other sources to cover these costs.

In 2019, direct costs were around three-quarters ($64.3 billion) of total academic R&D spending (NCSES ***HERD 2019***: **Table 16**). The largest direct cost component was the salaries, wages, and fringe benefits of those who conduct the R&D; in 2019, this was $36.6 billion, or around 44% of total academic R&D spending. Other direct cost components included software and equipment purchases, as well as funds passed to subrecipients.

Indirect costs included those recovered by institutions and unrecovered costs for which institutions were not reimbursed.[21] Unrecovered indirect costs, like all data from the HERD survey, were self-reported by institutions. The survey's technical notes explain: "the survey requests that the total amount of indirect costs associated with a research grant or contract be calculated and reported, including costs that were not reimbursed by the external funding source. The unrecovered indirect cost is calculated by multiplying the institution's negotiated indirect cost rate by the corresponding base and then subtracting the actual indirect cost recovery, preferably on a project-by-project basis." More detail on this topic is available in the **HERD technical notes**.

The relationship between levels of federal funding and levels of institutional funding, including the unrecovered indirect cost component, is complex. As mentioned earlier, precise accounting of institutionally financed R&D is difficult, and funds may be derived from many sources (for more, see Council on Governmental Relations 2019; Droegemeier 2017). While the total amount of unrecovered indirect costs increased slightly in inflation-adjusted dollars between 2012 and 2019 (from around $4.6 billion to $4.9 billion), institutional direct funding for research increased much faster (from $7.7 billion to $12.5 billion). As a result, during this time, unrecovered indirect costs as a percentage of total institutionally funded R&D expenditures decreased from around a third to around a quarter.

As a percentage of total indirect costs, unrecovered indirect costs are higher for public institutions (around 33%) than for private institutions (around 23%) (NCSES ***HERD 2019***: **Table 16**). However, when compared with total institutional spending on R&D, the proportions are about the same (NCSES ***HERD 2019***: **Table 69**).[22]

Academic R&D: International Comparisons

This section provides information on international comparisons of funding for higher education R&D expenditures. The forthcoming *Indicators 2022* report "Research and Development: U.S. Trends and International Comparisons" provides international comparisons of overall R&D.

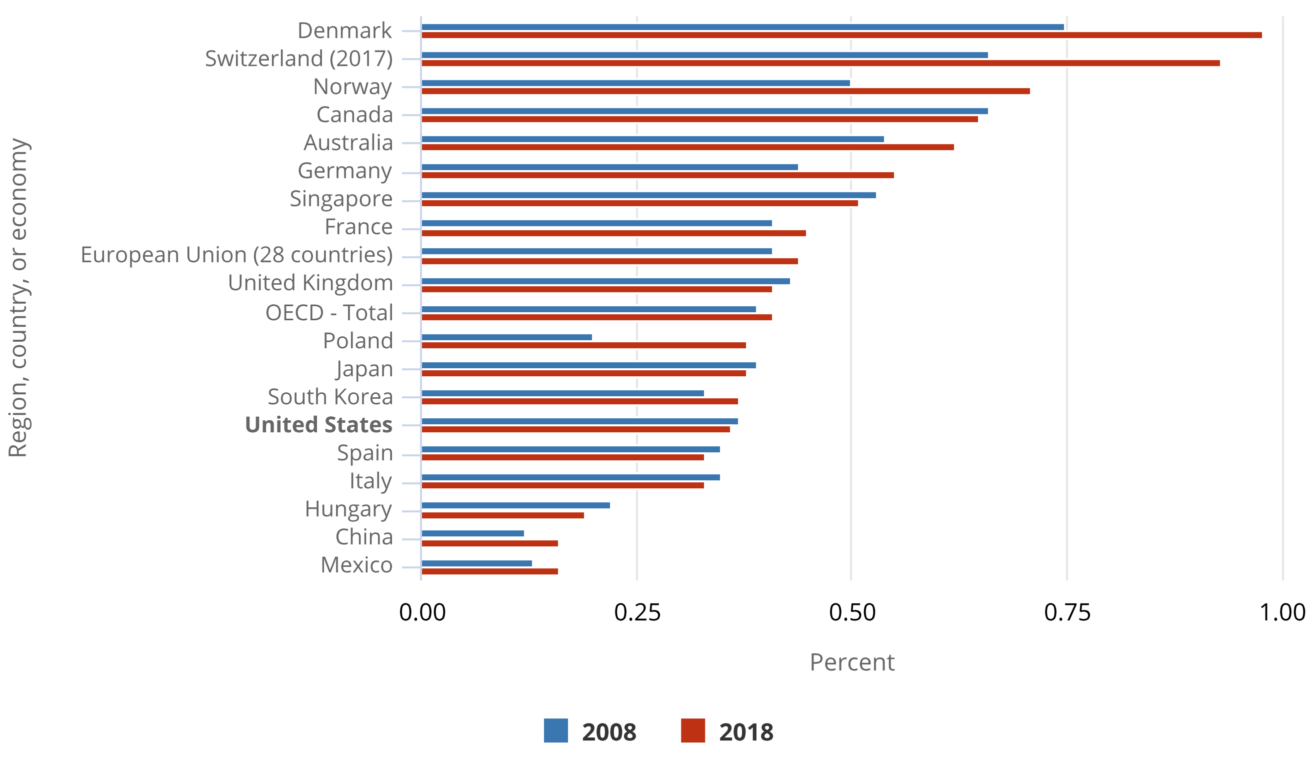
For a concise summary of trends in global R&D expenditures across all sectors, see Sargent (2020). For comparative detail on R&D performance across sectors, see UNESCO (2020).

International comparisons of academic R&D funding are available from OECD (2020). In terms of overall higher education expenditure on R&D, the United States is still by far the highest, at $74.7 billion in 2018. China is second, at $34.7 billion, followed by Germany ($24.8 billion), Japan ($19.8 billion), and France ($14 billion).

In terms of higher education expenditure on R&D as a percentage of GDP, in 2018 the United States ranked 23rd out of 44 countries or economies for which data were available (**Figure URD-17** shows data for selected countries or economies). The U.S. percentage was below the average for the European Union and OECD nations, although higher than several other nations, including China. From 2008 to 2018, the U.S. percentage remained roughly the same, as did its rank.[23]

Figure URD-17

Higher education expenditure on R&D as a percentage of gross domestic product for selected countries or economies: 2008 and 2018



OECD = Organisation for Economic Co-operation and Development.

Note(s):

Higher education expenditure on R&D represents 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.

Source(s):

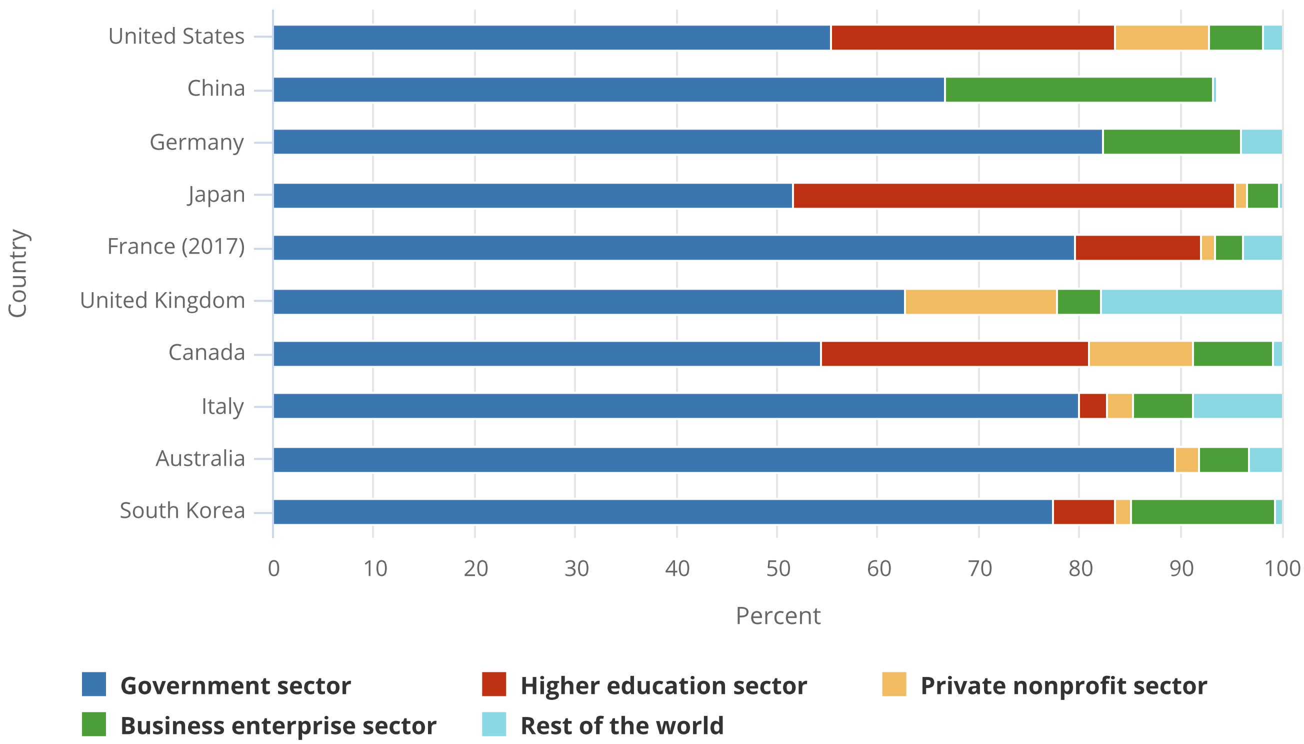
Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators (2020/1)*.

Science and Engineering Indicators

The OECD also provides data on sources of funding for higher education R&D (**Figure URD-18** shows data for the 10 countries or economies with the largest higher education expenditures on R&D). The relative contributions of different sectors to higher education R&D differ greatly among nations. In its distribution of funding across sources, the United States most resembles Canada in the proportions provided by funders across sectors, whereas nations such as China and Germany are more similar to one another in relying almost entirely on government and business funding.

Figure URD-18

Funding by sector for higher education expenditure on R&D for selected countries: 2018



OECD = Organisation for Economic Co-operation and Development.

Note(s):

Nations or economies are sorted by total 2018 expenditures. Numbers provided by China to the OECD do not sum to 100%. "Rest of the world" includes the members of the OECD (less the United States), Argentina, China, Romania, Russia, Singapore, South Africa, and Taiwan. R&D expenditures by others countries are not included but are likely to be small in relative terms.

Source(s):

Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators (2020/1)*.

Science and Engineering Indicators

Although government sources provide more than half of U.S. higher education R&D funding, this is a smaller percentage than 8 of the top 10 nations. The U.S. higher education sector provides more than one-quarter of the funding, higher than any other nation in the top 10 except Japan.

In some nations, government funds come from both direct government funding and general university funds. These funds are defined as "coming from the general grant universities receive from the central government (federal) ministry of education or the corresponding provincial (state) or local (municipal) authorities in support of their overall research/ teaching activities" (OECD 2015).

Six of the 10 nations shown in **Figure URD-18** reported separate expenditures from general university funds (Australia, Canada, France, Italy, Japan, and the United Kingdom), and four did not separately report these expenditures (China, Germany, South Korea, and the United States).[24] The proportion of total government funding from general university funds does not have a straightforward relationship with either total amount of government funding or the percentage of higher education R&D financed by governments.

Infrastructure for Academic R&D

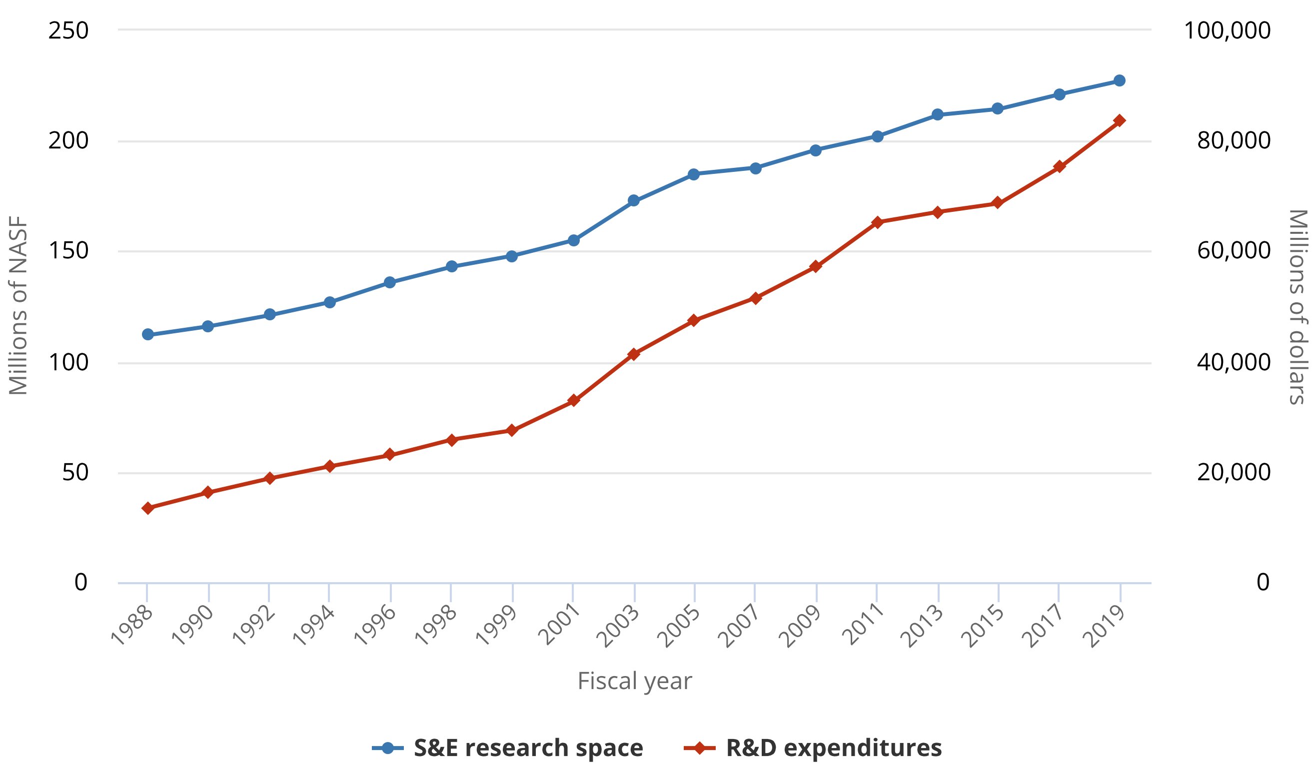
Physical infrastructure is an essential resource for the performance of R&D at academic institutions. The principal indicators of this infrastructure are the square footage of designated research space and research instrumentation expenditures. Two fields of research have primarily driven the continual increases in academic S&E research space: biological and biomedical sciences and engineering. These two fields accounted for 60% of total research space growth from 2007 to 2019. Research equipment expenditures have fluctuated over the past 15 years in constant dollars but stand at levels similar to those of a decade ago. Federal funding of research equipment declined to less than 50% in 2014 for the first time in decades and has remained below 50% since.

Research Facilities

Research-performing universities and colleges in the United States had 227.3 million net assignable square feet (NASF) of research space available in 2019, up 6.1 million NASF (2.8%) from 2017 (**Figure URD-19**). The total increase in research space between 2017 and 2019 was slightly less than the square footage of space added between 2015 and 2017 (6.7 million NASF) (NCSES ***Facilities 2019***: **Table 1**). Growth in research space and total academic R&D show similar upward trajectories over time.

Figure URD-19

S&E research space and R&D expenditures at academic institutions: FY 1988–2019



NASF = net assignable square feet.

Note(s):
The biennial survey cycle for the facilities survey ran on even years for FY 1988 to 1998 and on odd years for FY 1999 to 2019. For R&D funding, totals for FY 1988–2002 represent R&D expenditures in S&E fields only. From FY 2003 through FY 2009, some institution totals for all R&D expenditures may be lower-bound estimates because the National Center for Science and Engineering Statistics did not attempt to estimate for nonresponse on the non-S&E R&D expenditures item prior to FY 2010.

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

Science and Engineering Indicators

Research space in most S&E fields increased overall between 2007 and 2019. The exception to this norm was computer and information sciences, which declined by about 4% (from 4.8 million to 4.6 million NASF); however, the amount of space devoted to these fields increased from 2017 to 2019 (by 0.4 million NASF) (NCSES ***Facilities 2019***: **Table 1**). Engineering is the only major field in which total research space steadily increased during this 12-year interval.

Overall, biological and biomedical sciences accounted for 35% of total S&E research space growth over the past 12 years. The 58.7 million NASF of biological and biomedical sciences research space also accounted for the largest share of research space, with 26% of the total. Health sciences (18%), engineering (17%), agricultural sciences (12%), and physical sciences (10%) comprised the next-largest shares of S&E research space (NCSES ***Facilities 2019***: **Table 1**).

The distribution of research space across fields, as well as the total amount of research space, varies between institutions. For example, in 2019, the 25 institutions with the most research space were all very high research activity doctoral universities and contained around 31% of total research space. A ranking of institutions by NASF, showing the breakdown by field, is available at NCSES ***Facilities 2019***: **Table 3** (see also Gibbons 2020).

New research space is added each year through construction projects and the repurposing of existing space. According to Gibbons (2020), most new construction of research space is supported by institutional funds and other sources, including operating funds, endowments, private donations, tax-exempt bonds and other debt financing, and recovered indirect costs. Over the past two decades, state and local governments typically funded between a fifth and a third of new research construction. Federal government sources generally provide a lower proportion, often under 10%.

Academic institutions broke ground on 5.6 million NASF of new S&E research space construction projects in 2018–2019, which was smaller than the amount of new research space construction started in 2016–2017 (6.7 million NASF) (NCSES ***Facilities 2019***: **Table 8**). Institutions reported $5.1 billion in completion costs for these new construction projects, which were largely funded by the institutions' internal funds (76%) (NCSES ***Facilities 2019***: **Table 24**). Academic institutions also expended $5.5 billion on major repairs and renovation of S&E research space in 2018 or 2019 (NCSES ***Facilities 2019***: **Table 25**).[25]

Research Equipment

In 2019, universities spent about $2.4 billion on capitalized equipment necessary to conduct academic research projects (Table SURD-1).[26] This spending accounted for close to 3% of the $83.7 billion in total academic R&D expenditures and represented a 12% increase from 2018 when adjusted for inflation. Annual equipment spending has generally ranged between $1.9 billion and $2.3 billion over the last 15 years when adjusted for inflation. The inflation-adjusted total in the previous (2018) cycle was the lowest during this period.

Research equipment expenditures continue to be concentrated in three fields: life sciences (40%), engineering (32%), and physical sciences (16%). While shares for these three fields have consistently accounted for about 80% or more of total equipment expenditures, the combined shares have been at or near the highest on record for the past several years. Also noteworthy is that more than a third of all research equipment expenditures stemmed from two life sciences subfields: biological and biomedical sciences (19%) and health sciences (16%) (NCSES ***HERD 2019***: **Table 17**).

When adjusted for inflation, the 2019 level of equipment spending in engineering was the highest in the last 15 years (Table SURD-1). The 2019 level of science equipment spending was roughly equivalent to the level in FY 2015 and FY 2016, although lower than it was 10 years ago.

Unlike funding for new construction of research space, which relies heavily on institutional funds, the federal government typically plays a larger role in providing funding for academic research equipment. Before 2014, the share of research equipment expenditures funded by federal sources remained above 50% since data were initially collected in 1981. Since 2014, the federal government has funded 44% to 47% of research equipment expenditures (Table SURD-2).

The federal share of research equipment funding varied significantly by R&D field and subfield. Atmospheric sciences and meteorology (71%), ocean sciences and marine sciences (77%), physics (73%), and industrial and manufacturing engineering (71%) were the only fields receiving 70% or more of their R&D equipment funding from federal sources. Economics (8%) and anthropology (18%) were the only S&E subfields receiving less than 20% federal support for R&D equipment. Several non-S&E fields also received less than 20% federal support for R&D equipment.

Education, Training, and Academic R&D

Undergraduate and graduate students and postdoctoral researchers (postdocs) are vital to the academic R&D enterprise and constitute a significant portion of the individuals funded by research grants at many institutions (IRIS 2021). Education and training often go hand-in-hand with R&D performance at colleges and universities, and investments made by the federal government, academic institutions, and other funders in the education and training of S&E students and postdocs relate closely to their investments in academic R&D. For example, around 70% of full-time S&E graduate students primarily funded by the federal government in 2019 received research assistantships (RAs), which come from research grants. More than 80% of federally funded postdocs were paid through research grants. Additionally, the majority of S&E graduate students and postdocs are affiliated with the same universities that perform most of the nation's academic R&D (NCSES ***GSS 2019***: **Table 5-3**).[27]

Salaries, wages, and fringe benefits make up the largest component of academic R&D direct costs, and this section of the report adds detail to this component. The available data focus on financial support for graduate students and postdocs. Additional aspects of graduate study, including degrees by field and debt, are available in the forthcoming *Indicators 2022* report "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 "The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers." Comprehensive data on sources of support for undergraduates participating in research are not available. For information on how the COVID-19 pandemic affected academic R&D, see sidebar **COVID-19 and Academic R&D**.

Financial Support for S&E Graduate Students and Postdocs

Graduate Students

Graduate students' sources of financial support depended on their level of study.[28] Master's students were largely self-supporting, whereas only a small minority of doctoral students self-financed.[29] In 2019, around two-thirds of S&E master's students paid for their graduate program using personal sources (NCSES ***GSS 2019***: **Table 3-1**); by contrast, less than 10% of doctoral students did so.[30] These differences generally held across all S&E fields.

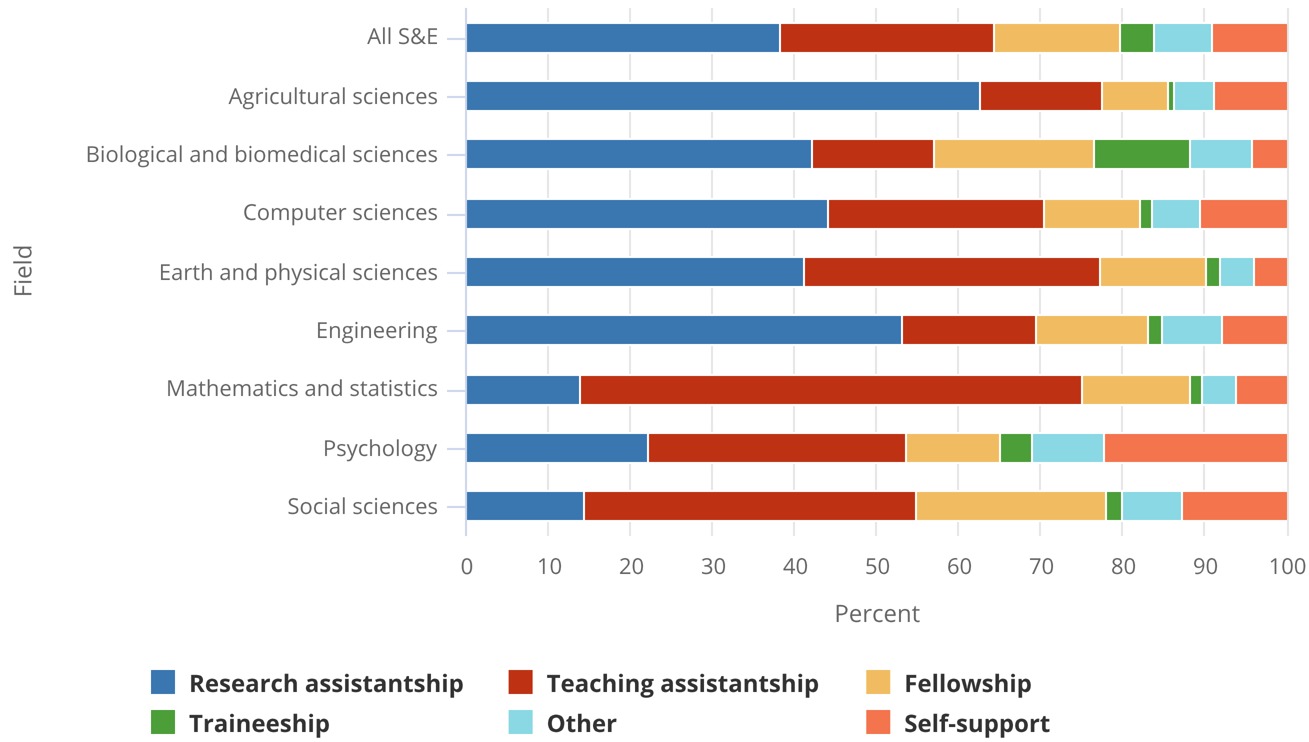
Other main sources of support for graduate students included academic institutions (where a student is enrolled) and the federal government. Academic institutions were the primary source of support for 24% of master's students and 59% of doctoral students. Institutional support includes tuition waivers and stipends. The federal government was the primary source of support for 5% of master's students and a quarter of doctoral students. Federal support includes financial support provided by federal agencies but excludes federally guaranteed student loans.

Financial support for graduate students may be delivered through various mechanisms, including RAs, teaching assistantships (TAs), and fellowships.[31] TAs and fellowships are mainly institutionally funded, whereas nearly half of RAs are funded through federal academic research grants.

Most doctoral students are supported by multiple sources or mechanisms during graduate school, even in a single academic year. Patterns of support varied by field (**Figure URD-20**; NCSES ***GSS 2019***: **Table 3-5**) and the type of institution attended. For example, full-time S&E graduate students from the Carnegie very high research doctoral universities were less likely to self-support than those who attended other types of institutions. Even among this group of institutions, however, public and private universities used funding mechanisms differently.

Figure URD-20

Full-time S&E doctoral students, by field and mechanism of primary support: 2019



Note(s):
Self-support includes any loans (including federal) and support from personal or family financial contributions. Total for All S&E includes health fields. Earth and physical sciences includes physical sciences plus geosciences, atmospheric sciences, and ocean sciences.

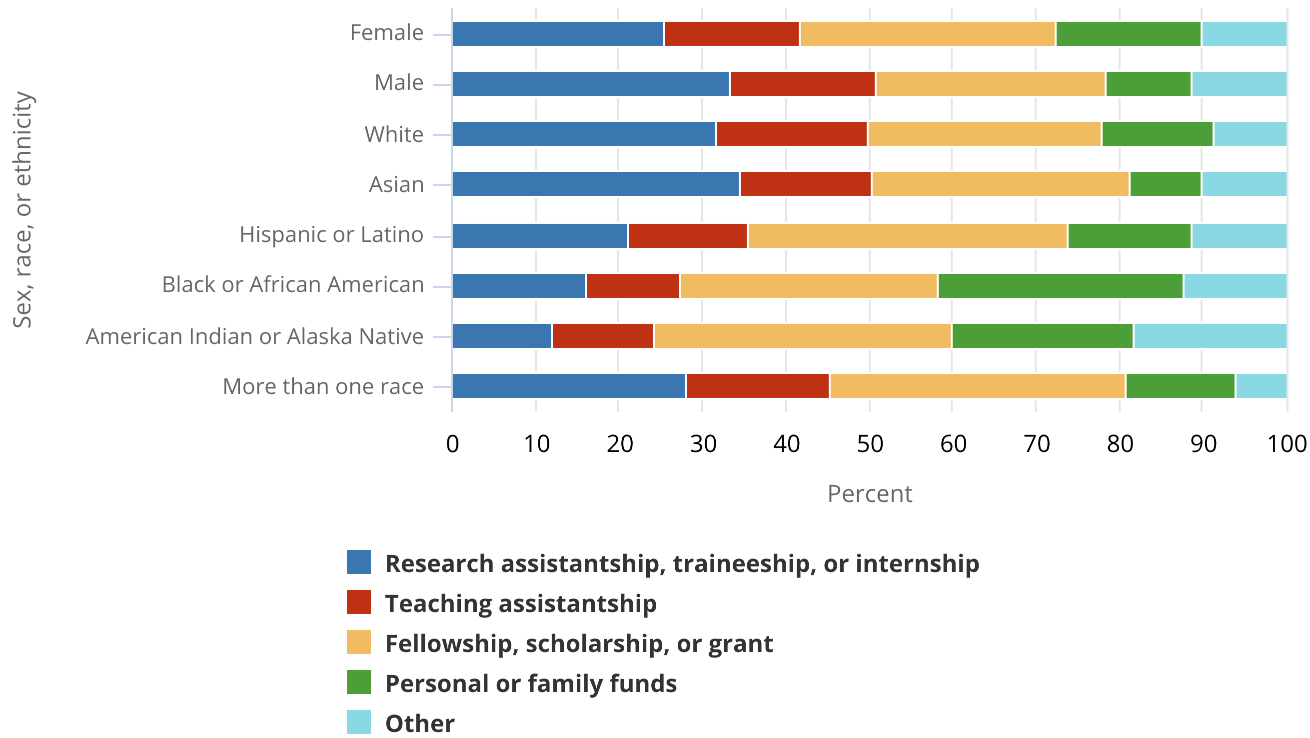
Source(s):
National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS).

Science and Engineering Indicators

Funding mechanisms also vary by demographic groups (**Figure URD-21**; NCSES ***SED 2019***: **Table 35**). Overall, among U.S. citizens and permanent residents who earned S&E doctorates between 2015 and 2019, men (33%) were more likely to be supported by RAs than women (25%), whereas women (17%) were more likely to self-support than men (11%). Women (16%) and men (17%) were around equally likely to be supported by TAs. Asians (35%) and Whites (32%) were more likely to have primary RA, traineeship, or internship support than doctoral recipients from underrepresented minority groups. Twenty-one percent of Hispanics or Latinos, 16% of Blacks or African Americans, and 12% of American Indians or Alaska Natives who earned S&E doctorates between 2015 and 2019 had RAs, traineeships, or internships as their primary source of financial support (NCSES ***WMPD 2021***: **Table 7-23**.) Additionally, Blacks or African Americans (30%) and American Indians or Alaska Natives (22%) were more likely to self-support than other groups.

Figure URD-21

Primary source of support for U.S. citizen and permanent resident S&E doctorate recipients, by sex, race, or ethnicity: 2015–19



Note(s):
Hispanic may be any race; race categories exclude Hispanic origin.

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

Science and Engineering Indicators

Doctorate recipients who are temporary visa holders exhibit different patterns of support than U.S. citizens and permanent residents. Overall, including non-S&E fields, temporary visa holders are more likely to hold RAs or traineeships, less likely to hold fellowships or use their own resources, and around equally likely to be supported by a TA. However, the patterns vary between broad fields of study (NCSES ***SED 2019***: **Table 35**).

To some extent, demographic differences in support mechanisms related to differences between groups in fields studied and institutions attended. However, certain patterns held across fields. For example, Black doctorate recipients were more likely than those from other groups to use personal sources of funding in almost every S&E field for which data were available (NCSES ***WMPD 2021***: **Table 7-23**).

Postdocs

Almost all U.S. academic postdoctoral appointments were concentrated at Carnegie very high research doctoral universities (83%), high research doctoral universities (5%), and medical schools and centers (10%) (NCSES ***GSS 2019***: **Table 5-3**). Just over half of postdocs (53%) were at public institutions (NCSES ***GSS 2019***: **Table 5-1**). Postdoctoral appointments were concentrated in the biological and biomedical sciences and health sciences (62% in 2019: NCSES ***GSS 2019***: **Table 3-2**).[32] Earth and physical sciences (13%) and engineering (12%) constituted most of the remainder.

In 2019, the federal government funded around half of all postdocs, down from around 60% in 2009 (NCSES ***GSS 2009***: **Table 70**). The federal government funded 40% of postdocs or more in all fields except mathematics and statistics (30%) and social sciences (22%). In 2019, institutions funded around a quarter of all postdocs and roughly this amount in most fields save mathematics and statistics (50%) and social sciences (44%).[33] Other domestic sources funded 15% of postdocs, and foreign sources around 2%.

Most postdocs (60%), including 81% of those funded by the federal government, were funded through research grants. Postdocs were also funded through fellowships (11%), traineeships (5%), and other mechanisms of support (23%) (NCSES ***GSS 2019***: **Table 3-6**).

Federal Support for S&E Graduate Students and Postdocs

Federal support for S&E graduate students and postdocs reflects a continuation of the historic partnership between the federal government and the nation's research universities to integrate the performance of basic scientific research and the education and training of the next generation of scientists and engineers (National Research Council 2012). It is an indicator of the strength of the university–government partnership.

The proportion of individuals in different roles (e.g., students, postdocs, faculty, staff) supported varies by agency.[34] For example, in 2019, NIH supported roughly equal numbers of graduate students (21,000) and postdocs (19,500), whereas NSF supported far more graduate students (21,800) than postdocs (3,600).

Graduate Students

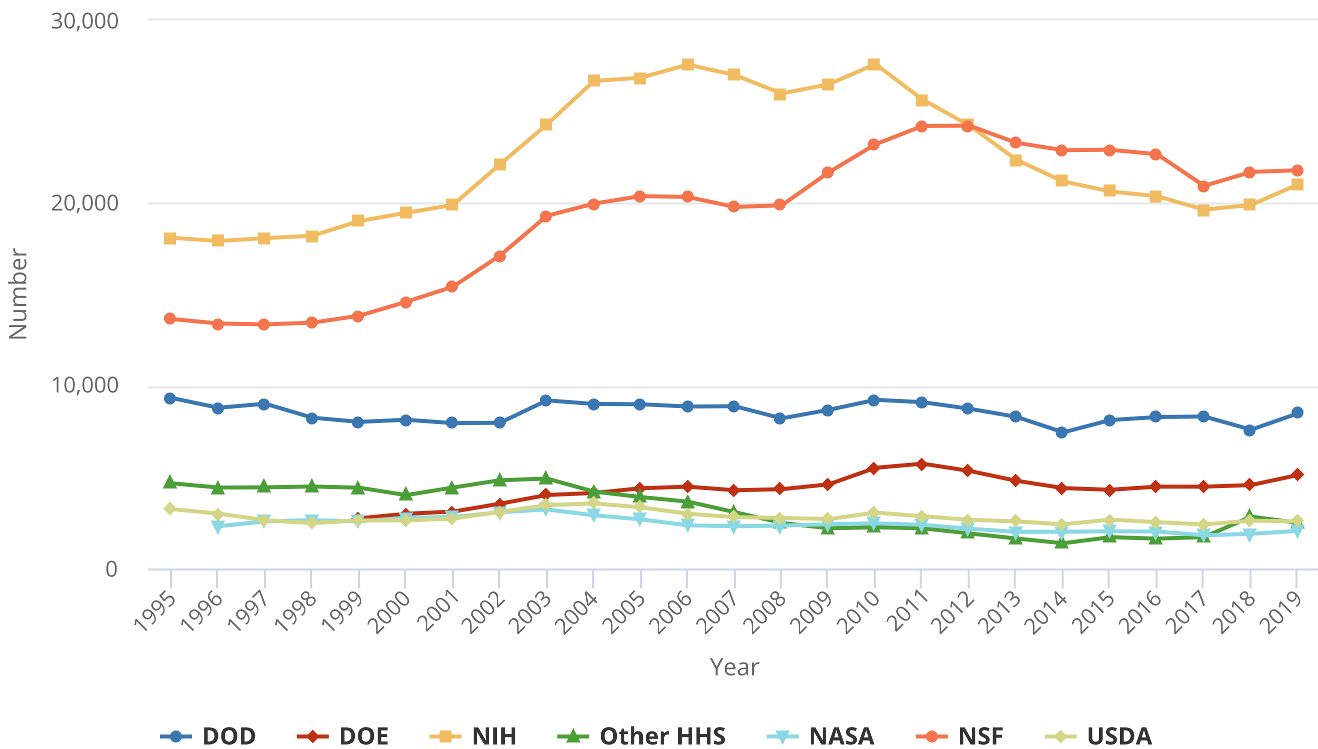
The federal government supported 15% of full-time S&E graduate students (around 74,000) in 2019 (NCSES ***GSS 2019***: **Table 1-6**), down from nearly 21% (84,000) in 2004. This overall figure masks differences in federal support for master's students (about 11,500, or 5%) and doctoral students (about 62,000, or 25%). Put another way, in 2019, 84% of S&E graduate students supported by the federal government were doctoral students (NCSES ***GSS 2019***: **Table 3-1**). This pattern is true for all S&E fields with the federal government supporting a higher percentage of doctoral students than master's students (NCSES ***GSS 2019***: **Table 3-1**).

The largest numbers of federally supported graduate students were in engineering (24,000), biological and biomedical sciences (18,500), and earth and physical sciences (13,000). Together, these fields contained around half of total graduate students but three-quarters of federally supported students (NCSES ***GSS 2019***: **Table 3-1**).

NSF (22,000) and NIH (21,000) supported the most graduate students in 2019. Together, these two agencies supported nearly 60% of federally supported graduate students (NCSES ***GSS 2019***: **Table 1-7**). Other agencies supporting substantial numbers of S&E graduate students in 2019 were DOD (8,500), DOE (5,100), and USDA (2,600); additional agencies were HHS (excluding NIH, 2,500) and NASA (2,100) (see **Figure URD-22**).

Figure URD-22

Full-time graduate students in science, engineering, and health primarily supported by the federal government, by agency: 1995–2019



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):
NASA was added in 1996 and DOE was added in 1999. In 2007, eligible fields were reclassified, newly eligible fields were added, and the survey was redesigned to improve coverage and coding of eligible units. 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 two private for-profit institutions offering mostly practitioner-based graduate degrees were determined to be ineligible. In 2017, enrollment and financial support 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 (GSS) 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.

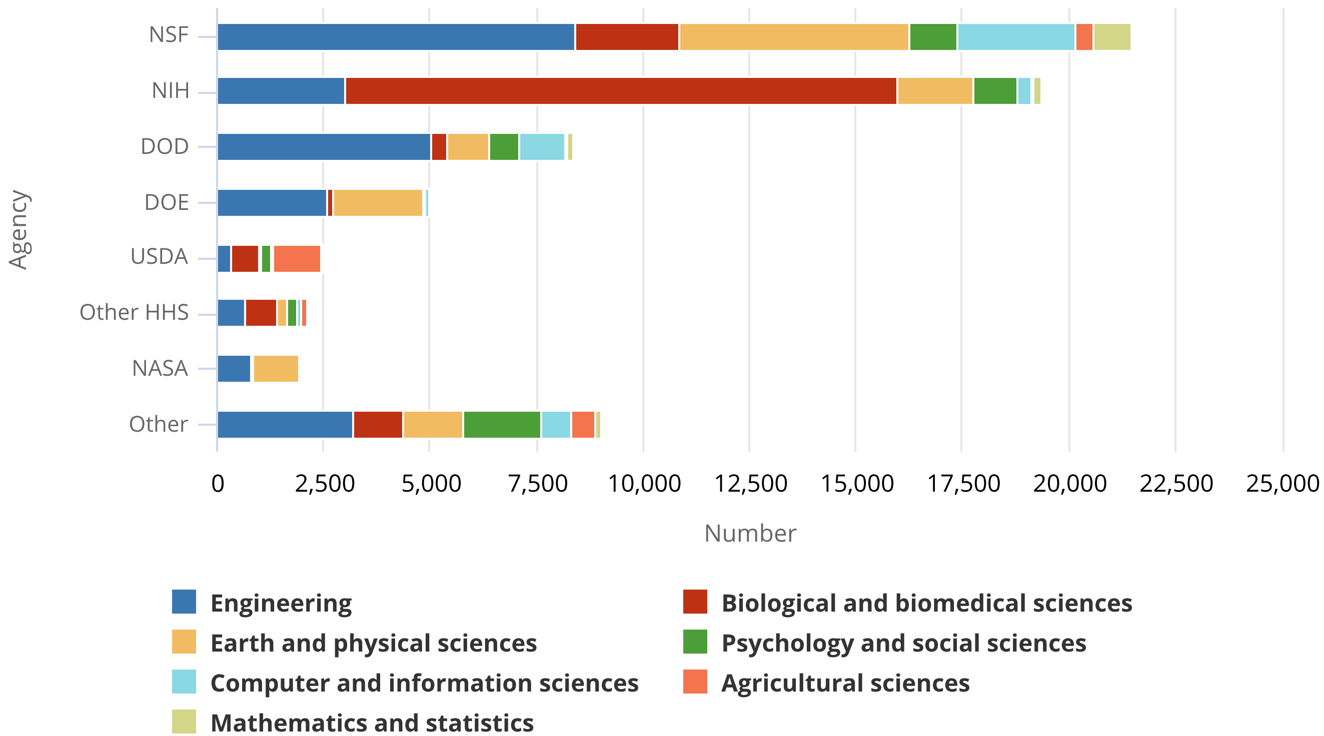
Source(s):
National Center for Science and Engineering Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS).

Science and Engineering Indicators

In their support patterns across fields, agencies took on portfolios consistent with their missions (**Figure URD-23**, NCSES ***GSS 2019***: **Table 3-3**). NSF supported substantial numbers of students across a range of fields, whereas over 60% of those supported by NIH were in biological and biomedical sciences. Sixty percent of the students funded by DOD studied engineering, and more than 90% funded by DOE were in earth and physical sciences and engineering.

Figure URD-23

Full-time graduate students in S&E primarily supported by the federal government, by field and agency: 2019



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):
Agricultural sciences also include natural resources and conservation. Earth and physical sciences include physical sciences plus geosciences, atmospheric sciences, and ocean sciences. Multi- and interdisciplinary studies were excluded, as were health fields (clinical medicine and other health).

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

Science and Engineering Indicators

RAs were the primary mechanism the federal government used to fund graduate students. Among full-time S&E graduate students primarily funded by the federal government in 2019, 71% received RAs, followed by fellowships (12%) and traineeships (8%).

Postdocs

The federal government supported half (49%, around 32,500) of S&E postdocs in 2019 (NCSES ***GSS 2019***: **Table 3-2**). The largest numbers of federally supported postdocs were in biological and biomedical sciences (12,000), clinical medicine (7,500), and earth and physical sciences (5,000). These fields contained around three-quarters of total postdocs and around the same proportion of those funded by the federal government (NCSES ***GSS 2019***: **Table 3-2**).

NIH supported the most postdocs in 2019: around 19,500 (60% of total federally supported postdocs) (NCSES ***GSS 2019***: **Table 3-4**). Other agencies supporting postdocs included NSF (3,600), DOD (2,400), and DOE (2,000). In total, these four agencies account for 85% of federally supported postdocs.

As with their support of graduate students, agencies funded postdocs across fields in a manner consistent with their missions (NCSES ***GSS 2019***: **Table 3-4**). NSF supported postdocs across a range of fields. Eighty percent of postdocs supported by NIH were in biological and biomedical sciences or clinical medicine. DOD funded postdocs primarily in engineering (40%) and earth and physical sciences (19%), as did DOE (32% in engineering, and 53% in earth and physical sciences).

RAs continue to be the primary mechanism the federal government uses to fund postdocs. Among postdocs primarily funded by the federal government in 2019, 81% received RAs, followed by fellowships and traineeships (8% each), with the remainder funded by other mechanisms.

Institutional Support for S&E Graduate Students and Postdocs

Graduate Students

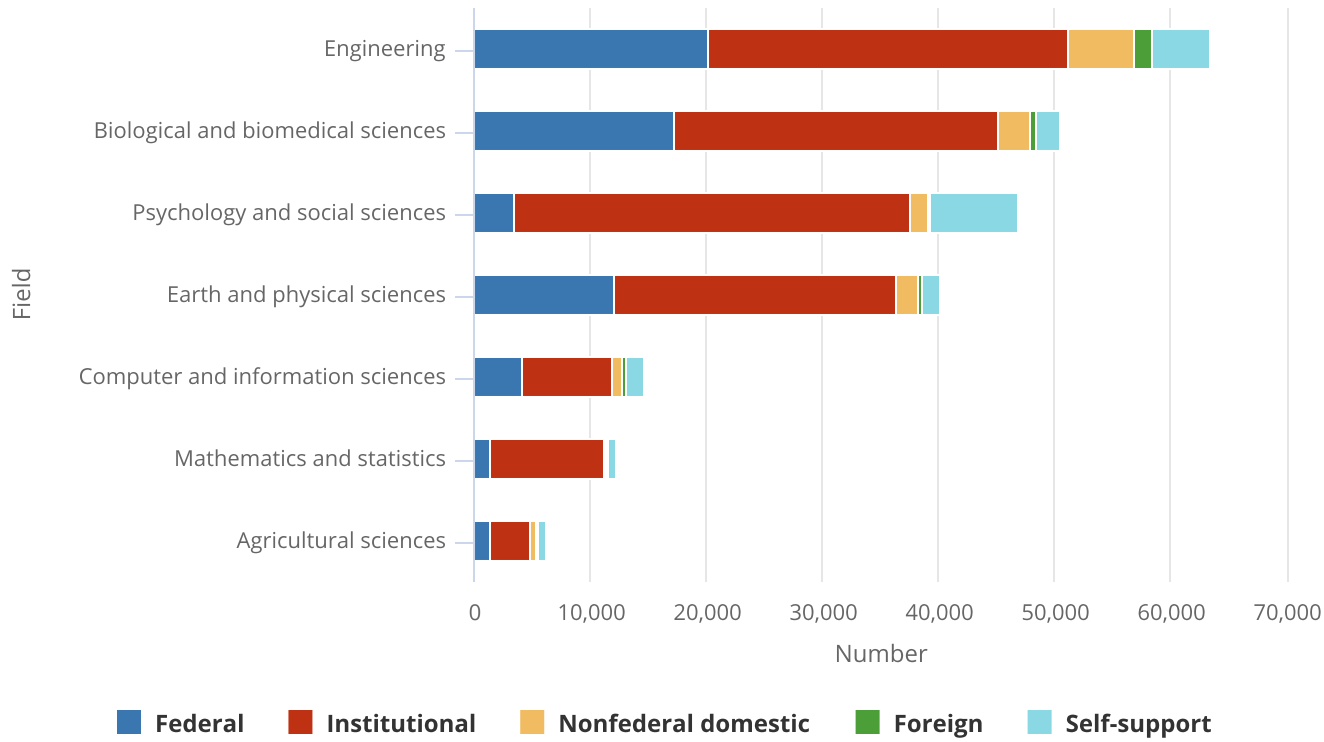
In 2019, institutions supported 41% of full-time S&E graduate students (around 206,000), more than any other source including self-support (NCSES ***GSS 2019***: **Table 3-1**); this is a long-standing trend.[35] Institutions supported nearly a quarter of master's students (60,000) and nearly 60% of doctoral students (146,000). Put another way, around 70% of S&E graduate students supported by institutions were doctoral students.

The largest numbers of institutionally supported graduate students were in engineering (44,000), biological and biomedical sciences (34,000), and social sciences (33,000). Across fields and levels, institutions supported more students than the federal government. For full-time S&E doctoral students, institutions supported higher numbers than any other source across fields (**Figure URD-24**). The percentage of full-time doctoral students supported by institutions varied from just under half for engineering to 80% for mathematics and statistics (NCSES ***GSS 2019***: **Table 3-1**).

Institutions mainly used TAs to support graduate students; 42% of institutionally funded graduate students in 2019 had TAs. RAs (around a quarter) and fellowships (17%) accounted for most of the rest.

Figure URD-24

Full-time doctoral students in S&E, by field and primary source of support: 2019



Note(s):
Agricultural sciences also include natural resources and conservation. Earth and physical sciences include physical sciences plus geosciences, atmospheric sciences, and ocean sciences. Multi- and interdisciplinary studies were excluded, as were health fields (clinical medicine and other health).

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

Science and Engineering Indicators

Postdocs

Institutions funded around a quarter of academic postdocs (about 15,500) in 2019 (NCSES ***GSS 2019***: **Table 3-2**). The largest numbers of institutionally funded postdocs were in biological and biomedical sciences (4,000), clinical medicine (4,000), and engineering (2,000). Institutions funded fewer postdocs than did the federal government for all broad fields except mathematics and statistics and social sciences. Institutions mainly funded postdocs through other support (around half) and RAs (around a third).

Other Support for S&E Graduate Students and Postdocs

Nonfederal Domestic Support

Other nonfederal domestic sources, including businesses and nonprofits, supported around 4% of S&E graduate students in 2019, including about 2% of master's students (4,900) and 6% of doctoral students (14,000) (NCSES ***GSS 2019***: **Table 3-1**). These sources supported the largest numbers of students in engineering (7,400), biological and biomedical sciences (3,300), and earth and physical sciences (2,000). They funded the largest percentages of total students in agricultural sciences (12%), engineering (6%), and natural resources and conservation (5%).

Nonfederal domestic sources supported 15% of total S&E postdocs (10,000) and between 8% and 18% of postdocs across fields (NCSES ***GSS 2019***: **Table 3-2**). These sources funded the most postdocs in biological and biomedical sciences (3,300), clinical medicine (2,600), and engineering (1,400).

Foreign Support

In 2019, less than 1% of S&E graduate students were supported by foreign sources, including around 1,500 master's students (0.6%) and 3,200 doctoral students (1.3%). Foreign sources funded less than 3% of students across degree levels and fields. They supported the most students in engineering (2,000) (NCSES ***GSS 2019***: **Table 3-1**).

Foreign sources also supported around 2.5% of academic postdocs (1,600). Most of these were in clinical medicine (400), biological and biomedical sciences (400), and engineering (300) (NCSES ***GSS 2019***: **Table 3-2**).

SIDEBAR

COVID-19 and Academic R&D

When the COVID-19 pandemic struck the United States in March 2020, it disrupted R&D performed by colleges and universities. The need for social distancing led to laboratory closures, curtailment of projects, and resource allocation shifts (Morgan and Sargent 2020). While most research activities have resumed as of the spring of 2021, lingering effects continue, and the pandemic's long-term implications for the U.S. academic R&D enterprise remain unclear.

Due to time lags between data collection and availability, the surveys used in this report do not yet provide information on the impact of COVID-19 on academic R&D. Other sources, however, offer an understanding of aspects of COVID-19's effects to date on research activities, institutions, and researchers themselves. Moreover, many of these sources reveal that impacts have been unequally distributed. This sidebar briefly addresses impacts of COVID-19 on academic R&D; additional impacts on S&E higher education, publication patterns (Viglione 2020; Vincent-Lamarre, Sugimoto, Larivière 2020), and the overall research enterprise will be addressed in other *Indicators* thematic reports.

Estimated effects on research

The pandemic shut down significant portions of university research operations (Walsh 2020; Wigginton et al. 2020). The immediate impacts of these shutdowns on research projects varied between project types and fields of study due to the nature of the work performed (Servick et al. 2020; Upadhaya et al. 2020). Some research, deemed essential, was not shut down at all (Gewin 2020a). Aggregated data from 10 major research universities indicate a large drop-off in spending from research grants between March and May 2020 (IRIS 2020). Guidance that allowed researcher salaries to be paid while research was slowed or suspended may have lingering effects on research project timelines and future funding.

When researchers began returning to labs, they did so with new restrictions to prevent transmission of the virus. This has led to a continuing state of reduced productivity (Korbel and Stegle 2020; Muzzio 2020; Walsh 2020), which one group has termed the "pandemic normal" (COGR 2020), estimating large research output losses and financial and economic impacts since the start of the pandemic (COGR 2021).

Estimated effects on institutions

While only part of its overall effects on higher education institutions, the pandemic introduced new costs related to R&D. Shutdown and ramp-up activities required time and money. Personal protective equipment, testing, and lost staff time continue to exact costs (Mayer 2020). Research universities began using their own funds to support core facilities and shared instrumentation normally supported by fees paid from grants (Walsh 2020). Institutions continue working to understand and quantify these costs (APLU et al. 2020; COGR 2021; Keane 2021).

Some institutions were able to reboot laboratories and research faster than others. For example, Purdue University, a flagship land-grant university in Indiana, was able to restart more than 95% of its campus research spaces and core labs under modified COVID-19 operation by the end of June 2020 (Mayer 2020). In contrast, at Oakland University, a regional public university in Michigan, only around half of research labs had resumed work by early September 2020 (Stone 2020). Part of the difficulties faced by smaller institutions, including many minority-serving institutions, was their reliance on undergraduate students, rather than graduate students and postdocs, in the R&D enterprise (Stone 2020: see also Sloan et al. 2020).

Estimated effects on researchers

Myers et al. (2020) surveyed young principal investigators about how much the COVID-19 pandemic had reduced the time they spend on research. Results varied by researchers' sex, field, and whether they had dependents, with particularly large declines in female researchers (Deryugina, Shurchkov, and Stearns 2021), those with young children, and those in "bench sciences" (Myers et al. 2020; see also Gewin 2020b; Giurge et al. 2020; Woolston 2020a).

The research and career plans for many graduate students (Muzzio 2020) and postdocs (Woolston 2020c) were altered. For example, many doctoral students' timelines for completing their degrees have been extended (Levine 2021), and the availability of faculty positions has declined (Langin 2020). Undergraduates faced difficulties obtaining research experience, with potentially detrimental effects on their abilities to finish their degrees and, over the longer term, whether they pursue S&E careers (Stone 2020). These populations exhibited increased anxiety and mental illness (Ro 2020; Woolston 2020b) as revealed partially through experience surveys and focus groups (Chirikov et al. 2020; CMU 2020; Levine et al. 2021; Ogilvie et al. 2020; University of California, Berkeley 2021).

International students and postdocs, many of whom participate in research, faced additional difficulties including travel and visa restrictions, housing limitations, and funding (Martel 2020a, 2020b). Recent estimates indicate that international students at U.S. higher education institutions decreased by 16% in the fall of 2020, with new student enrollment decreasing even more and most institutions reporting international student deferrals (Baer and Martel 2020).

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 across fields. The federal government, primarily through six agencies, provides more than half of academic R&D funding. Academic institutions themselves are the second-largest contributor to academic R&D. Most academic R&D is performed by the same small percentage 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 expenditure on R&D, but ranked 23rd out of 44 countries in higher education R&D expenditure as a percentage of GDP.

Physical infrastructure underlies the ability of academic institutions to perform R&D. Research equipment expenditures at academic institutions, when compared in constant dollars, are at their highest levels in six years. However, the federal share of total funding for research equipment has remained below 50% since 2014.

Investments made by the federal government, academic institutions, and other funders in the education and training of students and postdocs relate closely to their investments in academic R&D. Master's students are largely self-supporting, whereas doctoral students are primarily funded by academic institutions and the federal government. The federal government funds around half of S&E postdocs, mainly through research grants. Institutions themselves fund around a quarter of postdocs. S&E postdoctoral appointments are concentrated in the biological and biomedical sciences and health sciences.

Glossary

Definitions

Control (of institution): 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).

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.

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.

Key to Acronyms and Abbreviations

DOD: Department of Defense

DOE: Department of Energy

FY: fiscal year

GDP: gross domestic product

HBCU: historically Black colleges and universities

HERD: Higher Education Research and Development Survey

HHE: high-Hispanic-enrollment institution

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

TA: teaching assistantship

USDA: Department of Agriculture

References

Association of American Medical Colleges (AAMC). 2015. *Academic Medicine Investment in Medical Research: Technical Report*. Available at **https://www.huronconsultinggroup.com/-/media/Resource-Media-Content/Education/Academic-Medicine-Investment-in-Medical-Research---Technical-Report.pdf**. Accessed 23 March 2021.

Association of Public and Land-Grant Universities (APLU), Association of American Universities (AAU), Association of American Medical Colleges (AAMC), American Council on Education (ACE). 2020. *Agricultural Research and Cooperative Extension Impacts in the Face of COVID-19: Relief Funding to Maintain Support for America's Farmers, Families, and Businesses*. 30 June. Available at **https://www.aau.edu/sites/default/files/AAU-Files/Key-Issues/Research-Disrupted-Senate-Ag-Briefing-Slides-Final-6-30-2020.pdf**. Accessed 18 February 2021.

Atkinson RD, Foote C. 2019. *U.S. Funding for University Research Continues to Slide. Information Technology & Innovation Foundation*. Available at: **https://itif.org/publications/2019/10/21/us-funding-university-research-continues-slide**. Accessed 12 October 2020.

Baer J, Martel M. 2020. *Fall 2020 International Student Enrollment Snapshot. Institute of International Education*. Available at **https://www.iie.org/-/media/Files/Corporate/Open-Doors/Special-Reports/Fall-2020-Snapshot-Report---Full-Report.ashx?la=en&hash=D337E4E9C8C9FACC9E3D53609A7A19B96783C5DB**. Accessed 23 March 2021.

Carnegie Mellon University (CMU), Graduate Student Assembly. 2020. *Graduate Student Experience at Carnegie Mellon University During the COVID-19 Pandemic*. Available at **https://www.cmu.edu/stugov/gsa/External-Advocacy/graduate-student-covid-experience-at-cmu.pdf**. Accessed 18 February 2021.

Chirikov I, Soria KM, Horgos B, Jones-White D. 2020. *Undergraduate and Graduate Students' Mental Health During the COVID-19 Pandemic*. University of California, Berkeley, Center for Studies in Higher Education. Available at **https://escholarship.org/uc/item/80k5d5hw**. Accessed 18 February 2021.

Council on Governmental Relations (COGR). 2019. *Excellence in Research: The Funding Model, F&A Reimbursement, and Why the System Works*. Available at **https://www.cogr.edu/excellence-research-funding-model-fa-reimbursement-and-why-system-works-0**. Accessed 9 June 2021.

Council on Governmental Relations (COGR). 2020. *Research Impact under COVID-19: Financial Crisis and the "Pandemic Normal."* Available at **https://www.cogr.edu/sites/default/files/Research_COVID_August2020_COGR_FINAL.pdf**. Accessed 18 February 2021.

Council on Governmental Relations (COGR). 2021. *Research Impact under COVID-19: January 2021 Addendum*. Available at **https://www.cogr.edu/sites/default/files/Research_Impact_COVID_Jan_2021_COGR.pdf**. Accessed 23 March 2021.

Deryugina T, Shurchkov O, Stearns JE. 2021. *COVID-19 Disruptions Disproportionately Affect Female Academics.* National Bureau of Economic Research Working Paper 28360. Available at **https://www.nber.org/papers/w28360**. Accessed 23 March 2021.

Droegemeier KK. 2017. *The Role of Facilities and Administrative Costs in Supporting NIH-Funded Research*. Testimony presented before the U.S. House of Representatives, Committee on Appropriations, Subcommittee on Labor, Health and Human Services, Education, and Related Agencies, 24 October. Available at **https://docs.house.gov/meetings/AP/AP07/20171024/106525/HHRG-115-AP07-Wstate-DroegemeierK-20171024.pdf**. Accessed 29 August 2019.

Gewin V. 2020a. Safely Conducting Essential Research in the Face of COVID-19. *Nature.* 3 April. Available at **https://www.nature.com/articles/d41586-020-01027-y**. Accessed 18 February 2021.

Gewin V. 2020b. The Career Cost of COVID-19 to Female Researchers, and How Science Should Respond. *Nature.* 20 July. Available at **https://www.nature.com/articles/d41586-020-02183-x**. Accessed 18 February 2021.

Gibbons MT; National Center for Science and Engineering Statistics (NCSES). 2019. *Higher Education R&D Funding from All Sources Increased for Third Straight Year in FY 2018*. InfoBrief NSF 20-302. Alexandria, VA: National Science Foundation. Available at **https://www.nsf.gov/statistics/2020/nsf20302/**.

Gibbons, MT; National Center for Science and Engineering Statistics (NCSES). 2020. *University Research Space Increased by 6.1 Million Square Feet between FY 2017 and FY 2019.* NSF 21-310. Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21310/**.

Giurge LM, Yemiscigil A, Sherlock J, Whillans AV. 2020. *Uncovering Inequalities in Time-Use and Well-Being during COVID-19: A Multi-Country Investigation*. Harvard Business School, Working Paper 21-037. Available at **https://www.hbs.edu/faculty/Publication%20Files/21-037_ee41de59-0565-4e73-81b9-46385d4dd45a.pdf**. Accessed 18 February 2021.

Institute for Research on Innovation and Science (IRIS). 2020. *COVID-19 Impact Report Aggregate (10 IRIS Universities)*. Available at **https://iris.isr.umich.edu/wp-content/uploads/2020/10/COVIDreportAggregate_NEW-1.pdf**. Accessed 18 February 2021.

Institute for Research on Innovation and Science (IRIS). 2021. *Aggregate Reports on Universities' Research-Related Employment and Spending.* Available at **https://doi.org/10.21987/35M8-MB88**. Accessed 25 March 2021.

Keane CJ. 2021. *Building Back the U.S. Research Enterprise: COVID Impacts and Recovery*. Testimony presented before the U.S. House of Representatives, Committee on Science, Space, and Technology, 25 February. Available at **https://science.house.gov/download/keane-testimony**. Accessed 23 March 2021.

Korbel JO, Stegle O. 2020. Effects of the COVID-19 Pandemic on Life Scientists. *Genome Biology*, 21:113. 11 May. Available at **https://genomebiology.biomedcentral.com/articles/10.1186/s13059-020-02031-1**. Accessed 18 February 2021.

Langin K. 2020. Amid Pandemic, U.S. Faculty Job Openings Plummet. *Science*. 6 October. Available at **https://www.sciencemag.org/careers/2020/10/amid-pandemic-us-faculty-job-openings-plummet**. Accessed 18 February 2021.

Levine FJ. 2021. *The Impact of COVID-19 on Early Career Scholars and Doctoral Scholars*. Testimony presented before the U.S. House of Representatives, Committee on Science, Space, and Technology, 25 February. Available at **https://science.house.gov/download/levine-testimony**. Accessed 23 March 2021.

Levine FJ, Nasir NS, Rios-Aguilar C, Gildersleeve RE, Rosich KJ, Bang M, Bell NE, Holsapple MA. 2021. *Voices from the Field: The Impact of COVID-19 on Early Career Scholars and Doctoral Students*. American Educational Research Association; Spencer Foundation. Available at **https://doi.org/10.3102/aera20211**. Accessed 23 March 2021.

Martel M. 2020a. *COVID-19 Effects on U.S. Higher Education Campuses: From Emergency Response to Planning for Future Student Mobility*. Institute of International Education, COVID-19 Snapshot Survey Series, Report 2. May. Available at **https://www.iie.org/-/media/Files/Corporate/Publications/COVID-19-Survey-2-Report-WEBSITE.ashx?la=en&hash=B0B2FCFCECB1CD070E86B417F79680BEC66830B9**. Accessed 18 February 2021.

Martel M. 2020b. *COVID-19 Effects on U.S. Higher Education Campuses: New Realities for Global Student Mobility in Summer and Fall 2020.* Institute of International Education, COVID-19 Snapshot Survey Series, Report 3. July. Available at **https://www.iie.org/-/media/Files/Corporate/Publications/COVID-19-Survey-3-Report-WEBSITE.ashx?la=en&hash=A797C622E2BFAA7C7B3B26D1E1DBBBB456BE2C56**. Accessed 18 February 2021.

Mayer TS. 2020. *The Impact of the COVID-19 Crisis on University Research.* Testimony presented before the U.S. House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Research and Technology, 9 September. Available at **https://science.house.gov/download/09/08/2020/mayer-testimony**. Accessed 18 February 2021.

Morgan D, Sargent JF. 2020. *Effects of COVID-19 on the Federal Research and Development Enterprise*. Congressional Research Service. Available at **https://crsreports.congress.gov/product/pdf/R/R46309**. Accessed 18 February 2021.

Muzzio R. 2020. *The Impact of the COVID-19 Crisis on University Research.* Testimony presented before the U.S. House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Research and Technology, 9 September. Available at **https://science.house.gov/imo/media/doc/Muzzio%20Testimony.pdf**. Accessed 18 February 2021.

Myers KR, Tham WY, Yin Y, Cohodes N, Thursby JG, Thursby MC, Schiffer P, Walsh JT, Lakhani KR, Wang D. 2020. Unequal Effects of the COVID-19 Pandemic on Scientists. *Nature Human Behavior*, 4:880–883. 15 July. Available at **https://www.nature.com/articles/s41562-020-0921-y**. Accessed 18 February 2021.

National Academies of Sciences, Engineering, and Medicine (NASEM). 2019. *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce.* Washington, DC: The National Academies Press. Available at **https://doi.org/10.17226/25257**. Accessed 13 November 2020.

National Center for Science and Engineering Statistics (NCSES). 2009. *Survey of Graduate Students and Postdoctorates in Science and Engineering 2009 (GSS 2009)*. Detailed Statistical Tables NSF 12-300. Alexandria, VA: National Science Foundation. Available at **https://www.nsf.gov/statistics/nsf12300/**.

National Center for Science and Engineering Statistics (NCSES). 2019. *Survey of Earned Doctorates 2019 (SED 2019).* Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21308/data-tables**.

National Center for Science and Engineering Statistics (NCSES). 2019. *Survey of Graduate Students and Postdoctorates in Science and Engineering 2019 (GSS 2019)*. Data Tables NSF 21-318. Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21318**.

National Center for Science and Engineering Statistics (NCSES). 2020. *Science and Engineering Research Facilities: Fiscal Year 2019*. Detailed Statistical Tables NSF 21-311. Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21311**.

National Center for Science and Engineering Statistics (NCSES). 2021. *Higher Education Research and Development Survey: Fiscal Year 2019 (HERD 2019)*. Detailed Statistical Tables NSF 21-314. Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21314**.

National Center for Science and Engineering Statistics (NCSES). 2021. *Women, Minorities, and Persons with Disabilities in Science and Engineering 2021 (WMPD 2021).* Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21321/**.

National Center for Science and Engineering Statistics (NCSES). 2021. *National Patterns of R&D Resources: 2018–19 Data Update*. Detailed Statistical Tables NSF 21-325. Alexandria, VA: National Science Foundation. Available at **https://ncses.nsf.gov/pubs/nsf21325**.

National Research Council (NRC). 2012. *Research Universities and the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security*. Available at **https://www.nationalacademies.org/our-work/research-universities-and-the-future-of-america**. Accessed 9 June 2021.

National Science Board (NSB), National Science Foundation. 2018. *Science and Engineering Indicators 2018 (Indicators 2018).* NSB-2018-1. Alexandria, VA. Available at **https://www.nsf.gov/statistics/2018/nsb20181/**. Accessed 26 March 2019.

Ogilvie C, Brooks TR, Ellis C, Gowen G, Knight K, Perez RJ, Rodriguez SL, Schweppe N, Smith LL, Smith RA. 2020. *NSF RAPID: Graduate Student Experiences of Support and Stress During the COVID-19 Pandemic*. Available at **https://www.montana.edu/covid19_rapid/new%20NSF_RAPID_GraduateStudentExperiences_Covid19_White_Paper.pdf**. Accessed 23 March 2021.

Organisation for Economic Co-operation and Development (OECD). 2015. *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development.* 7th ed. Paris.

Organisation for Economic Co-Operation and Development (OECD). 2020. *Main Science and Technology Indicators.* Vol. 2020/1. Paris. Available at **https://www.oecd.org/science/msti.htm**. Accessed 1 November 2020.

Ro C. 2020. Pandemic Harms Canadian Grad Students' Research and Mental Health. *Nature*. 18 August. Available at **https://www.nature.com/articles/d41586-020-02441-y**. Accessed 18 February 2021.

Sargent JF. 2020. Global Research and Development Expenditures: Fact Sheet. Congressional Research Service. Available at **https://crsreports.congress.gov/product/pdf/R/R44283**. Accessed 19 March 2021.

Servick K, Cho A, Couzin-Frankel J, Guglielmi G. 2020. Coronavirus Disruptions Reverberate through Research. *Science* 367(6484):1289–90. 20 March. Available at **https://science.sciencemag.org/content/367/6484/1289**. Accessed 18 February 2021.

Sloan V, Haacker R, Batchelor R, Garza C. 2020. How COVID-19 Is Affecting Undergraduate Research Experiences. *Eos*. 18 June. Available at **https://eos.org/science-updates/how-covid-19-is-affecting-undergraduate-research-experiences**. Accessed 18 February 2021.

Stone D. 2020. *The Impact of the COVID-19 Crisis on University Research.* Testimony presented before the U.S. House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Research and Technology, 9 September. Available at **https://science.house.gov/imo/media/doc/Stone%20Testimony.pdf**. Accessed 18 February 2021.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). 2020. Global Investments in R&D. Fact Sheet No. 59. **http://uis.unesco.org/sites/default/files/documents/fs59-global-investments-rd-2020-en.pdf**. Accessed 19 March 2021.

University of California, Berkeley, Goldman School of Public Policy, Center for Studies in Higher Education. 2021. *SERU COVID-19 Survey Policy Briefs*. Available at **https://cshe.berkeley.edu/seru-covid-survey-reports**. Accessed 14 April 2021.

Upadhaya S, Yu JX, Oliva C, Hooton M, Hodge J, Hubbard-Lucey VM. 2020. Impact of COVID-19 on Oncology Clinical Trials. *Nature Reviews Drug Discovery*. 18 May. Available at **https://www.nature.com/articles/d41573-020-00093-1**. Accessed 18 February 2021.

Viglione G. 2020. Are Women Publishing Less during the Pandemic? Here's What the Data Say. *Nature.* 20 May. Available at **https://www.nature.com/articles/d41586-020-01294-9**. Accessed 18 February 2021.

Vincent-Lamarre P, Sugimoto CR, Larivière V. 2020. The Decline of Women's Research Production During the Coronavirus Pandemic. *Nature Index*. 19 May. Available at **https://www.natureindex.com/news-blog/decline-women-scientist-research-publishing-production-coronavirus-pandemic**. Accessed 18 February 2021.

Walsh JT. 2020. *The Impact of the COVID-19 Crisis on University Research.* Testimony presented before the U.S. House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Research and Technology, 9 September. Available at **https://science.house.gov/imo/media/doc/Walsh%20Testimony.pdf**. Accessed 18 February 2021.

Wigginton NS, Cunningham RM, Katz RH, Lidstrom ME, Moler KA, Wirtz D, Zuber MT. 2020. Moving Academic Research Forward during COVID-19. *Science* 368(6496): 1190–92. 12 June. Available at **https://science.sciencemag.org/content/368/6496/1190**. Accessed 18 February 2021.

Woolston C. 2020a. 'It's Like We're Going Back 30 Years': How the Coronavirus is Gutting Diversity in Science. *Nature*. 31 July. Available at **https://www.nature.com/articles/d41586-020-02288-3**. Accessed 18 February 2021.

Woolston C. 2020b. Signs of Depression and Anxiety Soar among U.S. Graduate Students during Pandemic. *Nature.* 18 August. Available at **https://www.nature.com/articles/d41586-020-02439-6**. Accessed 18 February 2021.

Woolston C. 2020c. Pandemic Darkens Postdocs' Work and Career Hopes. *Nature.* 8 September. Available at **https://www.nature.com/articles/d41586-020-02548-2**. Accessed 18 February 2021.

Notes

1 Data in this section are drawn from the National Center for Science and Engineering Statistics (NCSES) National Patterns of R&D Resources, the same source used in the *Indicators 2022* report "Research and Development: U.S. Trends and International Comparisons." Totals from this source may differ from those used in the rest of the report, which are from the Higher Education Research and Development Survey (2010 onward) and its predecessor, the Survey of Research and Development Expenditures at Universities and Colleges (1972–2009), for reasons outlined in more detail in note 4.

2 For examples of different types of research, see OECD (2015): 50–57.

3 U.S. basic research in 2018 totaled $101.1 billion. Businesses were the second-largest performer of basic research (29%). For more detail, see the forthcoming *Indicators 2022* report "Research and Development: U.S. Trends and International Comparisons."

4 In the rest of this report, financial data on academic R&D are drawn 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). HERD data are in current-year dollars and are reported on an academic year basis. For example, FY 2019 covers July 2018–June 2019 for most institutions and is referred to in this report as 2019. Comparisons over more than one year are made in inflation-adjusted constant 2012 dollars using GDP-implicit price deflators based on calendar year. GDP deflators come from the U.S. Bureau of Economic Analysis and are available at **https://www.bea.gov/national**, accessed August 2020. The totals presented from HERD differ from similar totals reported in NCSES's National Patterns of R&D Resources and *Indicators 2022* report "Research and Development: U.S. Trends and International Comparisons." These other sources remove approximately $7 billion in pass-through funds that are double counted in the HERD totals because such funds are counted by the universities initially receiving the money and by the universities to which the funds are passed. These other sources also present calendar year approximations based on fiscal year data.

5 Applied research has increased from 25% to 28%, and development has increased from 8% to 9%. Starting in 2010, the HERD survey asked institutions to categorize their R&D expenditures as either basic research, applied research, or development; prior surveys had asked how much total S&E R&D the institution performed and requested an estimate of the percentage of their R&D expenditures devoted to basic research. By only mentioning basic research, the survey question may have caused some respondents to classify a greater proportion of their activities in this category. The 2010 question provided definitions and examples of the three R&D categories to aid institutions in making more accurate assignments. In debriefing interviews, institutional representatives cited the changes in the survey question as the most important factor affecting their somewhat lower estimates of the amount of basic research institutions performed. The explicit inclusion of clinical trials and research training grants and the addition of non-S&E R&D may also have contributed.

6 The remainder, $3.3 billion (7%), is awarded by all other federal agencies.

7 The accounting systems or administrative practices of some universities, including some with very high research activity, do not enable the separation of the R&D component of multipurpose accounts. Because the HERD Survey measures only spending that is fully budgeted as R&D for these institutions, reported institutional funds are less than the full amount of academic R&D that the schools fund. More details on efforts to improve the measurement of institutionally financed R&D are in the HERD Technical Notes, available at **https://ncses.nsf.gov/pubs/nsf21314**.

8 *Unrecovered indirect costs* are calculated as the difference between an institution's negotiated indirect cost rate on a sponsored project and the amount that it recovers from the sponsor. *Committed cost sharing* is the sum of the institutional contributions required by the sponsor for specific projects (*mandatory cost sharing*) and the institutional resources made available to a specific project at the discretion of the grantee institution (*voluntary cost sharing*). For more on unrecovered indirect costs, see the section **Cost Components of Academic R&D**.

9 The 2019 HERD Survey included 916 institutions that had reported $150,000 or more in R&D expenditures during the previous fiscal year. For more detail on the survey population, see NCSES ***HERD 2019***: **Table A-4**.

10 Whether an institution is operated by publicly elected or appointed officials, or by privately elected or appointed officials and derives its major source of funds from private sources, is referred to as its control.

11 The Carnegie Classification of Institutions of Higher Education (**http://carnegieclassifications.iu.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 uses the 2018 Carnegie classification. 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 (i.e., exclusively biomedically focused institutions).

12 Of the 916 institutions included in the 2019 HERD Survey, 522 (57%) were public institutions and 394 (43%) were private institutions (NCSES ***HERD 2019***: **Table A-4**). Among the 131 very high research activity doctoral universities, 94 (72%) are public. Among the 63 U.S. institutions that are members of the Association of American Universities, 36 (57%) are public (**https://www.aau.edu/who-we-are/our-members**). Additionally, public universities, although less numerous overall, tend to be larger, as they enroll more students and award more degrees (*Indicators 2020* report "**Higher Education in Science and Engineering**").

13 These summations are of top R&D performers overall and include some institutions not in the very high research activity category. Johns Hopkins University includes the Applied Physics Laboratory, with $1.7 billion in total R&D expenditures in FY 2019.

14 In 2019, public universities received $1.1 billion (92%) of USDA's funding for academic R&D. Almost all of that funding ($990 million) went to the 75 public land-grant institutions reporting expenditures.

15 A total of 99 of these universities are public, and 60 are private.

16 There are currently 100 federally designated HBCUs, according to Department of Education data. Among research universities, the 2018 Carnegie classification includes 11 HBCUs designated as "high research activity."

17 For information on numbers of graduate students, postdocs, and nonfaculty researchers at HBCUs, see NCSES ***GSS 2019***: **Table 5-2**).

18 For more detail on HHEs, see the *Indicators 2020* report "**Higher Education in Science and Engineering**."

19 As shown in **Figure URD-12**, the percentage of total support for non-S&E fields provided by the federal government was lower, at around 25%.

20 An infographic displaying the difference between direct and indirect costs is available at **https://www.aau.edu/sites/default/files/Costs-of-Research-Infographic.pdf**. The history of indirect cost reimbursement in the context of the university–government research partnership is reviewed in Droegemeier (2017).

21 The academic R&D reported here includes separately accounted-for R&D and related recovered indirect costs. It also includes committed cost sharing and institutional estimates of unrecovered indirect costs associated with externally funded R&D projects. Some indirect costs are recovered as a result of indirect-cost proposals that universities submit based on their actual costs from the previous year.

22 Unrecovered indirect costs as a percentage of total institutional spending on R&D were about 27.5% for private universities and 27.0% for public universities.

23 An analysis of similar data is available in Atkinson and Foote (2019).

24 France did not report general university fund expenditures in 2017 but reported them in 2007 (and from 2008 through 2015). For Germany and South Korea, general university fund expenditures are included but not available separately.

25 More details on these and other research space trends are available on the NCSES website for the Survey of Science and Engineering Research Facilities at **https://nsf.gov/statistics/srvyfacilities/**.

26 Capitalized equipment spending is collected on the NCSES HERD Survey as payments for movable equipment exceeding an institution's capitalization threshold, including ancillary costs such as delivery and setup. The totals and trends presented here do not include purchases of research equipment that were below institutional capitalization thresholds, which may have changed over the long term. Some research equipment purchased through nonresearch accounts, such as equipment-only grants, is also excluded from the HERD survey and therefore not included in these totals. HERD respondents are directed to include R&D as defined by **OMB Circular A21, 2 CFR Part 200 Appendix III**, which also defines equipment and other capital expenditures.

27 For example, in 2019 two-thirds of S&E graduate students, including 55% of master's students and 82% of doctoral students, were at Carnegie very high research doctoral universities.

28 This report discusses *sources* and *mechanisms* of graduate student funding. Funding sources include federal, institutional, and personal or self-support, among others. Funding mechanisms include assistantships, fellowships, and traineeships, among others.

29 Starting with 2017, the Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS) collects data separately for master's and doctoral students. Analyses using GSS data in this report include health fields unless otherwise specified.

30 Personal sources include loans (including federal loans) or personal or family financial contributions.

31 In 2019, these were the most common funding mechanisms for S&E doctoral students (38% received RAs, 26% TAs, and 15% fellowships) (NCSES ***GSS 2019***: **Table 3-5**).

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

33 The data tables from 2009 do not separate out nonfederal sources of support for postdocs.

34 Data on this variation are produced by IRIS for its member universities.

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

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Gerald Blazey, Northern Illinois University

Nancy Calvin-Naylor, University of Michigan

Bryan Cook, Association of Public and Land-Grant Universities

Stephen Heinig, Association of American Medical Colleges

John King, University of California, Davis

Jan Palmowski, The Guild of European Research-Intensive Universities

Lydia Snover, Massachusetts Institute of Technology

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Report Authors

Josh Trapani
Senior Analyst
Science and Engineering Indicators Program
National Center for Science and Engineering Statistics
jtrapani@nsf.gov

NCSES

National Center for Science and Engineering Statistics
Directorate for Social, Behavioral and Economic Sciences
National Science Foundation
2415 Eisenhower Avenue, Suite W14200
Alexandria, VA 22314
Tel: (703) 292-8780
FIRS: (800) 877-8339
TDD: (800) 281-8749
ncsesweb@nsf.gov