



NATIONAL SCIENCE BOARD  
Science & Engineering Indicators



R&D

# Discovery: R&D Activity and Research Publications

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The National Science Board (Board) is required under the National Science Foundation (NSF) Act, 42 U.S.C. § 1863 (j) (1) to prepare and transmit the biennial *Science and Engineering Indicators (Indicators)* report to the President and Congress every even-numbered year. The report is prepared by the National Center for Science and Engineering Statistics (NCSES) within NSF under the guidance of the Board. It is subject to extensive review.

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# Executive Summary

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## Overall R&D Scale and Growth

**The United States maintained a large and expanding research and experimental development (R&D) enterprise in 2023, with total R&D expenditures reaching \$940 billion. The United States had the largest national R&D investment in 2022 using internationally comparable data.**

- In 2023, the United States performed an estimated \$940 billion in R&D across all sectors of the economy, up from \$892 billion in 2022 in current (nominal) U.S. dollars, an increase of 5% (2% in constant, or inflation-adjusted, 2017 U.S. dollars).
- When adjusted for international comparability, the United States had \$923 billion in gross domestic expenditures on R&D (GERD) in 2022, up 12% in current purchasing power parity (PPP) dollars from 2021. China recorded the second-highest GERD at \$812 billion, up 16% in current PPP dollars from 2021.
- GERD-to-gross domestic product (GDP) ratios, or national R&D intensities, are a useful summary measure to compare across economies. In 2022, Israel (6.0%) and South Korea (5.2%) topped this indicator, while seven economies had intensities between 3.0% and 4.0%, including Taiwan (4.0%), the United States (3.6%), Japan (3.4%), and Germany (3.1%). China's GERD-to-GDP ratio was 2.6%, and the European Union (EU-27) had a ratio of 2.1%.

## Sectoral Performance and Funding Distribution

**The business sector performed and funded the vast majority of R&D in the United States in 2023, accounting for 78% and 75% of these categories, respectively, and driving two-thirds of total U.S. R&D performance to focus on experimental development.**

### Performance

- The business sector performed the largest amount of R&D in the U.S. economy in 2023 (\$735 billion, or 78% of total U.S. R&D performance). Business R&D performance compound annual growth rate (CAGR) since 2013 was more than double the CAGR of all other sectors (6% in constant dollars).
- The higher education sector was the second-largest R&D performer in 2023 (\$102 billion, or 11% of total U.S. R&D performance), with 3% CAGR in constant dollars since 2013.
- The federal government was the third-largest R&D performer in 2023 (\$74 billion, or 8% of total U.S. R&D performance). This amount includes \$44 billion in R&D performed by federal agencies and \$29 billion performed by federally funded R&D centers. Federal R&D performance has changed little since 2013, with 1% CAGR in constant dollars.
- In 2023, about two-thirds of U.S. R&D performance across all sectors was for experimental development (67%), followed by applied research (18%) and basic research (15%). The large share of experimental development in total U.S. R&D performance is consistent with the role of the business sector as the largest performer (and funder) of R&D, given its focus on R&D on closer-to-market applications.

### Funding

- Businesses funded 75% of U.S. total R&D performed by all sectors in 2023, compared with 18% funded by the federal government. Between 2012 and 2023, the share of basic research performed across all sectors funded by businesses grew from 21% to an estimated 35%, while the federal government's share of basic research funding decreased from 52% to 41%.

- In FY 2023, 25% of federal R&D obligations were devoted to basic research (\$47 billion), 29% to applied research (\$54 billion), and 46% to experimental development (\$85 billion). About 43% of basic research and applied research obligations were dedicated to life sciences research, primarily from the U.S. Department of Health and Human Services.

## Industry Concentration and Key Focus Areas

**U.S. business sector R&D performed by companies with 10 or more domestic employees reached \$692 billion in 2022. Business sector R&D focused on critical technologies, such as biotechnology, artificial intelligence (AI), and nanotechnology, was concentrated in specific industries.**

- In 2022, about 80% of the \$692 billion of U.S. business R&D performed by companies with 10 or more domestic employees occurred in 5 industries: information (26%); chemicals manufacturing (18%); computer and electronic products manufacturing (including semiconductors) (15%); professional, scientific, and technical services (11%); and transportation equipment manufacturing (10%).
- In 2022, domestic software R&D performed in any industry accounted for 42% (\$292 billion) of U.S. R&D performed by businesses with 10 or more domestic employees.
- Biotechnology R&D accounted for 17% of total U.S. business R&D performed by businesses with 10 or more domestic employees in 2022. Three-fourths (75%, or \$87 billion) of biotechnology-focused R&D was performed within the pharmaceuticals and medicine manufacturing industry.
- U.S. businesses with 10 or more domestic employees performed \$37 billion of R&D in the AI technology focus area in 2022, and 43% of AI R&D was performed in the information industry.
- Nanotechnology R&D accounted for only 5% of total U.S. business R&D performed by businesses with 10 or more domestic employees but made up 58% (\$29 billion) of the R&D performed by the semiconductor manufacturing industry.

## Global Research Publications

**The United States maintained its position as a leading global producer of high-quality scientific research, demonstrating strength in research impact with high shares of highly cited publications in most S&E fields. However, China's gross publication output and growth outpaced those of the United States.**

- In 2023, four countries each produced more than 100,000 peer-reviewed articles; combined, these countries accounted for over 50% of worldwide article output: China, the largest producer, followed by the United States, India, and Germany.
- China's publication output has grown rapidly since 2003 and is now more than twice that of the United States.
- The top field for authors based in China was engineering (26% of all publications); in the United States, it was health sciences (36% of all publications); in India, it was computer and information sciences (28% of all publications); and in Germany, it was health sciences (24% of all publications).
- Since 2006, authors in the United States and the EU-27 have continued to publish large shares of highly cited S&E articles relative to their total output. During this period, the relative share of highly cited S&E articles published by authors in China has increased steadily, although it remains below those of authors in the United States and the EU-27.
- S&E publications coauthored by U.S. researchers with international collaborators have increased in number and as a share of U.S. publication output over the last 15 years, with researchers in China as the most frequent collaborators, although collaborations with authors based in China have decreased since 2019.

# Introduction

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U.S. and international research and experimental development (R&D) and one of its early results, research publications output, are important indicators of the performance of the U.S. science and engineering (S&E) ecosystem in a global context.<sup>1</sup> R&D contributes to economic output and productivity growth and supports national defense, cybersecurity, health, energy, physical infrastructure, environmental protection, and other national priorities (Baily, Bosworth, and Doshi 2020; Bloom et al. 2020; CRS 2020, 2023a; NASEM 2020). Research publications, in the form of peer-reviewed journal articles and conference proceedings, are important media for sharing scientific discoveries and contribute to a corpus of scientific knowledge that provides a foundation for future research and innovation.

R&D refers to creative and systematic work aimed at increasing the stock of knowledge and is broken down into three types of R&D: basic research, applied research, and experimental development (OECD 2015). R&D statistics are presented by major performing and funding sectors, by type of R&D, by intensity measures relative to gross domestic product (GDP) across economies, and by S&E fields. U.S. R&D data in this report are from the National Center for Science and Engineering Statistics (NCSES), U.S. National Science Foundation (NSF), including the National Patterns of R&D Resources (henceforth, *National Patterns*) database (NCSES 2025d). The Organisation for Economic Co-operation and Development (OECD) Main Science and Technology Indicators (MSTI) and the Analytical Business Enterprise Research and Development (ANBERD) databases are the sources for international R&D statistics (OECD 2024a, 2024d). Dollar amounts are reported in current (nominal) terms unless otherwise noted. All years are calendar years unless otherwise noted.

Research outputs are the result of inputs (often measured as R&D expenditures or numbers of scientists and engineers) and of the productivity or process efficiency using these inputs across different technologies, industries, institutional context, and geographies (Bloom et al. 2020). Outputs and outcomes include research publications as well as patents, licenses, products, and the formation of firms such as technology startups later in the innovation process (Ahmadpoor and Jones 2017; Aksnes et al. 2017; Kolev et al. 2022). Analyses of publication output covered in this report are indicators of research partnerships and scientific activity by location, sector, and field. Citation analysis and related research on diffusion and knowledge spillovers may be used to identify key linkages between public and private R&D, scientific output, and socioeconomic uses and impacts of R&D (Adams 1990; Akcigit, Hanley, and Serrano-Velarde 2021; Arora, Belenzon, and Sheer 2021; Arora et al. 2023; Crespi and Geuna 2005; Czarnitzki and Thorwarth 2012; Stephan 2012; Yin et al. 2022). Publications, citations, and scientific impact are analyzed in this report using bibliometric data from over 47 million English-language articles published from 2002 to 2023 using data from Scopus, a database of scientific literature with English-language titles and abstracts (Science-Metrix 2021a).<sup>2</sup> Research output in the form of patents and other forms of intellectual property (IP) protection will be covered in a separate *Science and Engineering Indicators 2026* report.

This report is the first *Indicators 2026* thematic report covering indicators from inputs for knowledge creation to dissemination, the resulting inventions and products, and other outcomes. Future thematic reports will focus on “STEM Talent: Education, Training, and Workforce” (education, training, and employment of scientists, engineers, and skilled technical workers) and “Translation to Impact: U.S. and Global Science, Technology, and Innovation Output” (IP trends, patent citations of scientific publications, and other measures of spillovers or technology transfer, venture capital, production output, and international trade).

# Trends in U.S. R&D Performance and Funding

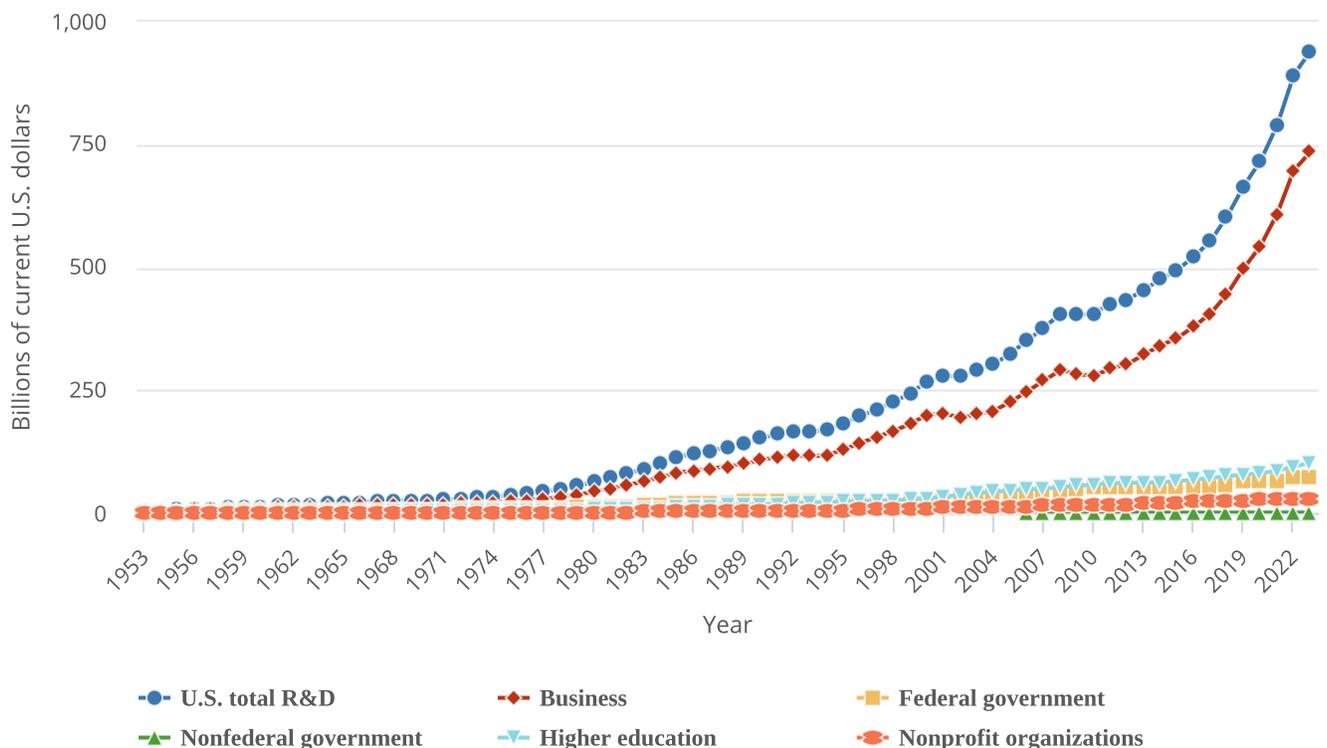
R&D activity presented in this report is measured as R&D performance and R&D funding. Performance of R&D focuses on the organization or sector that conducts R&D activities, which may be funded from a variety of internal and external sources. R&D funding refers to financial resources that may be devoted to internal R&D or to pay for R&D performed by other organizations or sectors. R&D-performing and R&D-funding sectors include businesses, governments, higher education institutions, and nonprofit organizations (OECD 2015).

As detailed further below, the business sector is by far the largest U.S. R&D-performing and R&D-funding sector; the federal government is the second-largest funding source. Higher education R&D performance has grown slowly, but steadily, in recent years, whereas R&D performance by the federal government has declined slightly since 2021 when adjusted for inflation.

## U.S. Total R&D and R&D Intensity

Recent growth in overall U.S. R&D performance is consistent with historical growth rates and is driven by the rapid growth of R&D performed by the business sector. The United States performed \$891.8 billion in 2022 and an estimated \$939.6 billion in 2023 in current U.S. dollars (Figure DISC-1, Figure DISC-2; Table DISC-1) (NCSES 2025d).<sup>3</sup> This is an increase of 5% from 2022 (2% in constant [inflation-adjusted] 2017 U.S. dollars).<sup>4</sup> Since 1953, U.S. R&D performance has increased annually at a 3% compound annual growth rate (CAGR) in constant dollars (NCSES 2025d: Table 1). For the past three decades, the CAGR for total U.S. R&D expenditures has fluctuated between 2% and 5%, driven largely by business sector performance (Figure DISC-3). From 2013 to 2023, business R&D performance grew at an annual CAGR of 6% in constant dollars, the highest sectoral growth rate over this period.

Figure DISC-1. U.S. R&D, by performing sector: 1953–2023



**Note(s):**

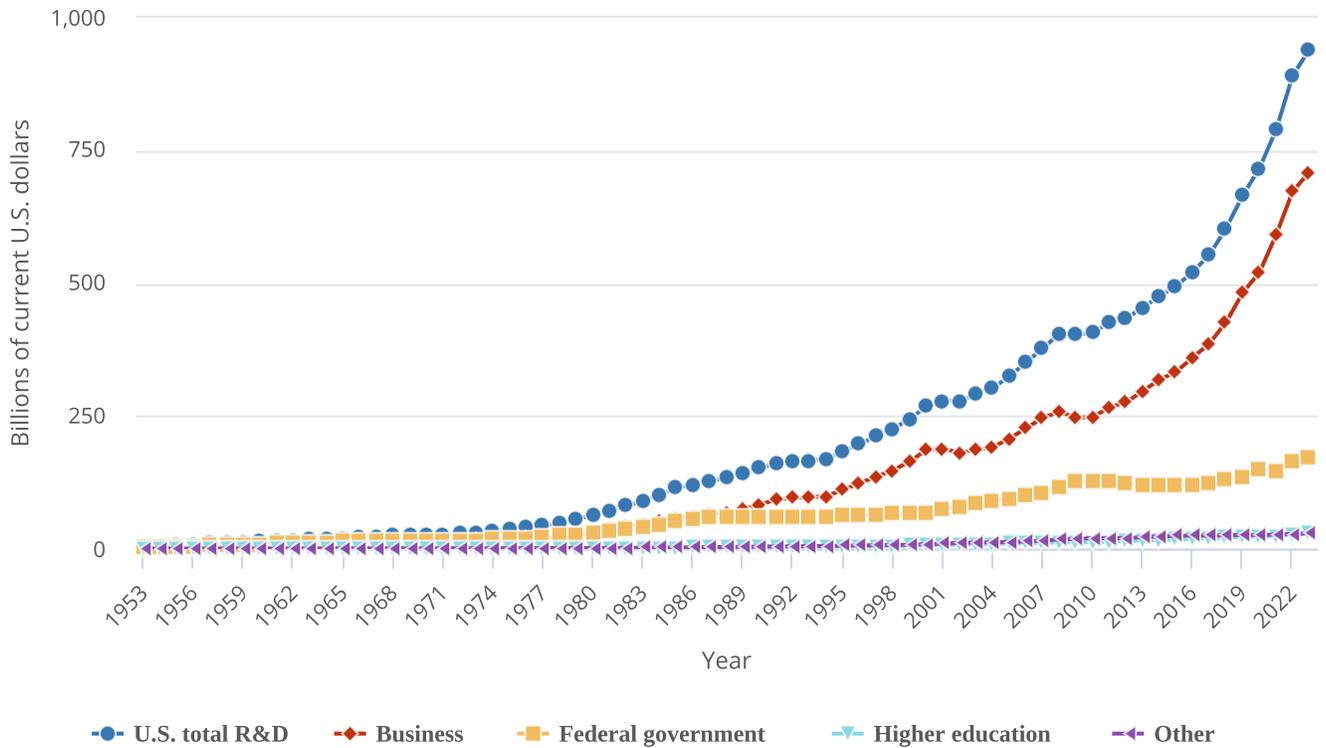
Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded R&D centers. Nonfederal government R&D performance is that of state governments (data in this series were not available prior to 2006). For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2022–23 edition).

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

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**Figure DISC-2. U.S. R&D, by source of funds: 1953–2023**



**Note(s):**

Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded R&D centers. R&D funding listed as Other combines data from nonfederal government (state and local) and nonprofit organizations. For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2022–23 edition).

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

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Table DISC-1. U.S. R&amp;D expenditures, by performing sector and source of funds: 2010–23

(Millions of current and constant 2017 dollars)

Performing sector and source of funds	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022 <sup>a</sup>	2023 <sup>b</sup>
Current \$millions														
All performing sectors	406,599	426,214	433,698	454,232	475,938	494,471	521,686	553,530	603,844	665,267	716,479	788,718	891,834	939,561
Business	278,977	294,092	302,251	322,528	340,728	355,821	379,529	405,792	445,563	498,175	543,220	608,625	697,256	734,959
Federal government	50,798	53,524	52,144	51,086	52,687	52,847	51,187	52,553	58,356	62,802	65,093	66,662	71,533	73,621
Federal intramural <sup>c</sup>	31,970	34,950	34,017	33,406	34,783	34,199	31,762	32,231	36,793	39,870	41,227	41,469	44,699	44,161
FFRDCs	18,828	18,574	18,128	17,680	17,903	18,649	19,424	20,322	21,563	22,932	23,866	25,193	26,834	29,460
Nonfederal government	691	694	665	620	583	595	620	632	643	675	683	685	719	742
Higher education	58,083	60,087	60,876	61,511	62,318	64,605	67,778	71,108	74,863	78,113	80,775	85,717	94,275	102,044
Nonprofit organizations	18,050	17,817	17,762	18,487	19,622	20,604	22,573	23,445	24,419	25,503	26,709	27,030	28,052	28,195
All funding sources	406,599	426,214	433,698	454,232	475,938	494,471	521,686	553,530	603,844	665,267	716,479	788,718	891,834	939,561
Business	248,126	266,426	275,728	297,188	318,410	333,243	360,291	386,533	426,472	482,199	520,324	590,946	673,127	709,161
Federal government	126,617	127,014	123,837	120,131	118,367	119,532	118,174	122,435	131,017	135,646	147,985	147,258	164,471	172,345
Nonfederal government	4,303	4,386	4,158	4,244	4,214	4,277	4,995	5,075	5,251	5,471	5,672	5,733	6,010	6,382
Higher education	12,262	13,103	14,282	15,341	16,176	17,260	18,729	19,878	20,987	21,882	22,557	23,786	26,560	29,043
Nonprofit organizations	15,292	15,284	15,694	17,327	18,771	20,160	19,497	19,608	20,118	20,070	19,940	20,996	21,665	22,629
Constant 2017 \$millions														
All performing sectors	453,633	465,904	465,418	479,297	493,604	508,109	531,030	553,530	590,321	639,808	680,024	715,899	755,622	768,410
Business	311,248	321,479	324,357	340,326	353,376	365,635	386,327	405,792	435,585	479,111	515,581	552,433	590,762	601,079
Federal government	56,674	58,508	55,958	53,905	54,643	54,305	52,103	52,553	57,049	60,398	61,781	60,507	60,608	60,210
Federal intramural <sup>c</sup>	35,668	38,205	36,504	35,250	36,074	35,142	32,331	32,231	35,969	38,344	39,129	37,640	37,872	36,116
FFRDCs	21,006	20,303	19,453	18,656	18,568	19,163	19,772	20,322	21,080	22,054	22,652	22,867	22,736	24,094
Nonfederal government	771	758	713	654	605	611	631	632	629	649	648	622	609	607
Higher education	64,802	65,682	65,328	64,905	64,631	66,386	68,991	71,108	73,186	75,123	76,665	77,803	79,876	83,456
Nonprofit organizations	20,138	19,476	19,061	19,507	20,350	21,172	22,977	23,445	23,872	24,527	25,350	24,534	23,768	23,059
All funding sources	453,633	465,904	465,418	479,297	493,604	508,109	531,030	553,530	590,321	639,808	680,024	715,899	755,622	768,410
Business	276,828	291,237	295,894	313,588	330,229	342,434	366,744	386,533	416,921	463,746	493,850	536,386	570,319	579,981
Federal government	141,263	138,842	132,894	126,760	122,760	122,829	120,290	122,435	128,082	130,455	140,456	133,662	139,351	140,950
Nonfederal government	4,800	4,795	4,462	4,478	4,370	4,394	5,084	5,075	5,133	5,262	5,384	5,204	5,092	5,219
Higher education	13,680	14,323	15,326	16,188	16,776	17,736	19,064	19,878	20,517	21,044	21,409	21,590	22,504	23,753
Nonprofit organizations	17,061	16,707	16,841	18,284	19,468	20,716	19,846	19,608	19,668	19,302	18,925	19,057	18,356	18,507

FFRDC = federally funded research and development center.

<sup>a</sup> Some data for 2022 are preliminary and may be revised later.

<sup>b</sup> The data for 2023 include estimates and are likely to be revised later.

<sup>c</sup> Federal intramural includes expenditures of federal intramural R&D as well as costs associated with administering extramural R&D.

**Note(s):**

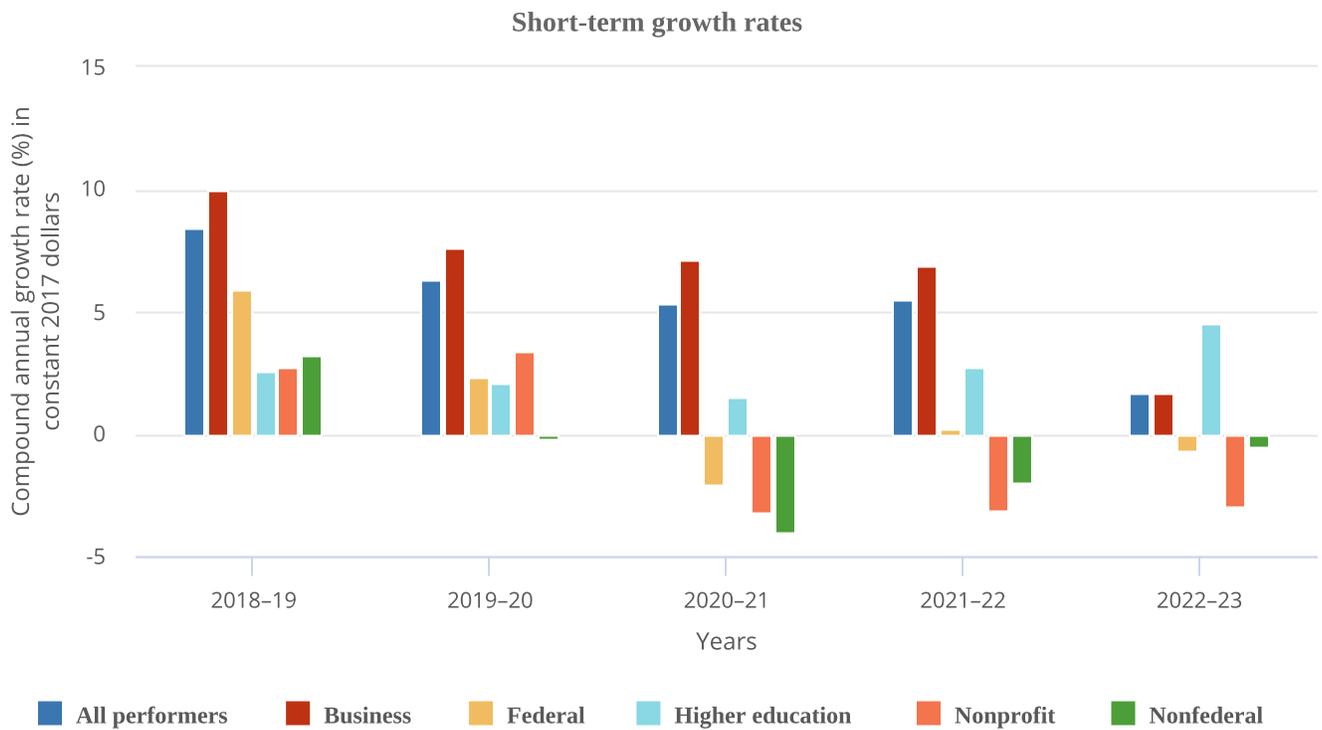
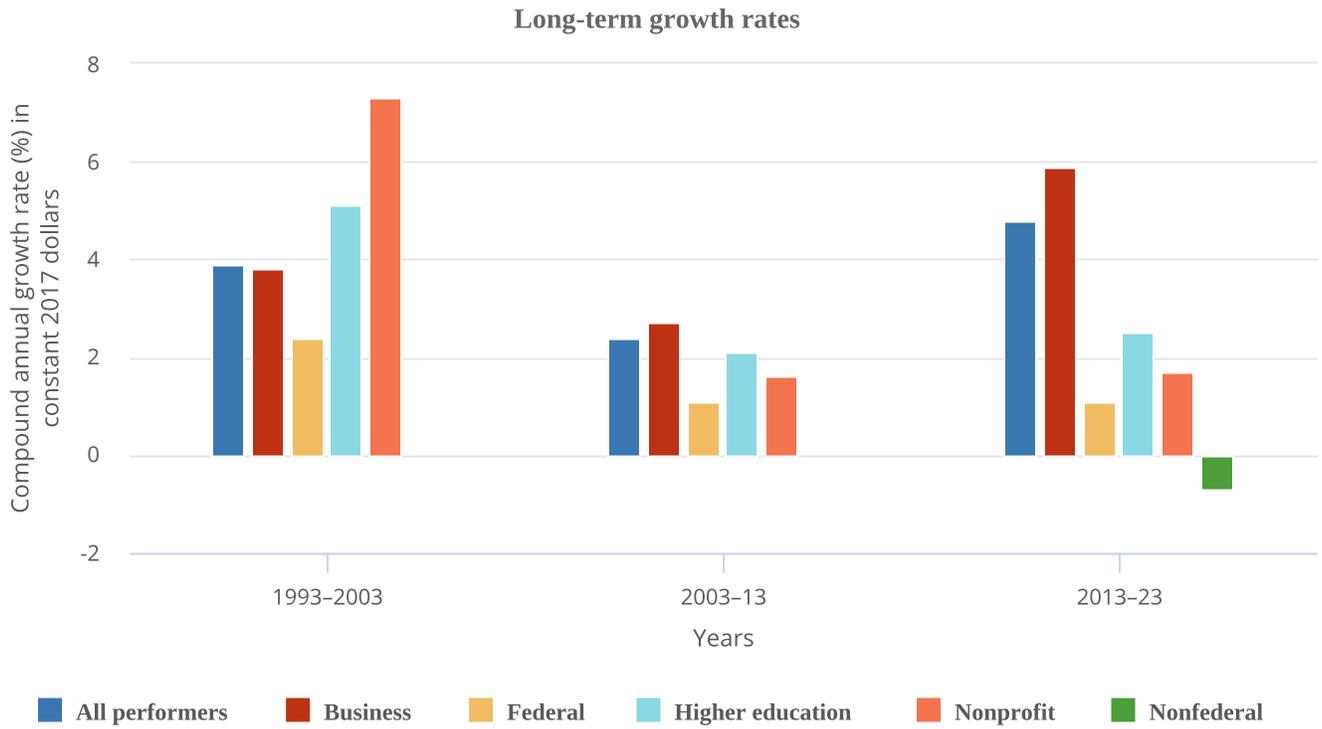
Data are based on annual reports by performers, except for the nonprofit sector. Expenditure levels for higher education, federal government, and nonfederal government performers are calendar year approximations based on fiscal year data.

**Source(s):**

National Center for Science and Engineering Statistics, *National Patterns of R&D Resources* (2022–23 edition).

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Figure DISC-3. Total U.S. R&D expenditures, by performer sector, with long- and short-term growth rates: 1993–2023



**Note(s):**

Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded R&D centers. Nonfederal government R&D performance is that of state governments (data in this series were not available prior to 2006). For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2022–23 edition).

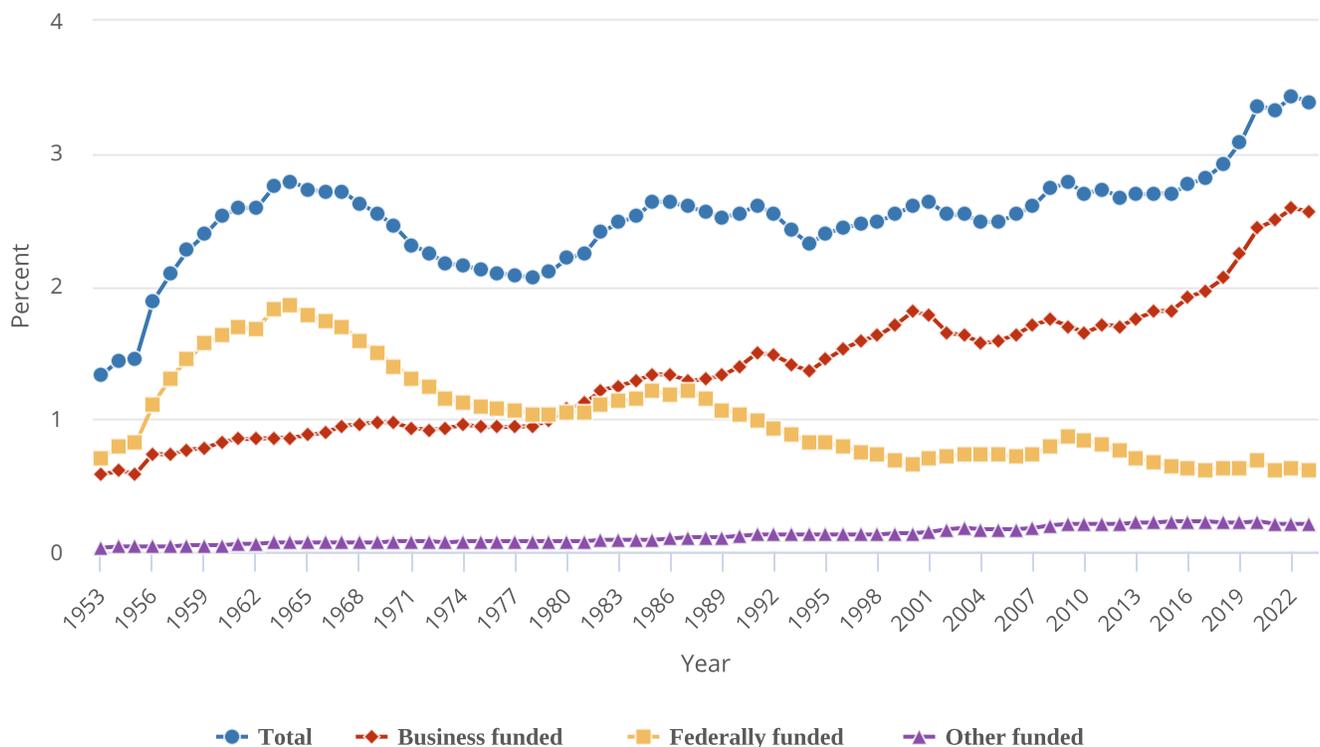
**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

Science and Engineering Indicators

National R&D intensity is the ratio of R&D expenditures to GDP. These intensities allow comparison across time, economies, and sectors. Since 2019, U.S. R&D intensity has been above 3.0%, reaching 3.4% in 2022 and 2023, based on National Patterns statistics ([Figure DISC-4](#)) (NCSES 2025d: [Table 1](#)).

**Figure DISC-4. Ratio of U.S. R&D to GDP, by funding source: 1953–2023**



GDP = gross domestic product.

**Note(s):**

Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. The Other funded category includes higher education, nonfederal government, and nonprofit organizations. The GDP data used reflect the Bureau of Economic Analysis statistics used in National Patterns of R&D Resources (2022–23 edition).

**Source(s):**

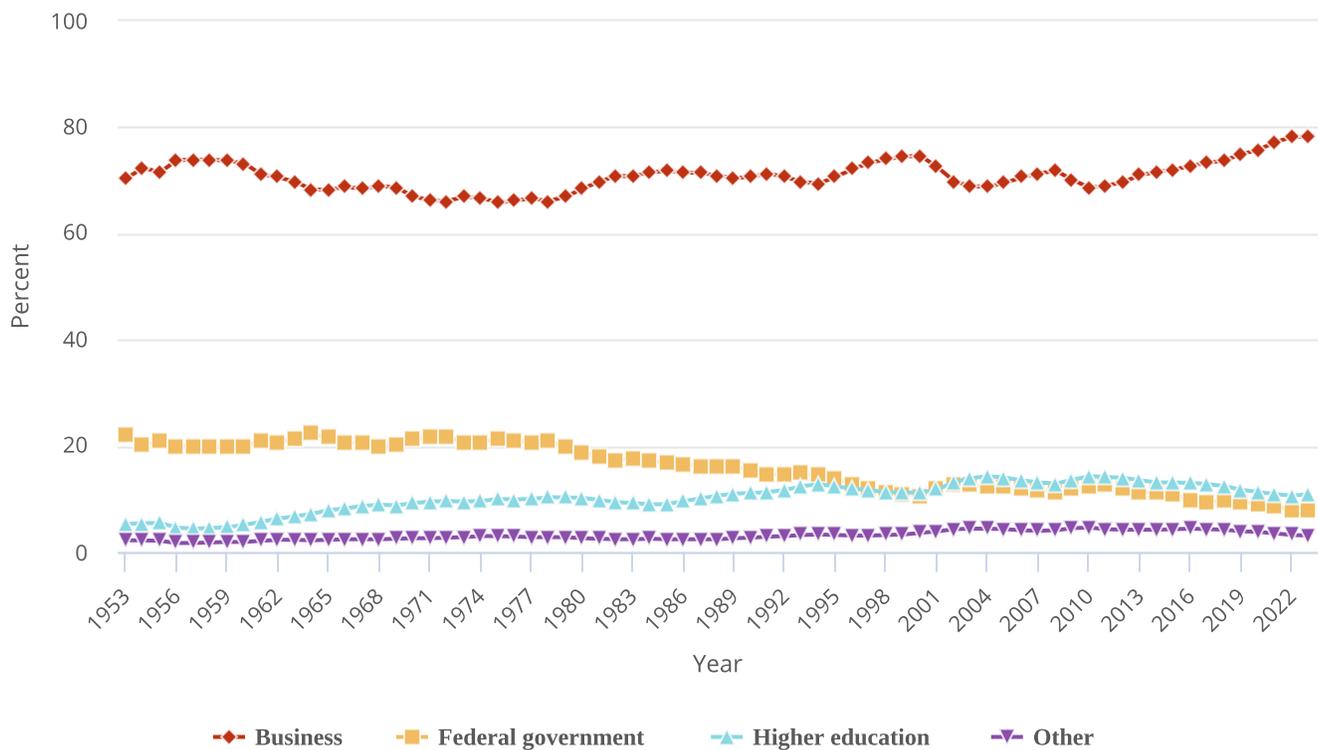
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

Science and Engineering Indicators

## R&D-Performing Sectors

The business sector is by far the largest U.S. R&D-performing sector, accounting for 78% of U.S. R&D performance in 2023, followed by the higher education sector (11%) and the federal government (8%) ([Figure DISC-5](#)).<sup>5</sup> The nonprofit sector and the nonfederal government sector (e.g., state and local governments) accounted for 3% and less than 1%, respectively.

Figure DISC-5. U.S. R&amp;D expenditures, shares by performing sector: 1953–2023

**Note(s):**

Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded R&D centers. R&D funding listed as Other combines data from nonfederal government (state and local) and nonprofit organizations. For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2022–23 edition).

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

Science and Engineering Indicators

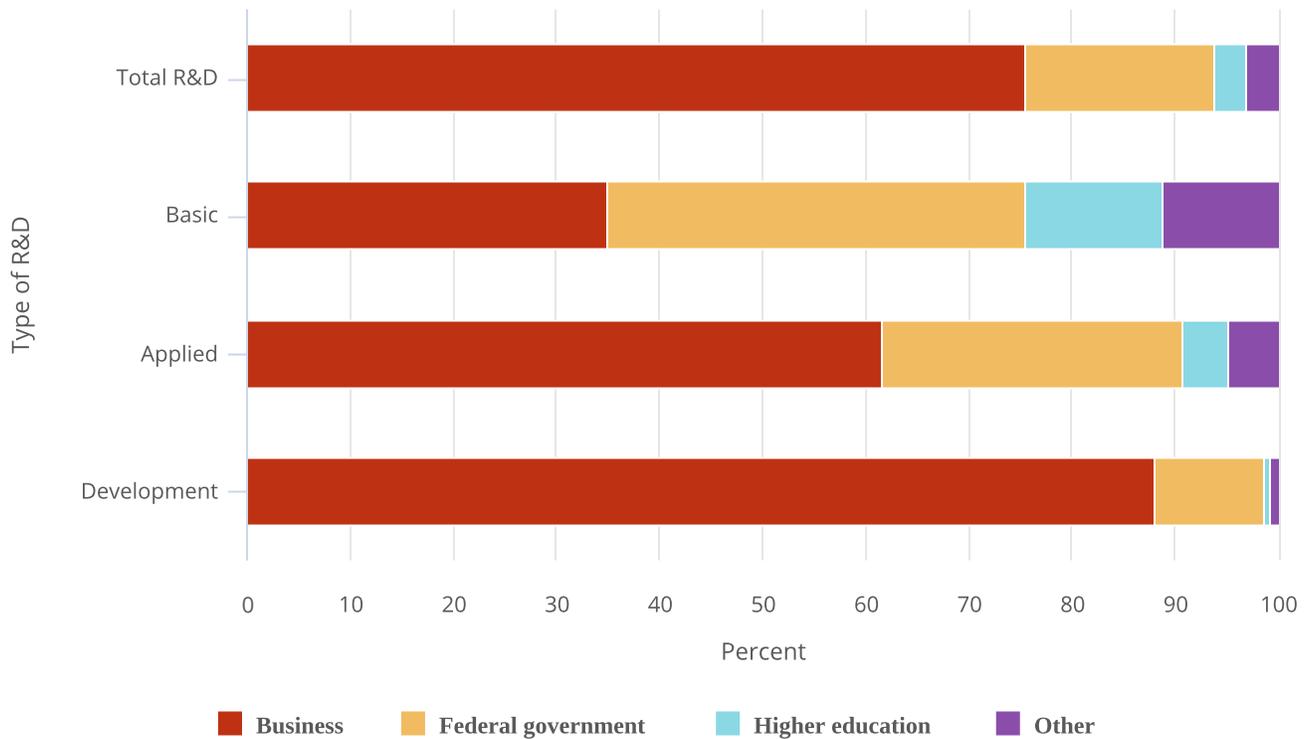
The business sector performed an estimated \$735.0 billion in domestic R&D in 2023 (current U.S. dollars), up from \$697.3 billion in 2022 for a 5% increase in current dollars and a 2% increase in constant dollars (Figure DISC-3; Table DISC-1).<sup>6</sup> This represented a 3% increase over 2022 in current dollars for the federal sector but a 1% decline in constant dollars (Table DISC-1). Since 2020, annual percent changes of federal R&D performance in constant dollars have been negative or below 1% (Figure DISC-3). Nonfederal government R&D performance in 2023 was estimated to be \$741.6 million in current dollars, or about 0.1% of the U.S. total. Nonprofit organizations (excluding higher education institutions, the federal government, and nonfederal governments) performed \$28.2 billion of R&D in 2023, or 3% of the total (Table DISC-1).

## Sources of Funding and Type of R&D

Businesses funded 75% of U.S. total R&D performed across all sectors in 2023, compared with 18% funded by the federal government. For basic research performed across all sectors, the federal government funded 41%, followed by 35% funded by businesses (Figure DISC-6). Historically, the business sector and the federal government are the largest funders of U.S. total R&D performance, with a combined funding share of over 90% since the 1950s. Since 1980, the business sector has accounted for the largest share of funding for R&D performance (Figure DISC-7). In the 70-year span from 1953 to 2023, business R&D funding grew at a 5% CAGR in constant 2017 dollars, compared with a 3% CAGR for federal government funding during the same period (NCSES 2025d: Table 6). Decadal growth rates of business R&D funding have exceeded federal R&D funding growth rates by at least 2% in CAGR constant dollar terms (NCSES 2025d: Table 1), except during the

late 1950s and 1960s—with this period’s anomalous government spending due in part to large increases in federal funding for space R&D (NCSES 2025a; NSB 2020b). [Figure DISC-8](#) presents long- and short-term growth rates by funding source. Business funding grew by 11% between 2018 and 2019 in constant dollars and has grown annually in the single digits since then. Federal R&D funding grew 8% between 2019 and 2020 in constant dollars, associated with COVID-19-related appropriations (Pece 2023, 2024); this was followed by a 5% decline in constant dollars in 2021. Overall, federal R&D funding growth rates averaged 1% annually in CAGR constant dollar terms over the 2013–23 period.

**Figure DISC-6. U.S. R&D, by type and funding source: 2023**



**Note(s):**

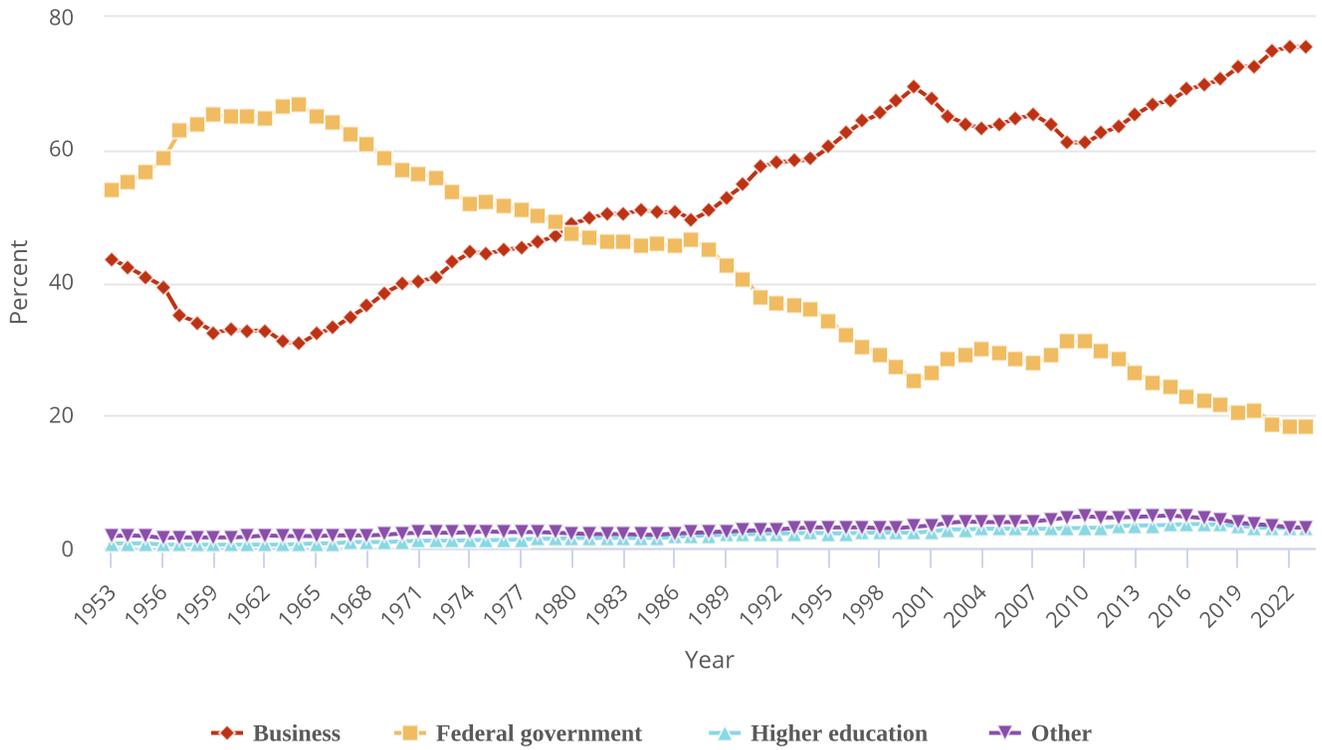
The data for 2023 are estimates and are likely to be revised later. R&D funding listed as Other combines data from nonfederal government (state and local) and nonprofit organizations.

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

*Science and Engineering Indicators*

Figure DISC-7. U.S. R&D expenditures, shares by funding sector: 1953–2023



**Note(s):**

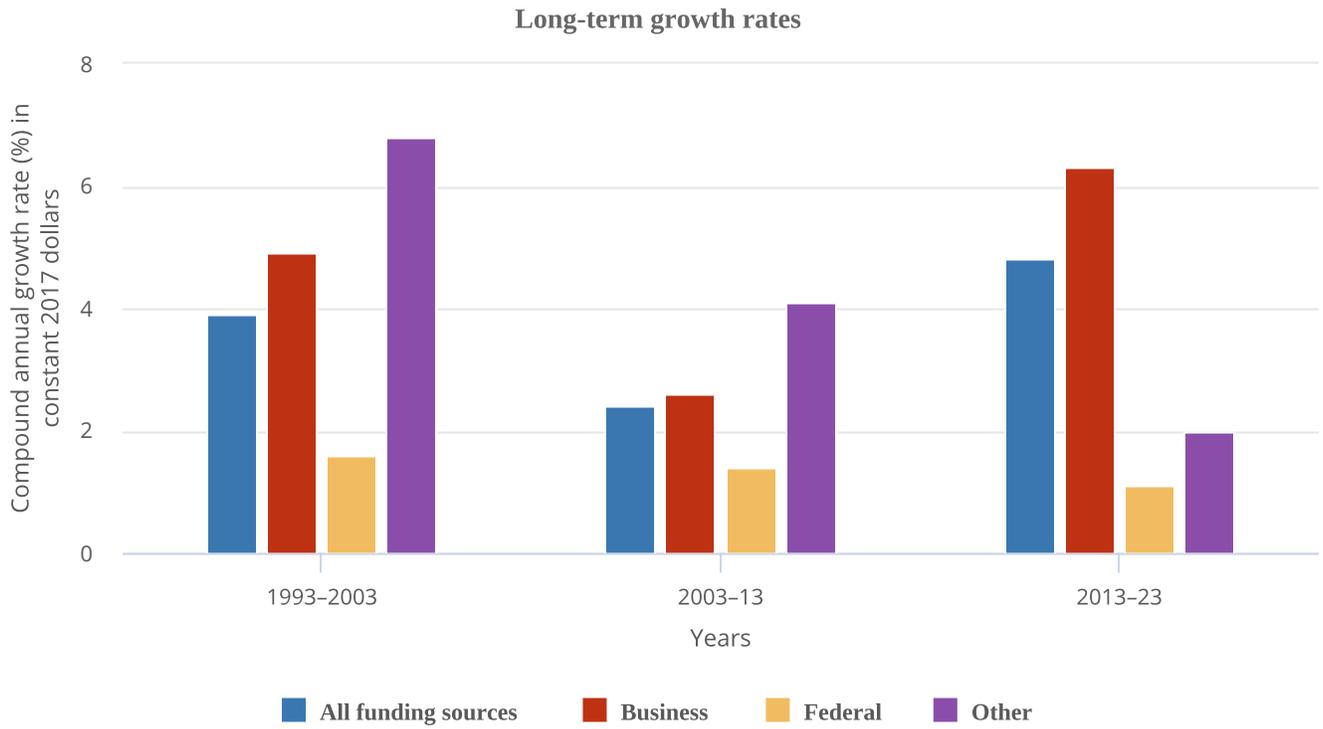
Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded R&D centers. R&D funding listed as Other combines data from nonfederal government (state and local) and nonprofit organizations. For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2022–23 edition).

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

Science and Engineering Indicators

Figure DISC-8. Total U.S. R&D expenditures, by source of funds, with long- and short-term growth rates: 1993–2023



**Note(s):**

Some data for 2022 are preliminary and may be revised later. The data for 2023 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded R&D centers. Other performers include higher education, nonprofit, and nonfederal government.

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2022–23 edition).

*Science and Engineering Indicators*

In 2023, the business sector funded an estimated \$709.2 billion, accounting for 75% of total U.S. R&D (Figure DISC-2) (NCSES 2025d: Table 6). Virtually all (99%) business R&D funding supported business R&D performance.<sup>7</sup> At the same time, however, government funding for R&D performed by academic institutions and federal laboratories also benefits corporate R&D in industries related to life sciences (Arora et al. 2023; CBO 2021; Furman et al. 2005; Toole 2012). The federal government was the second-largest source of funding for U.S. R&D, while other nonbusiness sectors accounted for smaller percentages. The federal government funded \$172.3 billion (18% of U.S. R&D) in 2023. The largest recipients were the higher education sector (31%), intramural federal R&D (26%), businesses (20%), and federally funded R&D centers (FFRDCs) (17%) (NCSES 2025d: Table 6).<sup>8</sup> The remaining sectors funded a total of 6% of U.S. total R&D: higher education (3%), nonprofits (2%), and state and other local or nonfederal governments (less than 1%).

Continuing a long-running trend, about two-thirds (67%) of U.S. R&D performance in 2022 was for experimental development (Table DISC-2). The large share of experimental development in total U.S. R&D performance is consistent with the role of the private business sector as the largest performer (and funder) of R&D, given its focus on R&D on closer-to-market applications. Basic research and applied research accounted for 15% and 18% of total U.S. R&D, respectively (Table DISC-2). The higher education sector performed about half (\$59.6 billion, or 46%) of the \$130 billion in basic research, followed by a third performed by the business sector (\$43.4 billion, or 33%). Further, of the \$59.6 billion in basic research performed by the higher education sector in 2022, the federal government funded 53%, and higher education itself funded another 28% of total U.S. basic research performance; see National Patterns data in (NCSES 2025d: Table 3).

**Table DISC-2. U.S. R&D expenditures, by type of R&D: Selected years, 2000–23**

(Billions of current dollars, billions of constant 2017 dollars, and percent distribution)

Type of R&D	2000	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022 <sup>a</sup>	2023 <sup>b</sup>
Billions of current dollars															
All R&D	267.9	406.6	426.2	433.7	454.2	475.9	494.5	521.7	553.5	603.8	665.3	716.5	788.7	891.8	939.6
Basic research	42.0	76.5	73.7	74.0	79.3	82.9	84.4	87.5	90.1	97.8	104.9	111.6	118.6	130.3	138.2
Applied research	56.5	78.9	81.7	86.6	88.0	91.6	97.1	109.5	113.3	118.2	130.1	132.4	143.7	161.6	170.4
Experimental development	169.4	251.2	270.8	273.1	287.0	301.4	313.0	324.7	350.1	387.8	430.3	472.5	526.4	600.0	631.0
Billions of constant 2017 dollars															
All R&D	368.5	453.6	465.9	465.4	479.3	493.6	508.1	531.0	553.5	590.3	639.8	680.0	715.9	755.6	768.4
Basic research	57.8	85.3	80.6	79.4	83.6	86.0	86.8	89.1	90.1	95.6	100.9	106.0	107.7	110.4	113.0
Applied research	77.7	88.0	89.3	93.0	92.8	95.0	99.7	111.4	113.3	115.6	125.1	125.6	130.4	136.9	139.4
Experimental development	233.0	280.3	296.0	293.1	302.8	312.6	321.6	330.5	350.1	379.1	413.8	448.5	477.8	508.3	516.0
Percent distribution															
All R&D	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Basic research	15.7	18.8	17.3	17.1	17.4	17.4	17.1	16.8	16.3	16.2	15.8	15.6	15.0	14.6	14.7
Applied research	21.1	19.4	19.2	20.0	19.4	19.2	19.6	21.0	20.5	19.6	19.6	18.5	18.2	18.1	18.1
Experimental development	63.2	61.8	63.5	63.0	63.2	63.3	63.3	62.2	63.3	64.2	64.7	65.9	66.7	67.3	67.2

<sup>a</sup> Some data for 2022 are preliminary and may be revised later.

<sup>b</sup> The data for 2023 are estimates and are likely to be revised later.

**Note(s):**

Data throughout the time series reported here are consistently based on the Organisation for Economic Co-operation and Development (OECD) *Frascati Manual 2015* (OECD 2015) definitions for basic research, applied research, and experimental development. Prior to 2010, however, some changes were introduced in the questionnaires of the sectoral expenditure surveys to improve the accuracy of respondents' classification of their R&D by type. Accordingly, small percentage changes in the historical data may not be meaningful.

**Source(s):**

National Center for Science and Engineering Statistics, *National Patterns of R&D Resources* (2022–23 edition).

*Science and Engineering Indicators*

Between 1953, the first year for which U.S. R&D expenditures are available, and 2012, the federal government funded the majority of basic research (performed across all sectors) in the United States. Since 2013, the share of basic research funded by the federal government has remained below 50%, largely due to increases in business sector funding over the last decade. Between 2012 and 2023, the share of basic research funded by the business sector grew from 21% to an estimated 35%, while the federal government's share of funding decreased from 52% to 41%. This decrease in the federal government's basic research funding share has occurred despite a constant dollar increase in funding expenditures between those years (NCSES 2025d: [Table 7](#)).

## U.S. Business R&D

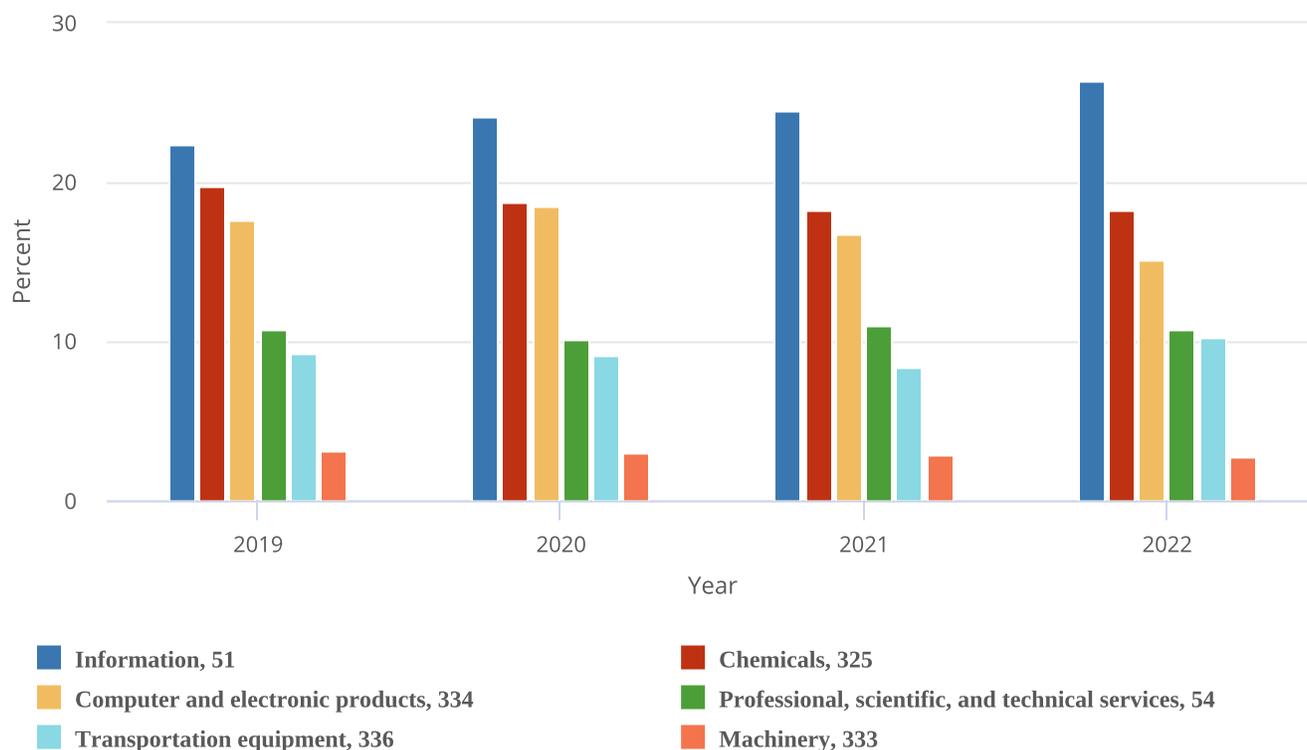
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The vast majority of business sector R&D is performed by companies with 10 or more employees. Of the \$697.3 billion of R&D performed by the business sector in 2022, \$691.5 billion was performed by companies with 10 or more domestic employees ([Table DISC-1](#)), and \$5.7 billion was performed by businesses with 9 or fewer domestic employees (or *microbusinesses*) (Hughes 2024; Kindlon 2024).<sup>9</sup> Early outputs from scientific research by the business sector include peer-reviewed publications and patents (Arora, Belenzon, and Sheer 2021; Arora et al. 2023). See the section [Output by Geography, S&E Field, and Sector](#) later in this report for information on publications by authors associated with the business sector (patents will be covered in the *Indicators 2026* report “Translation to Impact: U.S. and Global Science, Technology, and Innovation Output” [NSB forthcoming]). The rest of this section describes the scope and focus of U.S. industry R&D performance and funding.<sup>10</sup>

### Industries That Perform the Most U.S. Business R&D

Selected manufacturing and services industries accounted for the largest amount of R&D performance in 2022, most of which was internally funded but with notable differences in the source of external funding across industries. The largest proportion of the \$691.5 billion in R&D performed by businesses with 10 or more domestic employees in 2022 was conducted by the manufacturing sector (54%) ([Table DISC-3](#)).<sup>11</sup> Four-fifths of the \$691.5 billion was performed by five industries: information (including software publishing) at 26%; chemicals manufacturing (including pharmaceuticals and medicines) at 18%; computer and electronic products manufacturing (including semiconductors) at 15%; professional, scientific, and technical services (including R&D services) at 11%; and transportation equipment manufacturing (such as motor vehicles, including electric vehicles and aerospace products and parts) at 10% ([Figure DISC-9](#); [Table DISC-3](#)). Machinery manufacturing (which includes semiconductor machinery) performed another 3%. These six industries are R&D-intensive (also called *knowledge- and technology-intensive*) industries, as measured by domestic R&D-to-sales ratio ([Table DISC-3](#)). Notable components of these industries in terms of R&D intensities include scientific R&D services (29%), semiconductor and other electronic components manufacturing (24%), pharmaceuticals and medicines manufacturing (17%), and software publishers (14%).

Figure DISC-9. Industry share of U.S. business R&amp;D, by top R&amp;D-performing industries: 2019–22

**Note(s):**

Industry classification is based on the dominant business code from the North American Industry Classification System for domestic R&D performance, when available. For companies that did not report business codes, the classification used for sampling was assigned. Data do not include companies with fewer than 10 domestic employees.

**Source(s):**

National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development (BERD) Survey.

Science and Engineering Indicators

Table DISC-3. Domestic net sales, R&amp;D, and R&amp;D-to-sales ratio for companies that performed or funded U.S. business R&amp;D, by selected industry: 2022

(Millions of dollars and percent)

Industry, NAICS code	Domestic net sales <sup>a</sup>	Domestic R&D <sup>b</sup>	R&D-to-sales ratio (%)
All industries, 21–33, 42–81	14,184,308	691,547	4.9
Manufacturing industries, 31–33	7,322,263	372,459	5.1
Chemicals, 325	1,493,442	125,728	8.4
Pharmaceuticals and medicines, 3254	685,744	116,073	16.9
Machinery, 333	520,724	19,464	3.7
Computer and electronic products, 334	734,451	104,718	14.3
Semiconductor and other electronic components, 3344	209,620	49,330	23.5
Electrical equipment, appliances, and components, 335	190,989	7,086	3.7
Transportation equipment, 336	1,377,381	71,259	5.2
Motor vehicles, bodies, trailers, and parts, 3361–63	934,230	32,881	3.5
Aerospace products and parts, 3364	356,684	35,356	9.9
Nonmanufacturing industries, 21–23, 42–81	6,862,045	319,088	4.7
Information, 51	1,852,965	182,340	9.8
Software publishers, 5112	367,970	50,295	13.7
Data processing, hosting, and related services, 518	638,156	49,407	7.7

**Table DISC-3. Domestic net sales, R&D, and R&D-to-sales ratio for companies that performed or funded U.S. business R&D, by selected industry: 2022**

(Millions of dollars and percent)

Industry, NAICS code	Domestic net sales <sup>a</sup>	Domestic R&D <sup>b</sup>	R&D-to-sales ratio (%)
Finance and insurance, 52	1,250,350	17,222	1.4
Professional, scientific, and technical services, 54	561,046	74,773	13.3
Computer systems design and related services, 5415	186,067	22,534	12.1
Scientific R&D services, 5417	136,566	39,625	29.0

i = more than 50% of the estimate is a combination of imputation and reweighting to account for nonresponse.

NAICS = 2017 North American Industry Classification System.

<sup>a</sup> Dollar values are for goods sold or services rendered by R&D-performing or R&D-funding companies located in the United States to customers outside of the company, including the U.S. federal government, foreign customers, and the company's foreign subsidiaries. Included are revenues from a company's foreign operations and subsidiaries and from discontinued operations. If a respondent company is owned by a foreign parent company, sales to the parent company and to affiliates not owned by the respondent company are included. Excluded are intracompany transfers, returns, allowances, freight charges, and excise, sales, and other revenue-based taxes.

<sup>b</sup> Domestic R&D is the cost of R&D paid for and performed by the respondent company and paid for by others outside of the company and performed by the respondent company.

**Note(s):**

Data are for companies with 10 or more domestic employees. Detail may not add to total because of rounding. Industry classification was based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned.

**Source(s):**

National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development (BERD) Survey, 2022.

*Science and Engineering Indicators*

Although about 88% of overall U.S. business R&D is funded internally by the performing company, the relative roles of internal and external funding vary for some of the largest R&D-performing industries. While the internal funding share for the information industry is 99%, it is only 39% for aerospace products and parts manufacturing and 23% for scientific R&D services. The latter two industries have different primary external funding sources—namely, the federal government for the aerospace manufacturing industry and other domestic companies (contract R&D customers) for scientific R&D services (Table DISC-4).

**Table DISC-4. U.S. business R&D performance, by source of funds: 2022**

(Millions of dollars)

Industry, NAICS code	All R&D <sup>a</sup>	Paid for by the company	Paid for by others						
			Total	Federal	Companies		All others		
					Domestic	Foreign			
All industries, 21–33, 42–81	691,547	608,058	83,489	31,626	27,125	i	23,604	1,132	
Manufacturing industries, 31–33	372,459	326,998	45,461	24,082	6,623		14,360	397	r
Chemicals, 325	125,728	113,518	12,210	766	2,426		8,946	72	i
Pharmaceuticals and medicines, 3254	116,073	104,720	11,353	703	2,388		8,195	68	
Machinery, 333	19,464	18,246	1,218	673	165		358	22	r
Computer and electronic products, 334	104,718	99,234	5,483	2,560	537	i	2,263	123	r
Semiconductor and other electronic components, 3344	49,330	47,380	1,950	71	23		1,777	78	r
Electrical equipment, appliances, and components, 335	7,086	6,657	429	i	21		35	369	i
Transportation equipment, 336	71,259	46,468	24,790	19,934	3,060		1,676	i	120
Motor vehicles, bodies, trailers, and parts, 3361–63	32,881	30,722	2,159	D	528		1,559	i	NA
Aerospace products and parts, 3364	35,356	13,786	21,570	18,855	i	2,529	103	74	
Nonmanufacturing industries, 21–23, 42–81	319,088	281,060	38,028	i	7,544		20,502	i	9,245
Information, 51	182,340	181,392	947	176	332		413	27	
Software publishers, 5112	50,295	49,602	693	102	r	308	260	23	
Data processing, hosting, and related services, 518	49,407	49,270	137	33		13	87	5	i

**Table DISC-4. U.S. business R&D performance, by source of funds: 2022**

(Millions of dollars)

Industry, NAICS code	All R&D <sup>a</sup>	Paid for by the company	Paid for by others					
			Total	Federal	Companies		All others	
					Domestic	Foreign		
Finance and insurance, 52	17,222	17,173	49	0	49	0	0	
Professional, scientific, and technical services, 54	74,773	38,633	36,139	i 7,273	19,452	i 8,748	i 665	
Computer systems design and related services, 5415	22,534	18,878	3,656	897	408	2,278	72	
Scientific R&D services, 5417	39,625	i 9,297	30,328	i 5,084	18,562	i 6,170	i 513	

D = suppressed to avoid disclosure of confidential information; i = more than 50% of the estimate or its component(s) is a combination of imputation and reweighting to account for nonresponse; NA = not available; r = relative standard error of this estimate or its component(s) is more than 50%.

NAICS = 2017 North American Industry Classification System.

<sup>a</sup> All R&D is the cost of R&D paid for and performed by the respondent company and paid for by others outside of the company and performed by the respondent company.

**Note(s):**

Data are for companies with 10 or more domestic employees. Detail may not add to total because of rounding. Industry classification was based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. Excludes data for federally funded R&D centers.

**Source(s):**

National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development (BERD) Survey, 2022.

*Science and Engineering Indicators*

Business R&D performed by businesses with 10 or more domestic employees is highly geographically concentrated, with California, Washington, and Massachusetts accounting for about half in 2022 (NCSES [BERD 2022: Table 13](#)).<sup>12</sup> In some industries, such as semiconductor manufacturing and industries in their supply chain, business R&D is even more geographically concentrated. In 2021, 51% of company-funded U.S. R&D performed by the semiconductor manufacturing industry was performed in California, whereas the California share for the semiconductor machinery manufacturing industry was 65% (Moris and Rhodes 2024a, 2024b).

## U.S. Business R&D by Technology Focus

R&D in critical and emerging technologies and in advanced manufacturing processes contributes to economic competitiveness and national security (DOD/DSB 2022).<sup>13</sup> This section covers U.S. business R&D in four technology focus areas across all industries: software, artificial intelligence (AI), nanotechnology, and biotechnology.<sup>14</sup> For scientific publications and other activities in biotechnology and semiconductors, see sidebar [Biotechnology R&D and Publications Output](#), and see sidebar [Semiconductor Research Publication Output and International Collaboration](#) later in this report.

Information technology (IT) has long been recognized for its role in productivity growth (Jorgenson 2001) and for national and economic security (CRS 2016, 2023b). In 2022, domestic software R&D performed in any industry accounted for 42% (\$291.7 billion) of U.S. R&D performed by businesses with 10 or more domestic employees ([Table DISC-5](#)).<sup>15</sup> Over half of U.S. software R&D was performed by the information services industry. Across industries, 5% (\$37.0 billion) of business R&D was in the AI application area. The largest industries performing AI business R&D in 2022 were information services (43%), computer manufacturing (including semiconductors) (22%), and the professional, scientific, and technical services industry (including scientific R&D services) (17%). Nanotechnology R&D accounted for only 5% of total U.S. business R&D but for 58% of the R&D performed by the semiconductor manufacturing industry. This is consistent with the role of nanotechnology tools and materials for energy efficiency and overall speed and performance of chips for AI and other applications (“Nanotech Powers On-Chip Intelligence” 2025).

Table DISC-5. U.S. business R&amp;D performed, by industry and select technology focus: 2022

(Millions of U.S. dollars)

Industry	NAICS code	Domestic R&D	Software products and embedded software	Biotechnology	Nanotechnology	Artificial intelligence
All industries	21 - 23, 31 - 33, 42 - 81	691,547	291,661 i	117,108	36,665 i	37,014 i
Manufacturing industries	31 - 33	372,459	56,589	97,021	33,721 i	12,326 i
Chemicals	325	125,728	1,632	88,646	704	292
Pharmaceuticals and medicines	3254	116,073	1,382	87,320	264	218
Machinery	333	19,464	2,333	128 i	2,376 i	853 i
Computer and electronic products	334	104,718	36,487 i	2,318 i	29,088 i	8,135 i
Semiconductor and other electronic components	3344	49,330	13,067 i	31	28,586 i	5,118 i
Electrical equipment, appliances, and components	335	7,086	1,029 i	14 i	15 i	165 i
Transportation equipment	336	71,259	8,930	101	818	1,981
Motor vehicles, bodies, trailers, and parts	3361 - 63	32,881	3,540	2	6	769 i
Aerospace products and parts	3364	35,356	5,070	96	809	1,210
Nonmanufacturing industries	21 - 23, 42 - 81	319,088	235,072 i	20,087 i	2,944 i	24,688 i
Information	51	182,340	157,931 i	340	1,694 i	15,819 i
Software publishers	5112	50,295	34,679	316	1,690 i	3,759
Data processing, hosting, and related services	518	49,407	47,396	21	2	4,130 i
Finance and insurance	52	17,222	16,217	2	3	894 i
Professional, scientific, and technical services	54	74,773	28,776	18,132 i	1,216 i	6,210 i
Computer systems design and related services	5415	22,534	13,716	45	481 i	1,392 i
Scientific R&D services	5417	39,625 i	7,673 i	17,494 i	499 i	2,719 i

i = more than 50% of the estimate is a combination of imputation and reweighting to account for nonresponse.

NAICS = 2017 North American Industry Classification System.

**Note(s):**

Data are for companies with 10 or more domestic employees. Detail may not add to total because of rounding. Industry classification is based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. Companies could report R&D in one, more than one, or no application area.

**Source(s):**

National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development (BERD) Survey, 2022.

Science and Engineering Indicators

Lastly, biotechnology is a separate technology focus area, prominent in industries related to the life sciences and the bioeconomy (CRS 2022a; White House 2025). Biotechnology business R&D accounted for 17% of total U.S. business R&D in 2022. Three-fourths (75%) of biotechnology-focused R&D was performed within pharmaceuticals and medicine manufacturing (North American Industry Classification System [NAICS] 3254).

## Academic R&D

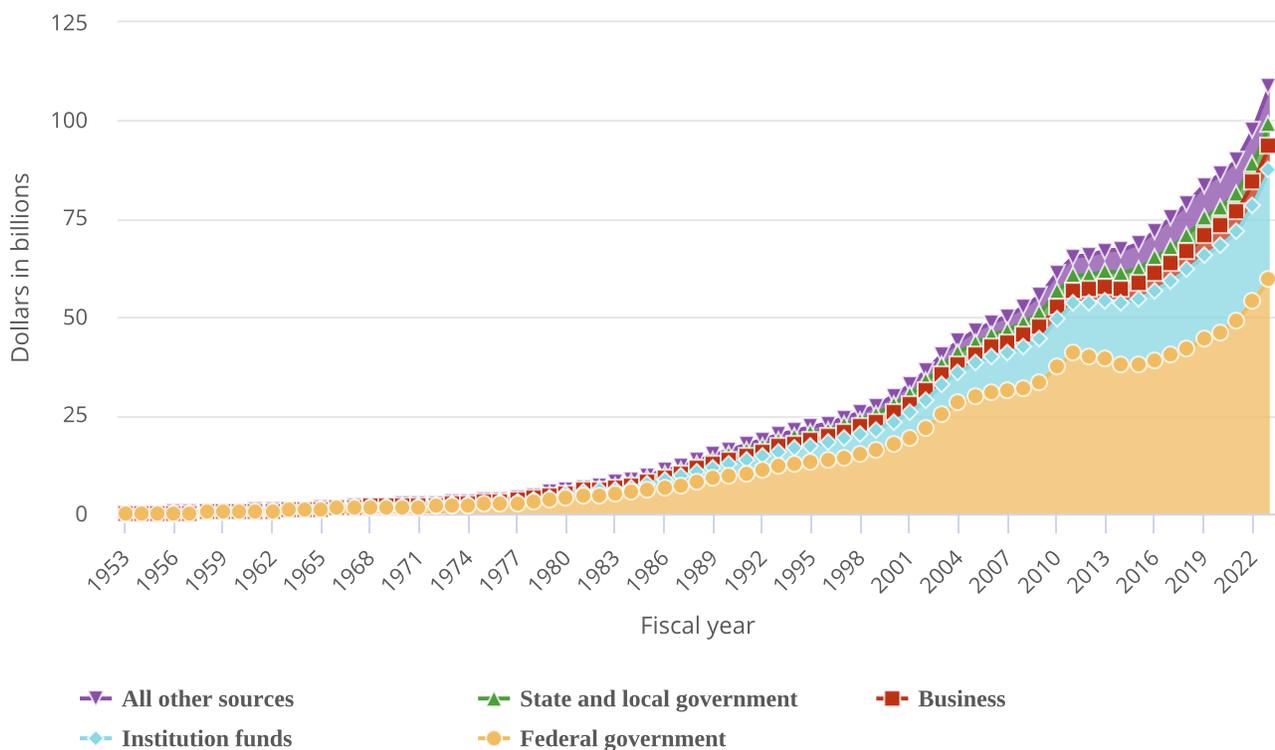
Many academic institutions balance both an educational mandate and a capacity for original research, performing a large share of R&D, funded either internally, using the institution's own funds, or externally. Academic R&D pursues research topics that contribute to public knowledge through peer-reviewed articles (see the section [Publication Output by Geography and Scientific Field](#)) and other research outputs, to education and workforce development (see the *Indicators 2026* report "STEM Talent: Education, Training, and Workforce" [NSB forthcoming]), and to downstream innovation activities such as patents, technology licensing, and the formation of new companies (see the *Indicators 2026* report "Translation to Impact: U.S. and Global Science, Technology, and Innovation Output" [NSB forthcoming]).

Higher education institutions expend R&D funding either on performance within the higher education sector or in other sectors. Academic R&D expenditures increased by \$11.0 billion in FY 2023 to \$108.8 billion (Gibbons 2024a; NCSSES *HERD 2023: Table 1*).<sup>16</sup> Physical infrastructure, in terms of research space at U.S. academic institutions, grew by 4 million square feet from FY 2021 to FY 2023, reaching 240.2 million square feet (Gibbons 2024b).

### Funding Sources of Academic R&D

The federal government remains the main driver of academic R&D, funding 55% (\$59.7 billion of the total \$108.8 billion) of expenditures in 2023. Academic institutions' own funds were the second-largest source of academic R&D at \$27.7 billion (25% of total) (Figure DISC-10).<sup>17</sup> Six agencies provided 93% of federal funds supporting academic R&D in FY 2023 (Table DISC-6). The U.S. Department of Health and Human Services (HHS), which includes the National Institutes of Health, was the largest source, providing 56% of federal agency support for academic R&D in FY 2023. The Department of Defense (DOD) and NSF combined accounted for over a quarter of federal support for academic R&D (at 15% and 11%, respectively).

Figure DISC-10. Academic R&D expenditures, by source of funds: FYs 1953–2023



**Note(s):**

Federal data include funds from the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA was an important source of federal expenditures for academic R&D during the economic downturn and recovery from 2010 to 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 (HERD) Survey.

Science and Engineering Indicators

**Table DISC-6. Federal agency support of academic R&D spending: FYs 2013, 2018, 2022, and 2023**

(Dollars in billions and percent)

Agency	Dollars in billions				Percentage of federal agency support of academic R&D spending			
	FY 2013	FY 2018	FY 2022	FY 2023	FY 2013	FY 2018	FY 2022	FY 2023
HHS	21.22	22.92	30.29	33.10	53.8	54.6	56.1	55.5
DOD	5.04	5.90	7.98	9.05	12.8	14.1	14.8	15.2
NSF	5.40	5.27	6.04	6.70	13.7	12.6	11.2	11.2
DOE	1.87	1.82	2.49	2.67	4.7	4.3	4.6	4.5
NASA	1.33	1.52	2.04	2.30	3.4	3.6	3.8	3.9
USDA	1.09	1.19	1.50	1.70	2.8	2.8	2.8	2.9
Other agencies	3.52	3.33	3.63	4.09	8.9	7.9	6.7	6.9
Total	39.47	41.95	53.97	59.60	100.0	100.0	100.0	100.0

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

**Note(s):**

Gross domestic product deflators come from the Bureau of Economic Analysis and are available at <https://www.bea.gov/data/gdp/gross-domestic-product> (accessed October 2024). This table includes only institutions reporting \$1 million or more in total R&D expenditures in 2022. Institutions reporting less than \$1 million in total R&D expenditures in 2022 completed a shorter version of the survey form in FY 2023, and that form did not collect federally financed R&D expenditures by source.

**Source(s):**

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

Science and Engineering Indicators

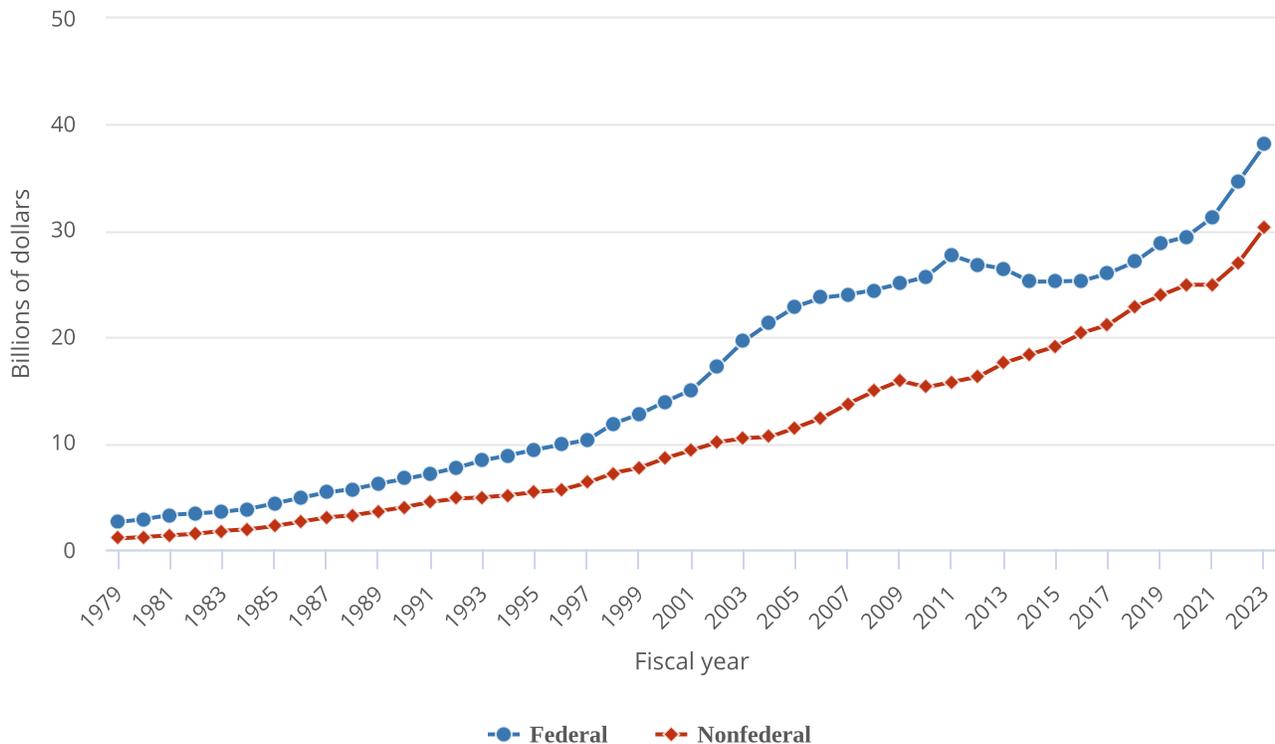
Between 2013 and 2023, the share of academic R&D expenditures funded by the federal government dropped from 59% to 55%, while the share funded by academic institutions themselves increased from 22% to 25% (Figure DISC-10). This is partly due to the federal American Reinvestment and Recovery Act (ARRA) funds, which boosted federal funding of academic R&D to a peak in 2011; by 2015, all ARRA funds had been expended. Between 2013 and 2023, businesses and state and local governments each accounted for between 5% and 6% of expenditures, while all other sources combined—including nonprofit organizations, foreign governments, and other universities or gifts from individual donors directed to research funding—funded around 8%–10% of U.S. academic R&D.

## Academic R&D by Type of R&D

The mission of academic institutions is typically different from other sectors, and this is reflected in the distribution of R&D performed. In contrast to the business sector, the majority of academic R&D expenditures in 2023 were devoted to basic research (\$68.5 billion, or 63% of total R&D), followed by applied research (\$29.6 billion, or 27%) and by experimental development (\$10.6 billion, or 10%). This distribution has been largely stable since at least 2013, when the shares were 66%, 25%, and 9%, respectively (NCSES *HERD 2023*: Table 9).

Academic basic research is funded by all sectors. The federal government funded \$38.1 billion (\$31.2 billion in constant dollars) in academic basic research in 2023, a 10% increase from 2022 (6% increase in constant dollars) (Figure DISC-11; Table SDISC-1). Further, between 2018 and 2023, the CAGR for academic basic research funded by the federal government was 3% in constant dollars. Academic basic research funded by nonfederal sources increased from \$27.1 billion in 2022 to \$30.3 billion in 2023 (from \$22.9 billion to \$24.8 billion in constant dollars), a 12% increase (8% increase in constant dollars). From 2018 to 2023, the CAGR of academic basic research funded by nonfederal sources was 2% in constant dollars.

Figure DISC-11. Federal and nonfederal funding of academic basic research: FYs 1979–2023



**Note(s):**

The type-of-R&D estimation procedure was revised for FY 1998 and later years; hence, these data are not directly comparable with data for FY 1997 and earlier years. Before FY 2010, R&D expenditures by type of R&D were based on percentage estimates of basic research provided by universities and colleges. Beginning in FY 2010, institutions were asked for dollar amounts of federally funded and nonfederally funded R&D expenditures for basic research, applied research, and experimental development. Federal data include funds from the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA was an important source of federal expenditures for academic R&D during the economic downturn and recovery from 2010 to 2012 and continued to contribute to such spending, although in smaller amounts, in 2013 and 2014. By 2015, all ARRA funds had been spent. Gross domestic product deflators come from the Bureau of Economic Analysis and are available at <https://www.bea.gov/data/gdp/gross-domestic-product> (accessed October 2024).

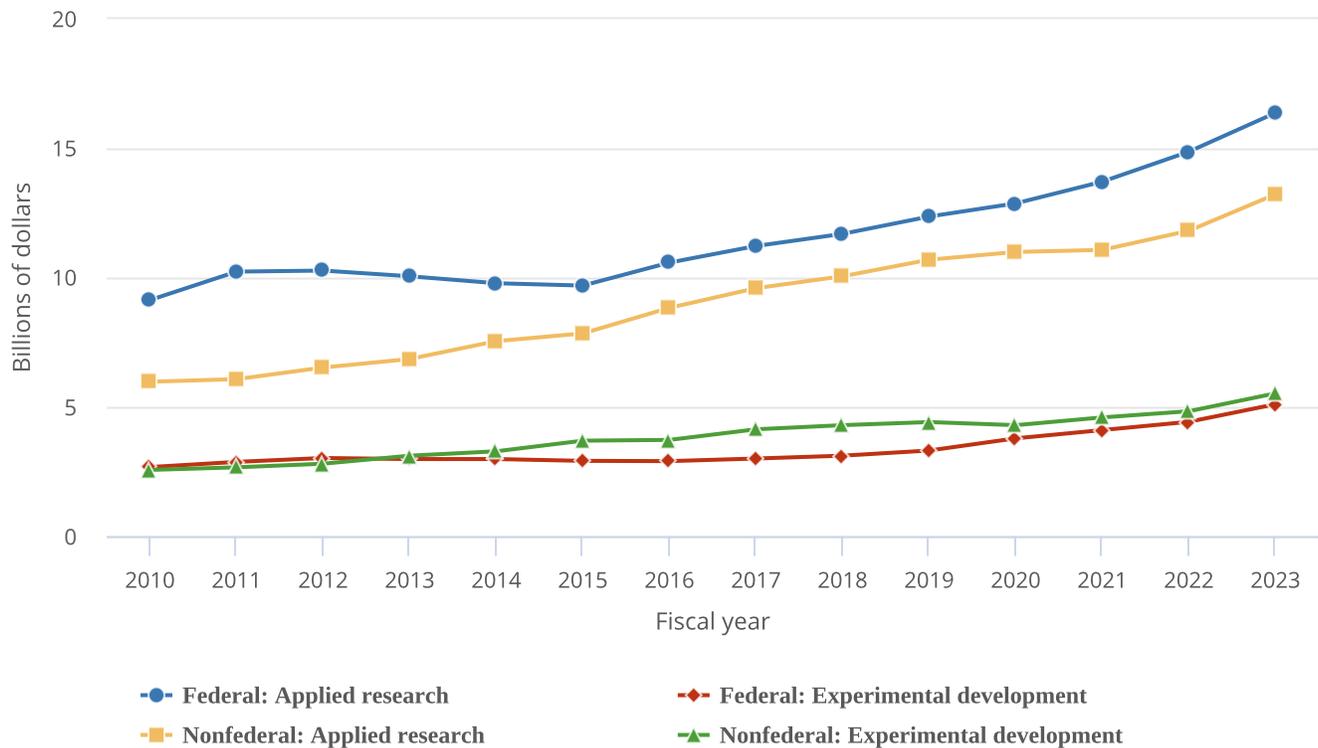
**Source(s):**

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

Science and Engineering Indicators

In 2023, federal funding for academic applied research reached \$16.4 billion, and nonfederal funding for academic applied research reached \$13.2 billion (Figure DISC-12; Table SDISC-1). Since 2018, federally funded applied research and experimental development at academic institutions grew at a CAGR of 3% and 7% in constant dollars, respectively. Nonfederal funding for academic applied research and experimental development grew at a CAGR of 2% and 1% in constant dollars, respectively, over the same period.

Figure DISC-12. Federal and nonfederal funding of academic experimental development and applied research: FYs 2010–23

**Note(s):**

Federal data include funds from the American Recovery and Reinvestment Act of 2009 (ARRA). ARRA was an important source of federal expenditures for academic R&D during the economic downturn and recovery from 2010 to 2012 and continued to contribute to such spending, although in smaller amounts, in 2013 and 2014. By 2015, all ARRA funds had been spent. Gross domestic product deflators come from the Bureau of Economic Analysis and are available at <https://www.bea.gov/data/gdp/gross-domestic-product> (accessed October 2024).

**Source(s):**

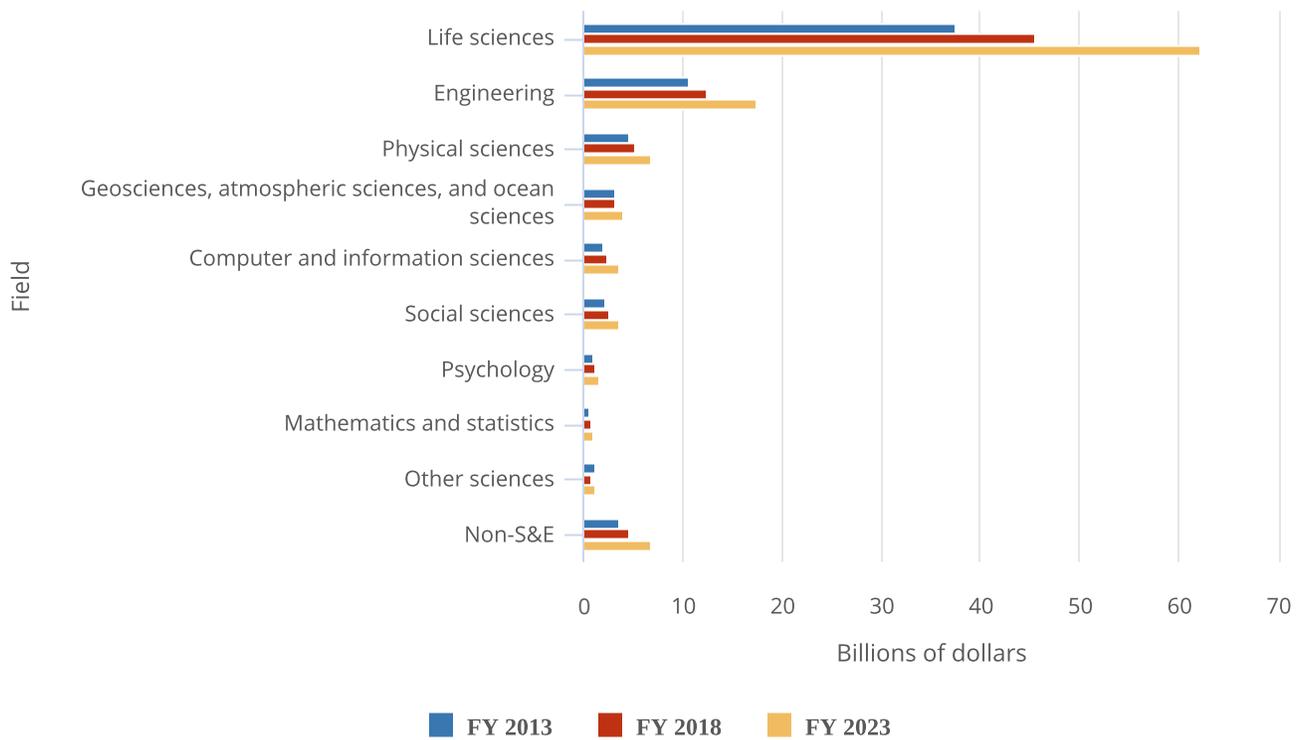
National Center for Science and Engineering Statistics, Higher Education Research and Development (HERD) Survey.

*Science and Engineering Indicators*

## Academic R&D by S&E Field

Academic R&D expenditures are classified into three major categories: science (78% in FY 2023), engineering (16%), and non-S&E fields (6%) (the latter include business management and administration, communication and communications technologies, education, humanities, social work, law, and visual and performing arts) (Table SDISC-2). The distribution of academic R&D expenditures across research fields has changed little since 2013 (Figure DISC-13). The life sciences continue to account for a majority of total spending, \$62.2 billion (57%) in 2023 (56%–58% share since 2013). The concentration of life sciences R&D in the higher education sector is consistent with the large share of health sciences in U.S. publications output discussed later in this report and with the large share of research space devoted to biological and biomedical sciences.<sup>18</sup>

Figure DISC-13. Academic R&amp;D spending, by field: FYs 2013, 2018, and 2023

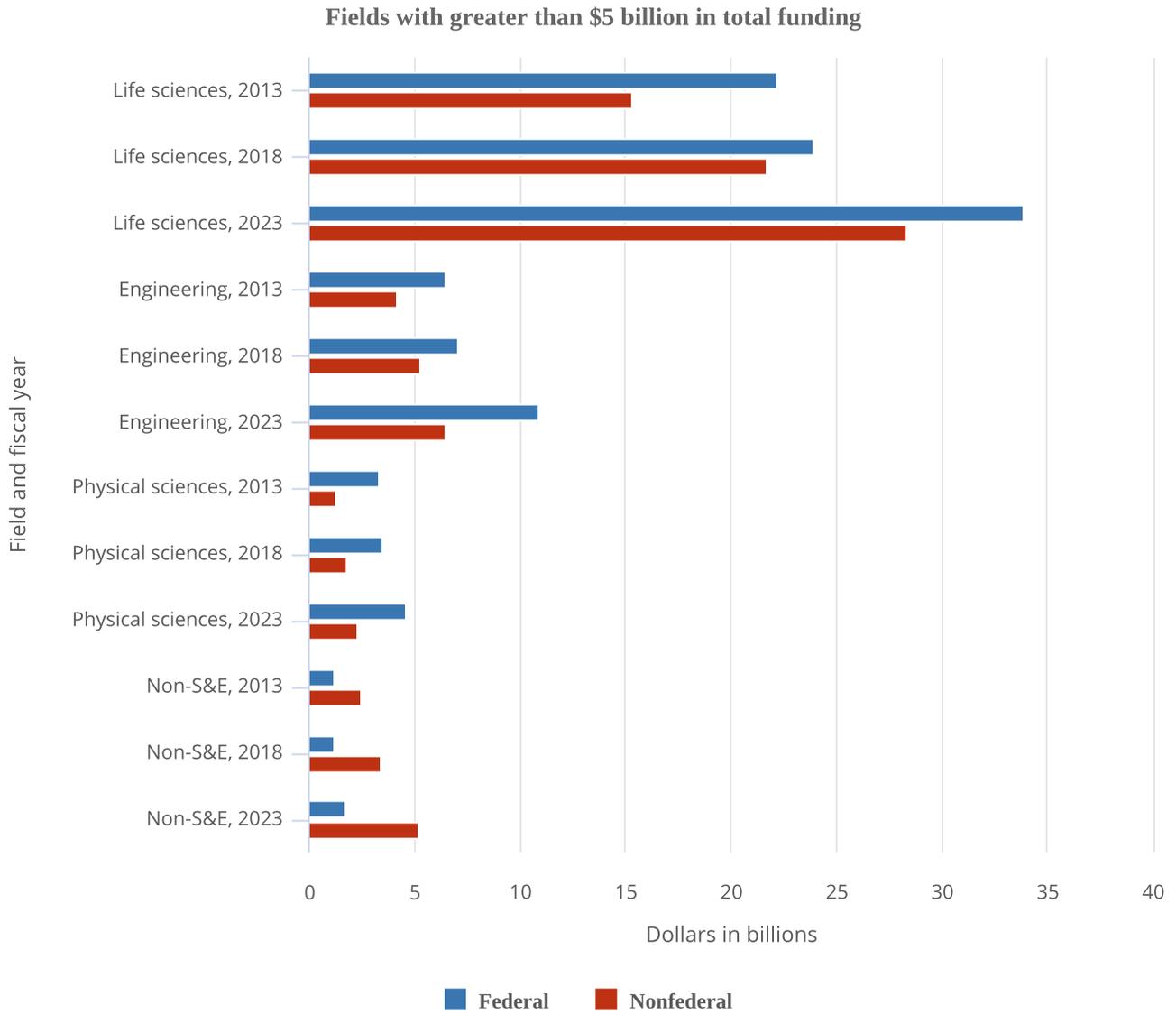
**Source(s):**

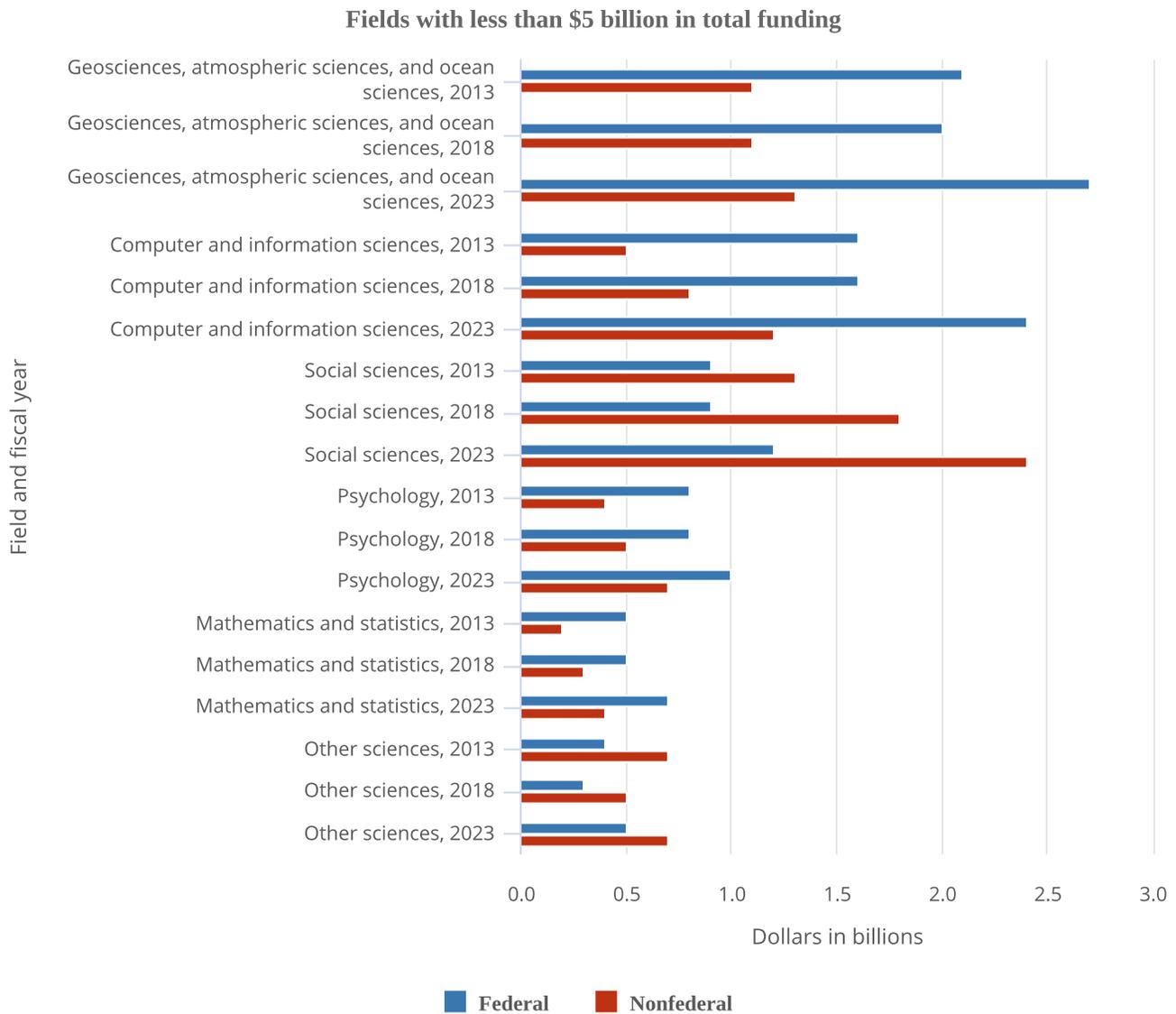
National Center for Science and Engineering Statistics, Higher Education Research and Development (HERD) Survey.

*Science and Engineering Indicators*

The proportion of funding for academic R&D by federal and nonfederal sources differs by scientific field (Figure DISC-14). The social sciences receive a relatively high proportion of funding from nonfederal sources (67% nonfederal in 2023). By comparison, geosciences, atmospheric sciences, and ocean sciences (67% federal), computer and information sciences (67% federal), and physical sciences (67% federal) were among the highest federally funded fields as a proportion of total funding in 2023.

Figure DISC-14. Federally and nonfederally funded academic R&D spending, by field: FYs 2013, 2018, and 2023



**Note(s):**

See also (NCSES *HERD 2023*: [Table 11](#), [Table 12](#)) for additional years.

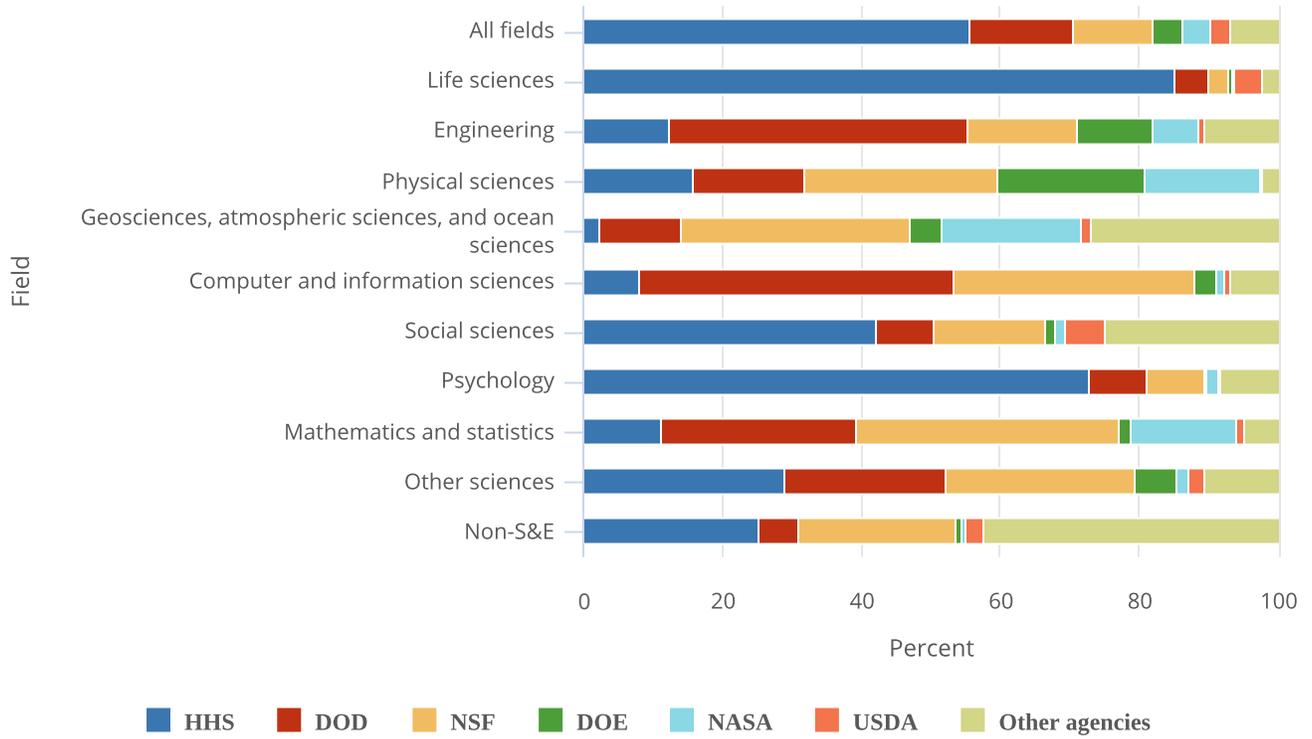
**Source(s):**

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

*Science and Engineering Indicators*

The funding portfolios for federal agencies reflects the variety of S&E fields that support their diverse missions ([Figure DISC-15](#)). For example, among federal agencies, HHS funds most academic R&D in life sciences, psychology, and social sciences, whereas DOD was one of the top two agencies funding computer and information sciences, engineering, and mathematics and statistics R&D. NSF was the leading funder among all federal agencies for academic R&D in mathematics and statistics; geosciences, atmospheric sciences, and ocean sciences; and physical sciences.

Figure DISC-15. Federally financed academic R&D expenditures, by agency and field: FY 2023



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):**  
See also (NCSES *HERD 2023: Table 14*).

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

*Science and Engineering Indicators*

## Federal Support for U.S. R&D

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For many decades, federal funding for R&D has been a key feature of U.S. science and technology policy, supporting national defense, space exploration, energy, the environment, health, general science, and other national goals (CRS 2022b, 2023a; Mowery 1992; NASEM 2020), as reflected, for example, in publications output (NSB 2023: [Figure PBS-A](#)). More recently, federal obligations for R&D have seen two major spikes since 2008, in line with several supplemental appropriations: one in FYs 2009–10, and another beginning in FY 2021 and extending into FY 2024, the most recent year for which preliminary data are available ([Table DISC-7](#)).<sup>19</sup>

Table DISC-7. Federal obligations for R&amp;D and R&amp;D plant, by agency: FYs 2008–24

(Millions of dollars)

Agency	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016 <sup>a</sup>	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024 (preliminary)
All agencies	129,050	144,758	146,968	139,703	140,670	127,626	132,779	131,578	118,274	121,627	133,278	146,801	173,553	193,914	196,634	192,081	200,928
Department of Defense	71,997	75,974	73,624	75,328	73,974	63,655	65,129	61,683	44,927	45,164	53,444	59,389	67,007	70,876	72,607	86,181	93,221
Department of Health and Human Services	29,701	35,736	37,617	30,928	31,336	29,513	30,799	30,425	32,367	33,902	37,116	39,434	61,775	77,050	74,388	53,012	50,055
Department of Energy	8,990	11,562	11,645	10,680	10,635	10,397	11,296	12,343	13,343	13,584	14,894	16,622	15,778	16,121	17,977	19,437	18,487
National Aeronautics and Space Administration	5,847	5,958	8,691	8,429	10,758	10,494	10,881	11,413	12,462	12,638	10,814	13,616	10,574	11,267	11,750	11,824	11,693
National Science Foundation	4,506	6,925	6,073	5,537	5,705	5,328	5,800	5,990	6,022	5,946	6,358	6,648	6,793	7,138	7,425	7,971	7,344
Department of Agriculture	2,246	2,345	2,615	2,377	2,188	2,031	2,269	2,352	2,380	2,575	2,523	2,666	3,433	2,955	3,315	3,592	3,698
Department of Commerce	1,196	1,533	1,683	1,309	1,231	1,294	1,568	1,519	1,636	1,847	1,832	1,999	1,981	2,242	2,390	3,159	9,540
Department of Veterans Affairs	480	510	563	613	615	639	589	662	695	682	1,349	1,508	1,565	1,698	1,696	1,916	1,954
Department of Transportation	825	846	929	862	936	876	848	884	962	987	1,077	1,052	1,224	1,163	1,132	1,208	1,198
Department of Homeland Security	1,057	984	1,132	1,128	832	719	944	1,645	689	870	913	648	507	549	599	664	609
Environmental Protection Agency	532	553	572	582	581	530	538	521	513	498	492	490	493	526	531	574	540
Patient-Centered Outcomes Research Trust Fund	na	na	na	41	41	334	283	152	115	884	492	578	470	460	522	553	543
Department of the Interior	645	739	728	717	743	717	762	809	860	868	769	831	844	915	947	522	516
Department of Education	328	322	363	346	338	310	322	251	244	262	266	236	240	364	402	372	417
Smithsonian Institution	188	227	213	249	246	240	231	229	235	241	261	269	276	63	297	316	332
Agency for International Development	124	160	84	119	77	125	60	212	193	192	167	221	194	82	221	252	252
Department of Justice	114	103	125	102	85	119	161	150	208	127	107	121	96	85	111	115	125
Tennessee Valley Authority	NA	6	13	10	8	17	28	111	121								
All other agencies	272	282	309	357	349	304	301	338	423	354	392	461	293	343	294	302	283

na = not applicable; agency or subagency did not exist as such or in that organization in that year. NA = not available; data were not collected at that level for that fiscal year.

<sup>a</sup> Beginning with FY 2016, the totals reported for development obligations represent a refinement to this category by more narrowly defining it to be "experimental development." Most notably, totals for development do not include the Department of Defense (DOD) Budget Activity 7 (Operational Systems Development) obligations. Those funds, previously included in DOD's development obligation totals, support the development efforts to upgrade systems that have been fielded or have received approval for full-rate production and anticipate production funding in the current or subsequent fiscal year. Therefore, the data are not directly comparable with totals reported in previous years.

**Note(s):**

Because of rounding in source tables, detail may not add to total. This table lists (in general) agencies with R&D and R&D plant obligations greater than \$100 million in FY 2023. Agency rankings are based on FY 2023 data. All other agencies includes the Social Security Administration, Department of Housing and Urban Development, Department of Labor, Department of State, Department of the Treasury, Administrative Office of the U.S. Courts, Appalachian Regional Commission, Consumer Product Safety Commission, Federal Communications Commission, Federal Trade Commission, Library of Congress, National Archives and Records Commission, Nuclear Regulatory Commission, Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act Centers of Excellence Research Grants Program, Agency for Global Media, and Postal Service. FYs 2009–10 obligations include additional funding provided by the American Recovery and Reinvestment Act of 2009. Obligations for FYs 2020–22 include additional funding provided by supplemental COVID-19-related appropriations (e.g., Coronavirus Aid, Relief, and Economic Security [CARES] Act).

**Source(s):**

National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Volume 73, FYs 2023–24.

## Federal Obligations for R&D and R&D Plant by Major Agency

Two agencies accounted for 72% of FY 2023 federal R&D and R&D plant (R&D facilities and major equipment; see [Glossary](#) section) obligations. DOD obligated \$86.2 billion, or 45% of the \$192.1 billion in federal total obligations, and HHS obligated \$53.0 billion (28% of total). Other top agencies included the Department of Energy (DOE) (\$19.4 billion, or 10% of total), the National Aeronautics and Space Administration (\$11.8 billion, or 6% of total), and NSF (\$8.0 billion, or 4% of total) ([Table DISC-7](#)). In FY 2023, total federal obligations for R&D and R&D plant decreased slightly from FY 2022 (\$192.1 billion and \$196.6 billion, respectively), although they are expected to revert to a record high of \$200.9 billion in current dollars in FY 2024 based on preliminary data. HHS funding decreased 29% in FY 2023 (down from \$74.4 billion in FY 2022), driven largely by a reduction in COVID-19 pandemic-related obligations to the Center for the Biomedical Advanced Research and Development Authority within HHS (Pece 2024). This FY 2023 decrease followed two large increases in obligations in both FY 2020 (a 57% increase to \$61.8 billion, up from \$39.4 billion the year prior) and FY 2021 (up 25% to \$77.1 billion from FY 2020).

R&D plant accounted for just 3% of the overall R&D and R&D plant obligations in FY 2023 (\$5.7 billion of the total \$192.1 billion) ([Table DISC-8](#)). DOE R&D plant obligations, which were primarily for FFRDCs, accounted for the majority of the total across agencies (\$3.3 billion).

**Table DISC-8. Federal obligations for R&D and R&D plant, by agency and performer: FY 2023**

(Millions of dollars and percent)

Agency	Total	R&D	R&D plant	Total by performers			
				Intramural performers	Percentage of total	Extramural performers	Percentage of total
All agencies	192,081	186,417	5,664	64,077	33.4	128,004	66.6
Department of Defense	86,181	85,890	291	27,063	31.4	59,118	68.6
Department of Health and Human Services	53,012	52,528	484	10,529	19.9	42,483	80.1
Department of Energy	19,437	16,145	3,292	13,755	70.8	5,683	29.2
National Aeronautics and Space Administration	11,824	11,715	109	4,260	36.0	7,564	64.0
National Science Foundation	7,971	7,490	481	471	5.9	7,500	94.1
Department of Agriculture	3,592	3,529	64	1,988	55.3	1,605	44.7
Department of Commerce	3,159	2,348	810	2,260	71.6	899	28.4
Department of Veterans Affairs	1,916	1,916	0	1,916	100.0	0	0.0
Department of Transportation	1,208	1,173	35	348	28.8	860	71.2
Department of Homeland Security	664	648	16	285	43.0	379	57.0
Environmental Protection Agency	574	572	2	288	50.1	287	49.9
Patient-Centered Outcomes Research Trust Fund	553	553	0	0	0.0	553	100.0
Department of the Interior	522	516	6	412	79.0	110	21.0
Department of Education	372	372	0	0	0.0	372	100.0
Smithsonian Institution	316	242	74	316	100.0	0	0.0
Agency for International Development	252	252	0	24	9.5	228	90.5
Department of Justice	115	115	0	5	4.2	110	95.8
Tennessee Valley Authority	111	111	0	0	0.0	111	100.0
All other agencies	302	302	0	158	52.2	144	47.8

**Note(s):**

Because of rounding in source tables, detail may not add to total. R&D is basic research, applied research, and experimental development, and it does not include R&D plant. Intramural activities include actual intramural R&D performance and costs associated with planning and administration of both intramural and extramural programs by federal personnel, including federally funded R&D centers. Extramural performers includes federally funded R&D performed in the United States and U.S. territories by businesses, universities and colleges, other nonprofit institutions, state and local governments, and foreign organizations. All other agencies includes the Social Security Administration, Department of Labor, Department of State, Department of the Treasury, Agency for Global Media, Appalachian Regional Commission, Consumer Product Safety Commission, Federal Trade Commission, Library of Congress, Nuclear Regulatory Commission, Postal Service, and Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act Centers of Excellence Research Grants Program.

**Source(s):**

National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Volume 73, FYs 2023–24.

Science and Engineering Indicators

## Federal Obligations by Performer and Type of R&D

Agencies obligate funds for R&D and R&D plant to both intramural performers (federal agencies and FFRDCs) and extramural performers (those outside the federal government: businesses, institutions of higher education, nonprofit organizations, state and local governments, and foreign organizations). Two-thirds of federal R&D and R&D plant obligations (\$128.0 billion) went to extramural performers in FY 2023. Intramural R&D performers accounted for 33% (\$64.1 billion).

Across all agencies, 25% of federal R&D obligations were devoted to basic research (\$47.3 billion), 29% to applied research (\$54.3 billion), and 46% to experimental development (\$84.8 billion) in FY 2023 (Table DISC-9). DOD obligated the majority of federal funding for experimental development (\$74.3 billion of the total \$84.8 billion). HHS obligated the most basic research funding (\$22.7 billion of the total \$47.3 billion) and applied research funding (\$29.7 billion of the total \$54.3 billion) among federal agencies.

**Table DISC-9. Federal obligations for R&D, by agency and type of R&D: FY 2023**

(Millions of dollars and percent)

Agency	Total R&D	Basic research	Applied research	Experimental development	Percentage of total R&D		
					Basic research	Applied research	Experimental development
All agencies	186,417	47,335	54,273	84,809	25.4	29.1	45.5
Department of Defense	85,890	3,823	7,755	74,312	4.5	9.0	86.5
Department of Health and Human Services	52,528	22,738	29,744	47	43.3	56.6	0.1
Department of Energy	16,145	6,470	6,104	3,571	40.1	37.8	22.1
National Aeronautics and Space Administration	11,715	4,798	1,995	4,922	41.0	17.0	42.0
National Science Foundation	7,490	6,305	1,185	0	84.2	15.8	0.0
Department of Agriculture	3,529	1,598	1,627	304	45.3	46.1	8.6
Department of Commerce	2,348	302	1,577	469	12.9	67.2	20.0
Department of Veterans Affairs	1,916	842	1,038	36	44.0	54.2	1.9
Department of Transportation	1,173	38	868	268	3.2	74.0	22.8
Department of Homeland Security	648	76	180	392	11.8	27.7	60.5
Environmental Protection Agency	572	0	445	128	0.0	77.7	22.3
Patient-Centered Outcomes Research Trust Fund	553	0	553	0	0.0	100.0	0.0
Department of the Interior	516	44	430	41	8.6	83.5	7.9
Department of Education	372	32	251	89	8.6	67.5	23.9
Smithsonian Institution	242	242	0	0	100.0	0.0	0.0
Agency for International Development	252	3	197	52	1.2	78.1	20.7
Department of Justice	115	17	85	13	15.2	73.9	10.9

**Table DISC-9. Federal obligations for R&D, by agency and type of R&D: FY 2023**

(Millions of dollars and percent)

Agency	Total R&D	Basic research	Applied research	Experimental development	Percentage of total R&D		
					Basic research	Applied research	Experimental development
Tennessee Valley Authority	111	0	18	93	0.0	16.2	83.8
All other agencies	302	6	223	73	2.0	73.9	24.1

**Note(s):**

This table lists all agencies covered in [Table DISC-7](#) and as ranked there. Because of rounding in source tables, detail may not add to total. All other agencies includes the Social Security Administration, Department of Labor, Department of State, Department of the Treasury, Agency for Global Media, Appalachian Regional Commission, Consumer Product Safety Commission, Federal Trade Commission, Library of Congress, Nuclear Regulatory Commission, Postal Service, and Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act Centers of Excellence Research Grants Program.

**Source(s):**

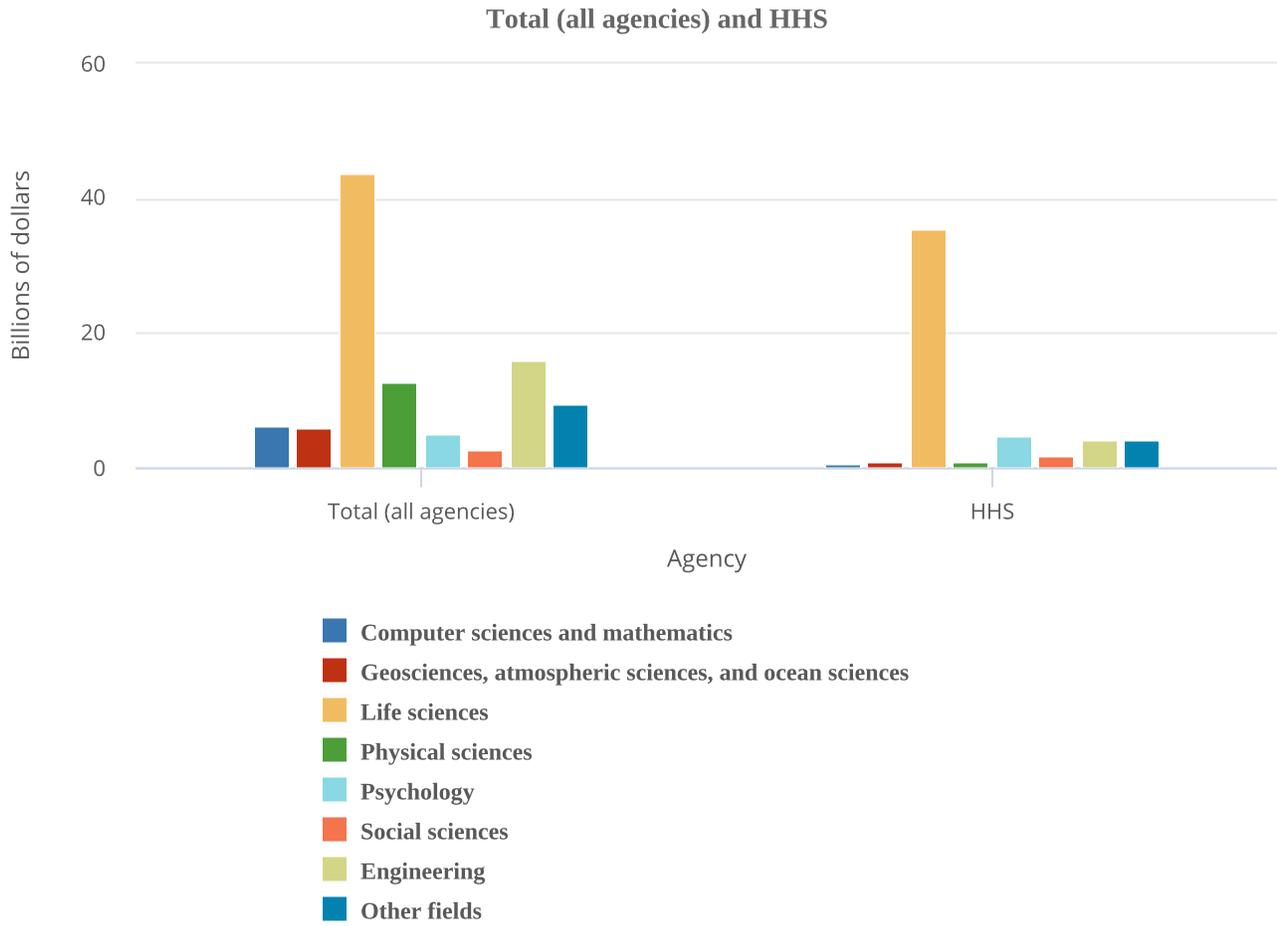
National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Volume 73, FYs 2023–24.

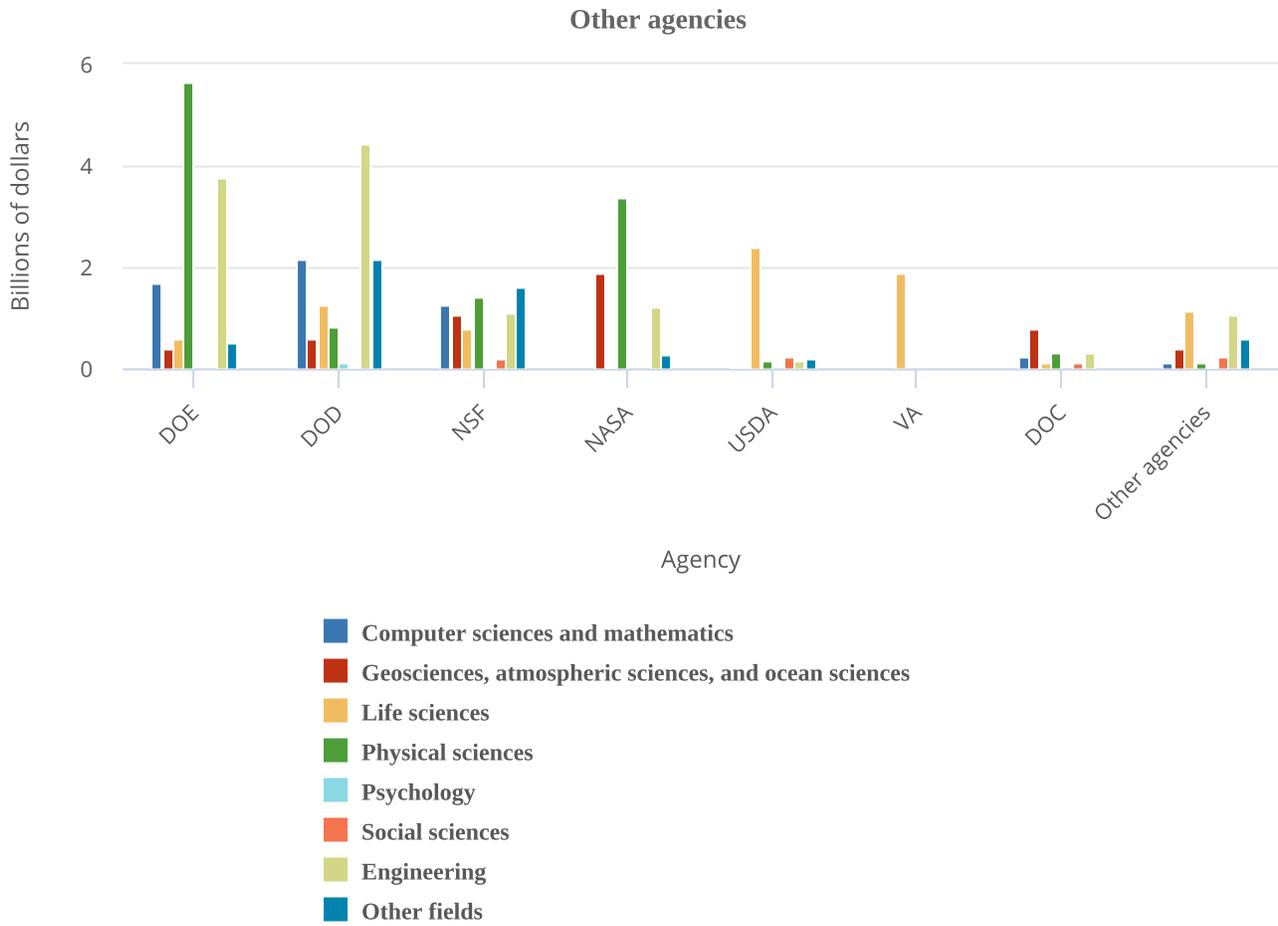
*Science and Engineering Indicators*

## Federal Obligations for Research by S&E Fields

Federal agencies fund and perform research in a broad range of S&E fields, and each agency's mission area is reflected in the major S&E fields in which it obligates funds. The information on federal obligations for research in S&E fields presented in this section addresses both basic research and applied research but does not include obligations for experimental development. In FY 2023, federal research obligations reached \$101.6 billion across all S&E fields ([Figure DISC-16](#); NCSES 2025b: [Table 24](#)), with over half of this total (\$52.5 billion) obligated by HHS. Among S&E fields, obligations were highest in the life sciences (\$43.7 billion, or 43% of total obligations), and the largest federal funder of life sciences research was HHS (81% of the total in the field). HHS also obligates nearly all federal funding for psychology research (96% of the \$4.9 billion total). Other top agencies include DOE, with \$5.6 billion obligated for physical sciences (44% of the total \$12.7 billion in that field) and \$3.8 billion for engineering (23% of the total \$16.0 billion), and DOD, with \$2.2 billion for computer sciences and mathematics research (35% of the total) and \$4.5 billion for engineering (28% of the total).

Figure DISC-16. Federal obligations for research, by agency and major S&E field: FY 2023





DOC = Department of Commerce; 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; VA = Department of Veterans Affairs.

**Note(s):**

The scales differ for total (all agencies) and HHS compared with the scales for the other agencies listed. Research includes basic and applied research.

**Source(s):**

National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Volume 73, FYs 2023–24.

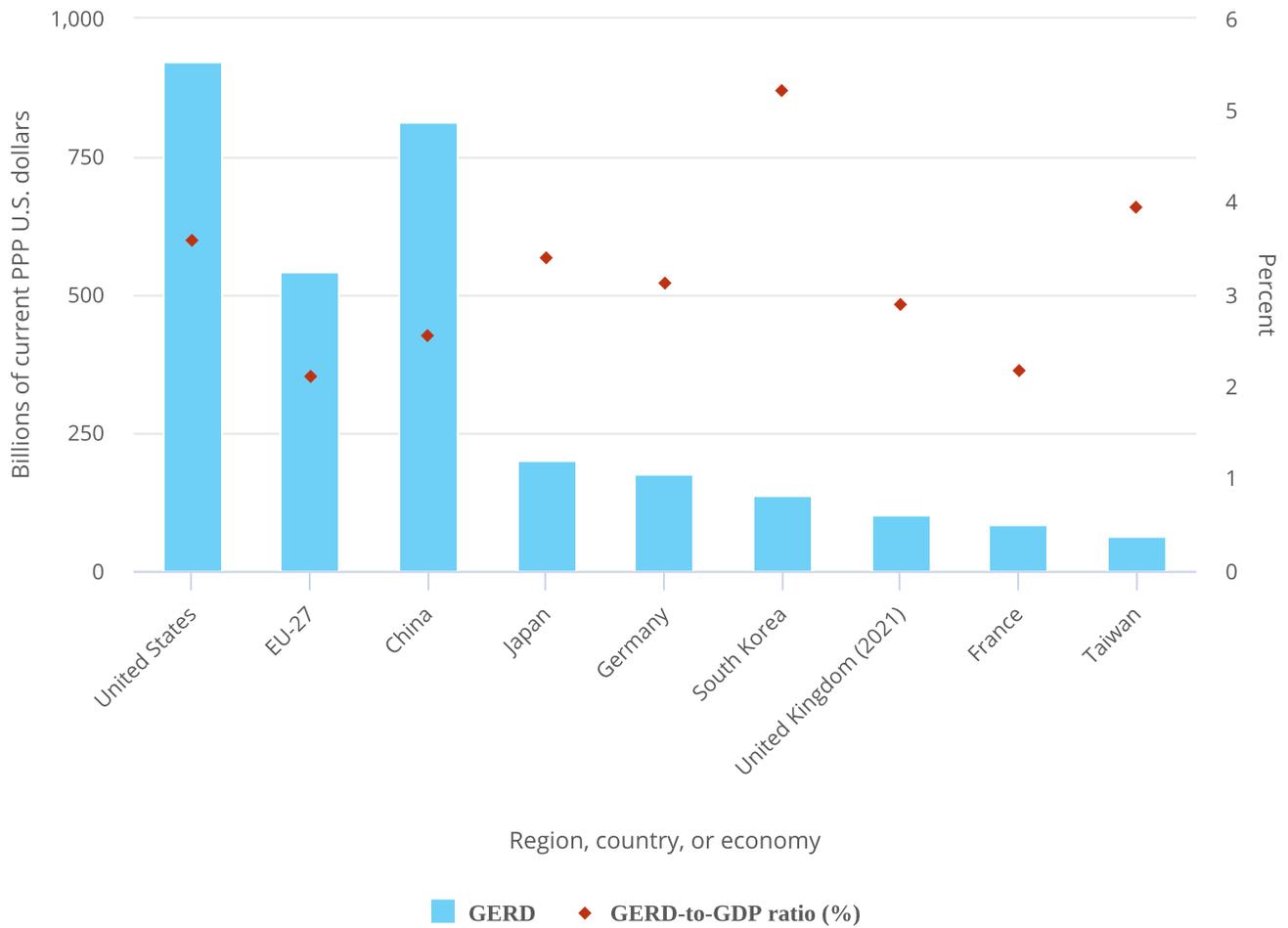
## Global R&D and International Comparisons

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R&D underpins competitiveness and national security and also contributes to addressing global challenges such as public health, energy, the environment, and the development and deployment of critical technologies (CRS 2023a, 2023b, 2024; CSIS 2021; OECD 2023; USCC 2024). The global total for R&D expenditures in 2022 was \$3.1 trillion in current U.S. purchasing power parity (PPP) dollars, based on all 38 OECD members plus another 9 regions, countries, or economies available in the OECD R&D database (Argentina, Bulgaria, China, Croatia, Romania, Russia, Singapore, South Africa, and Taiwan) (Table SDISC-3).<sup>20</sup>

The top 8 individual R&D-performing regions, countries, or economies accounted for 82% of global R&D expenditures in 2022, with the United States (30%) and China (27%) accounting for over half (Figure DISC-17; Table DISC-10; Table SDISC-3). As a region, the European Union (EU-27) accounted for 18% of global R&D expenditures. Adjusted for international comparability, the United States had \$923.2 billion in gross domestic expenditures on R&D (GERD) in 2022 (\$761.6 billion in constant 2015 U.S. PPP-converted dollars), up 12% from 2021 (5% in constant PPP dollars).<sup>21</sup> China, the second-highest performer of domestic R&D, reached \$811.9 billion in 2022 (\$686.7 billion in constant PPPs in U.S. dollars), up 16% from 2021 (8% in constant PPPs) (OECD 2024d). Japan (\$200.8 billion), Germany (\$174.9 billion), South Korea (\$139.0 billion), the United Kingdom (\$102.6 billion), France (\$85.2 billion), and Taiwan (\$64.0 billion) round up the top 8 individual R&D-performing regions, countries, or economies in current U.S. PPP dollars, based on OECD statistics (Figure DISC-17, Figure DISC-18; Table SDISC-3).<sup>22</sup>

Figure DISC-17. GERD and GERD-to-GDP ratio, by selected region, country, or economy: 2022 or most recent year



EU-27 = European Union; GDP = gross domestic product; GERD = gross domestic expenditures on R&D; PPP = purchasing power parity.

**Note(s):**

Some data are preliminary and may be revised later. The most recent year of data for the United Kingdom was 2021.

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition); Organisation for Economic Co-operation and Development, Main Science and Technology Indicators, July 2024, [https://stats.oecd.org/Index.aspx?DataSetCode=MSTI\\_PUB](https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

**Table DISC-10. GERD, GDP, GERD-to-GDP ratio, and growth rates, by selected region, country, or economy: Selected years, 1990–2022**

(Billions of U.S. current PPP dollars and percent)

Region, country, or economy	GERD						GDP						GERD-to-GDP ratio (%)						Longer-term growth rates (CAGR)									
																			GERD					GDP				
	1990	2000	2010	2020	2021	2022	1990	2000	2010	2020	2021	2022	1990	2000	2010	2020	2021	2022	1990–2000	2000–10	2010–20	2010–22	2021–22	1990–2000	2000–10	2010–20	2010–22	2021–22
United States	152.39	268.56	408.50	730.24	821.81	923.24	5,963.14	10,250.95	15,048.97	21,322.95	23,594.03	25,744.11	2.56	2.62	2.71	3.42	3.48	3.59	5.83	4.28	5.98	7.03	12.34	5.57	3.91	3.55	4.58	9.11
China	NA	32.90	212.19	607.60	701.11	811.86	1,114.20	3,683.89	12,381.94	25,246.67	28,821.65	31,773.15	NA	0.89	1.71	2.41	2.43	2.56	NA	20.49	11.09	11.83	15.80	12.70	12.89	7.38	8.17	10.24
Japan	65.44	98.94	140.51	174.93	183.47	200.77	2,458.76	3,461.20	4,525.40	5,358.32	5,599.03	5,895.69	2.66	2.86	3.10	3.26	3.28	3.41	4.22	3.57	2.21	3.02	9.43	3.48	2.72	1.70	2.23	5.30
Germany	35.94	53.89	86.95	150.79	161.23	174.86	1,379.33	2,236.36	3,184.88	4,815.44	5,153.14	5,582.29	2.61	2.41	2.73	3.13	3.13	3.13	4.13	4.90	5.66	5.99	8.45	4.95	3.60	4.22	4.79	8.33
South Korea	NA	18.52	52.15	112.22	123.46	139.00	358.19	871.48	1,572.68	2,340.03	2,514.52	2,667.44	NA	2.13	3.32	4.80	4.91	5.21	NA	10.91	7.97	8.51	12.58	9.30	6.08	4.05	4.50	6.08
United Kingdom (GERD 2021)	19.02	25.15	37.53	94.64	102.61	NA	976.33	1,562.41	2,290.20	3,220.30	3,541.78	3,847.92	1.95	1.61	1.64	2.94	2.90	NA	2.84	4.09	9.69	NA	NA	4.81	3.90	3.47	4.42	8.64
France	23.36	33.27	50.85	76.07	80.92	85.17	1,027.25	1,589.45	2,334.27	3,344.39	3,648.08	3,914.74	2.27	2.09	2.18	2.27	2.22	2.18	3.60	4.33	4.11	4.39	5.25	4.46	3.92	3.66	4.40	7.31
Taiwan	NA	9.15	25.05	47.62	55.74	63.97	204.02	478.13	889.67	1,319.47	1,471.39	1,615.72	NA	1.91	2.82	3.61	3.79	3.96	NA	10.60	6.64	8.13	14.77	8.89	6.41	4.02	5.10	9.81
Russia (GERD 2020)	24.11	10.50	33.08	47.95	NA	NA	1,274.54	1,073.59	3,143.87	4,367.29	4,762.30	NA	1.89	0.98	1.05	1.10	NA	NA	-7.97	12.16	3.78	NA	NA	-1.70	11.34	3.34	NA	NA
Italy	12.69	15.47	25.38	39.58	42.10	43.51	1,056.39	1,541.76	2,083.74	2,627.33	2,950.84	3,295.26	1.20	1.00	1.22	1.51	1.43	1.32	2.00	5.07	4.54	4.59	3.35	3.85	3.06	2.35	3.89	11.67
Turkey	1.08	2.84	10.07	32.70	37.33	43.14	456.73	609.01	1,268.55	2,391.49	2,662.21	3,259.42	0.24	0.47	0.79	1.37	1.40	1.32	10.17	13.51	12.50	12.89	15.56	2.92	7.61	6.55	8.18	22.43
Canada	8.26	16.74	24.89	35.74	39.77	41.35	560.18	901.00	1,363.58	1,847.84	2,133.08	2,415.84	1.48	1.86	1.83	1.93	1.86	1.71	7.32	4.04	3.69	4.32	3.98	4.87	4.23	3.09	4.88	13.26
Spain	4.14	7.73	20.07	26.01	29.19	33.39	531.56	875.74	1,475.43	1,845.71	2,068.30	2,326.11	0.78	0.88	1.36	1.41	1.41	1.44	6.45	10.01	2.63	4.33	14.38	5.12	5.35	2.26	3.87	12.46
Netherlands	5.49	9.09	12.75	24.73	26.93	30.30	286.50	507.62	748.29	1,065.12	1,186.87	1,319.46	1.92	1.79	1.70	2.32	2.27	2.30	5.17	3.45	6.85	7.48	12.52	5.89	3.96	3.59	4.84	11.17
Israel	NA	6.18	8.63	22.01	25.00	29.99	73.02	161.81	223.84	378.29	433.32	498.27	NA	3.82	3.85	5.82	5.77	6.02	NA	3.39	9.82	10.94	19.98	8.28	3.30	5.39	6.90	14.99

NA = not available.

CAGR = compound annual growth rate; GDP = gross domestic product; GERD = gross domestic expenditures on R&amp;D; PPP = purchasing power parity.

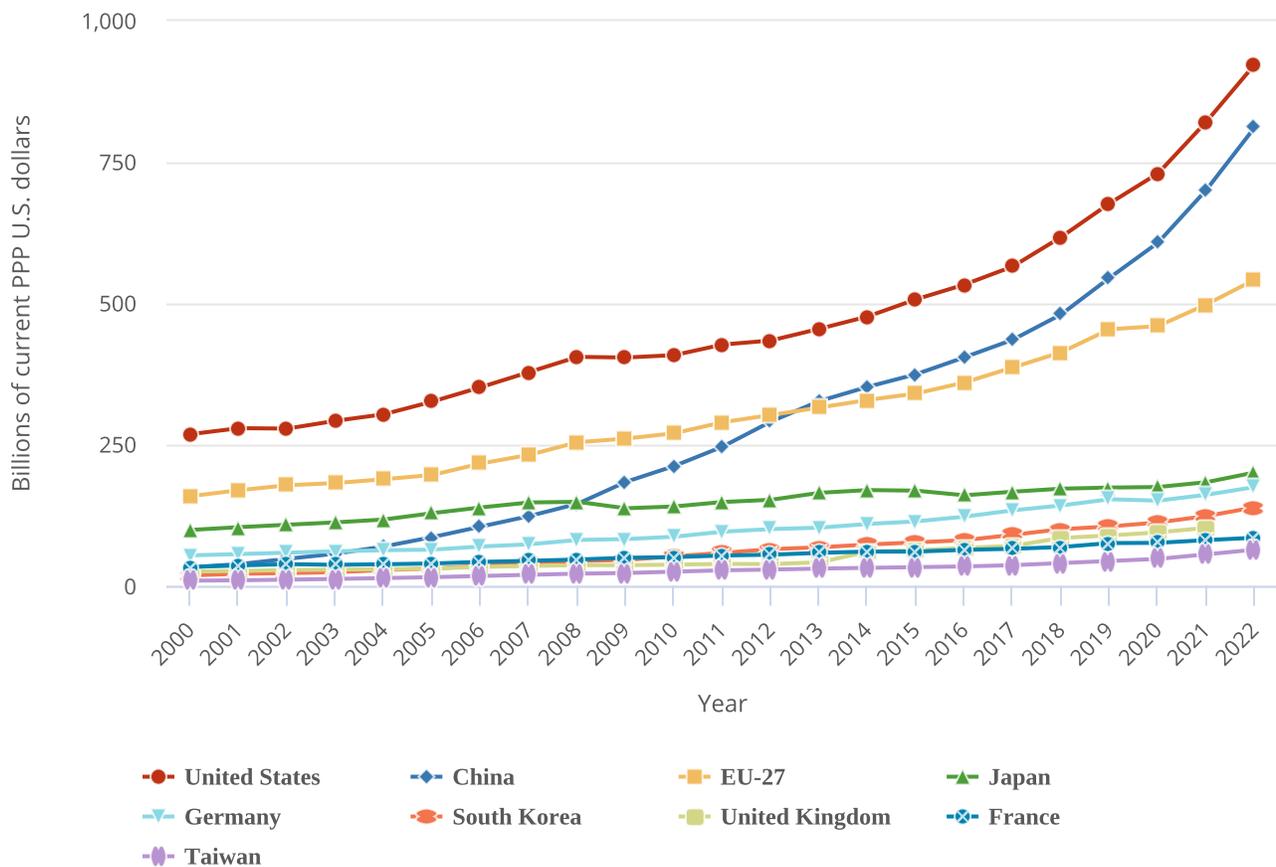
**Note(s):**

The most recent year of GERD data for the United Kingdom was 2021. The most recent year of GERD data for Russia was 2020. Data for U.S. GERD differ slightly from the U.S. total R&D data tabulated elsewhere in this report. For better consistency with international standards, U.S. GERD includes federal capital funding for federal intramural and nonprofit R&D, in addition to what is reported as U.S. total R&D. Some data are preliminary and may be revised later. Foreign currencies are converted by the Organisation for Economic Co-operation and Development (OECD) to U.S. dollars using PPP. U.S. data have been adjusted for international comparability. For more information on GERD and GDP statistics across regions, countries, or economies, see Table SDISC-3.

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition); OECD, Main Science and Technology Indicators, July 2024, [https://stats.oecd.org/Index.aspx?DataSetCode=MSTL\\_PUB](https://stats.oecd.org/Index.aspx?DataSetCode=MSTL_PUB).

Figure DISC-18. Gross domestic expenditures on R&amp;D, by selected region, country, or economy: 2000–22



EU-27 = European Union; PPP = purchasing power parity.

**Note(s):**

Data are for the top eight R&D-performing regions, countries, or economies with R&D data reported by the Organisation for Economic Co-operation and Development (OECD). Some data are preliminary and may be revised later. Data for the United Kingdom dating back to 2014 are provisional and may be revised; data for the United Kingdom for 2022 are not available. U.S. data have been adjusted for international comparability.

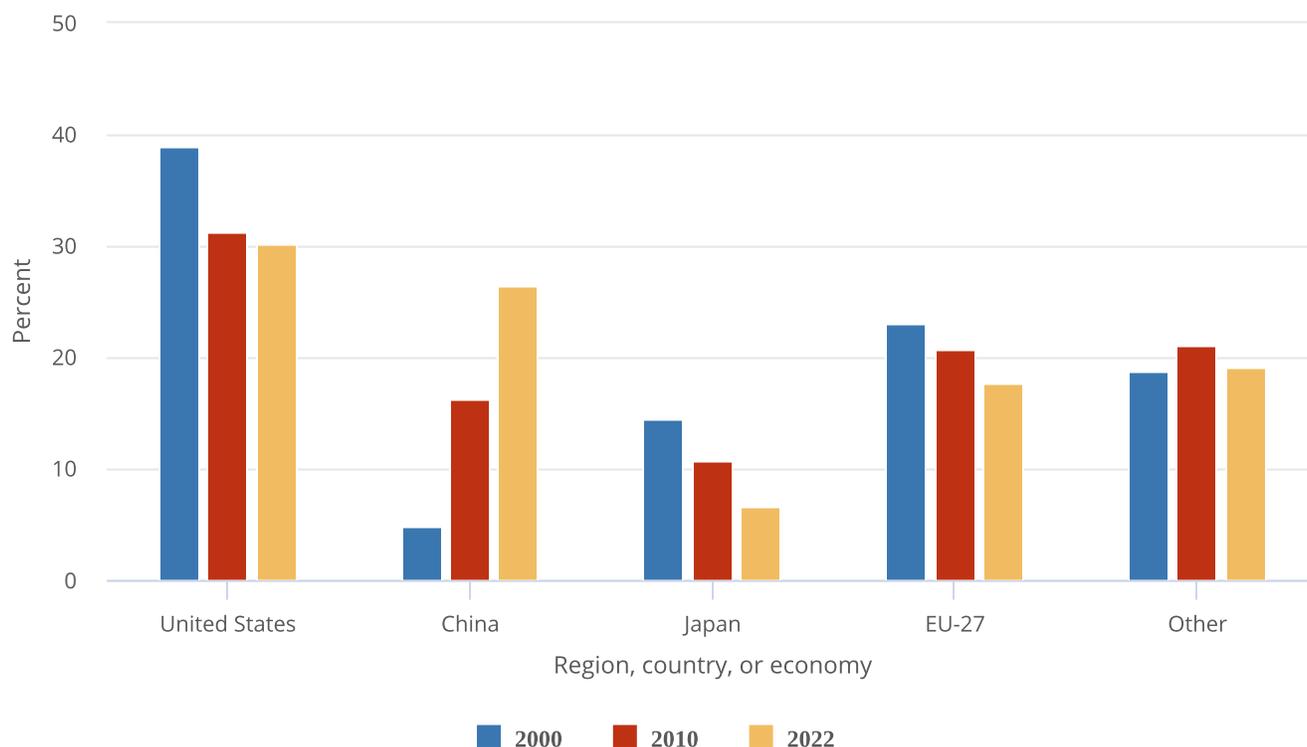
**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition); OECD, Main Science and Technology Indicators, July 2024, [https://stats.oecd.org/Index.aspx?DataSetCode=MSTL\\_PUB](https://stats.oecd.org/Index.aspx?DataSetCode=MSTL_PUB).

Science and Engineering Indicators

The U.S. share of global R&D declined from 39% in 2000 to 31% in 2010, remaining stable at 30% in 2022. China's share of global R&D increased steadily since 2000, with corresponding declines in the shares of Japan and the EU-27 (Figure DISC-19). China's GERD grew annually on average by double digits (CAGR in current dollars) in 2000–10 (20%) and in 2010–22 (12%), exceeding the rate of GDP growth over each of these periods, measured in current U.S. PPP dollars, adjusted for international comparability (Table DISC-10; Table SDISC-3). R&D expenditures' growth over these decades coincided with several long-term policy plans by the Chinese government to advance scientific and technological capabilities (CRS 2024). For the United States, GERD and GDP grew annually between 2000 and 2010 by 4% (CAGR in current [nominal] dollars). For 2010–22, U.S. GERD grew 7% annually (CAGR in current dollars), faster than the nominal GDP growth rate of 5%.

Figure DISC-19. Share of global GERD, by selected region, country, or economy: 2000, 2010, and 2022



EU-27 = European Union; GERD = gross domestic expenditures on R&D.

**Note(s):**

Some data are preliminary and may be revised later. U.S. data have been adjusted for international comparability.

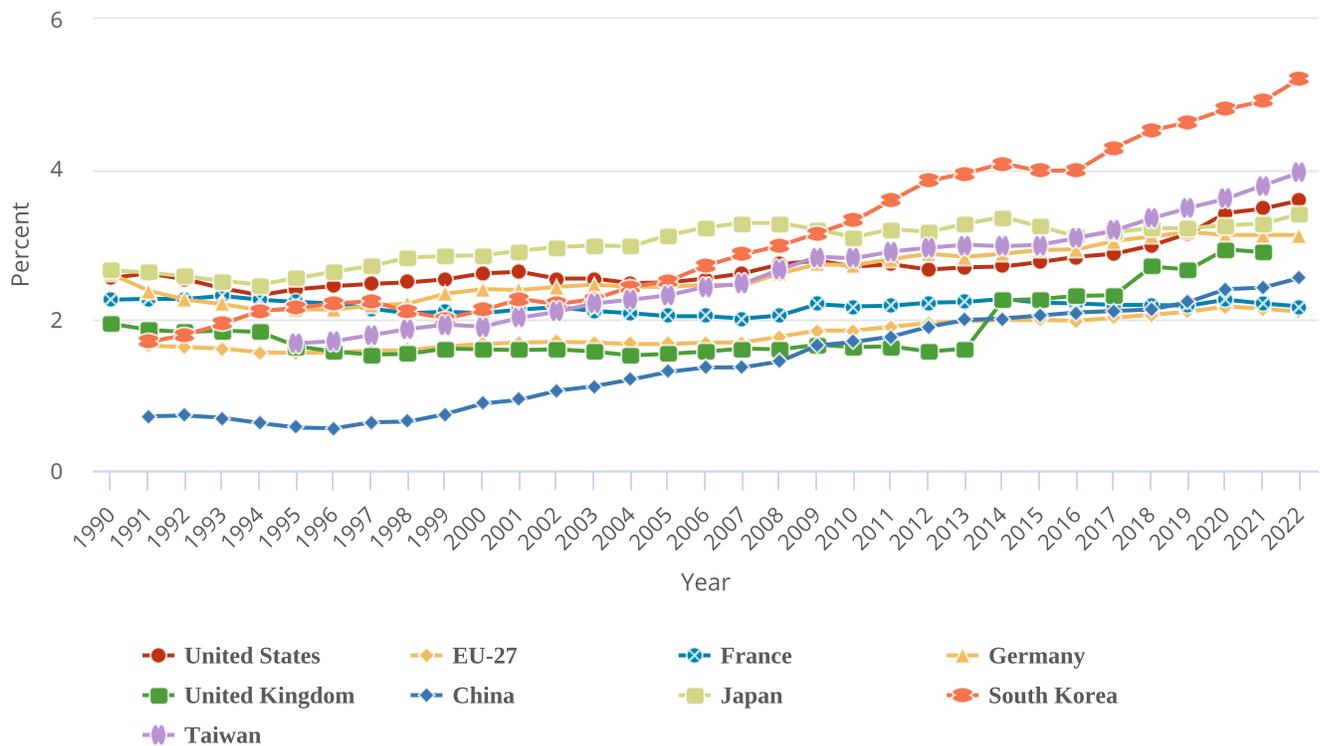
**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition); Organisation for Economic Co-operation and Development, Main Science and Technology Indicators, July 2024, [https://stats.oecd.org/Index.aspx?DataSetCode=MSTI\\_PUB](https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

*Science and Engineering Indicators*

GERD-to-GDP ratios, or national R&D intensities, are a useful summary measure to compare across economies (Table SDISC-3). In 2022, Israel (6.0%) and South Korea (5.2%) topped this indicator, while seven economies had intensities between 3.0% and 4.0%, including Taiwan (4.0%), the United States (3.6%), Japan (3.4%), and Germany (3.1%). China's GERD-to-GDP ratio was 2.6%, and the EU-27 had a ratio of 2.1% in 2022 (Figure DISC-20).

Figure DISC-20. GERD as a share of GDP, by selected region, country, or economy: 1990–2022



EU-27 = European Union; GDP = gross domestic product; GERD = gross domestic expenditures on R&D.

**Note(s):**

Data are not available for the EU-27, China, and South Korea for 1990; for Taiwan for 1990–94; or the United Kingdom for 2022. Data for U.S. GERD differ slightly from the U.S. total R&D data tabulated elsewhere in this report. For better consistency with international standards, U.S. GERD includes federal capital funding for federal intramural and nonprofit R&D in addition to what is reported as U.S. total R&D. Data for Japan from 1996 onward may not be consistent with earlier data because of changes in methodology.

**Source(s):**

National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition); Organisation for Economic Co-operation and Development, Main Science and Technology Indicators, July 2024, [https://stats.oecd.org/Index.aspx?DataSetCode=MSTI\\_PUB](https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

Science and Engineering Indicators

The sectoral composition of R&D activities varies among countries and regions. Across the top 8 individual R&D-performing economies, the business sector is the largest performer and funder of R&D (Table DISC-11). For 5 of the top 8 R&D-performing economies, businesses performed more than three-fourths of R&D. The government sectors in the United Kingdom and France performed about 20% of R&D, compared with 10% for the United States and 8% for China. The higher education sector had double-digit performing shares only in China, Germany, and France among the largest R&D performers, with available detail in the OECD MSTI database (Table DISC-11; Table SDISC-4). The government sector funded between 17% and 23% of GERD in South Korea, the United Kingdom, the United States, and China in 2022.<sup>23</sup>

**Table DISC-11. GERD for selected region, country, or economy, by performing sector and source of funds: 2022 or most recent year**

(Billions of current U.S. PPP dollars and percent)

Region, country, or economy	GERD (PPP US\$billions)	R&D-performing sector: Share of total (percent)				R&D source of funds: Share of total (percent)			
		Business	Government	Higher education	Nonprofit <sup>a</sup>	Business	Government	Other domestic	Rest of world
United States <sup>b</sup>	923.24	78.95	9.91	8.17	2.98	70.03	18.11	4.98	6.87
EU-27	542.12	65.82	21.91	10.85	1.42	NA	NA	NA	NA
China	811.86	77.57	7.84	14.59	NA	79.02	17.77	NA	0.17
Japan	200.77	79.38	11.53	7.89	1.19	78.49	15.10	5.69	0.71
Germany	174.86	67.37	18.13	12.10	2.39	NA	NA	NA	NA
South Korea	139.00	79.38	9.15	9.38	2.08	76.31	22.64	0.74	0.31
United Kingdom (2021)	102.61	70.92	22.52	5.09	1.47	58.54	19.40	11.42	10.63
France	85.17	65.81	20.62	11.55	2.02	NA	NA	NA	NA
Taiwan	63.97	85.50	6.46	7.93	0.10	85.39	13.93	0.58	0.10

NA = not available.

EU-27 = European Union; GERD = gross domestic expenditures on R&amp;D; PPP = purchasing power parity.

<sup>a</sup> The private nonprofit sector comprises all nonprofit institutions serving households except those classified as part of the higher education sector.<sup>b</sup> Data for U.S. GERD differ slightly from the U.S. total R&D data tabulated elsewhere in this report. For better consistency with international standards, U.S. GERD includes federal capital funding for federal intramural and nonprofit R&D, in addition to what is reported as U.S. total R&D. The data for U.S. funding from the rest of the world include funding for business R&D and academic R&D.**Note(s):**

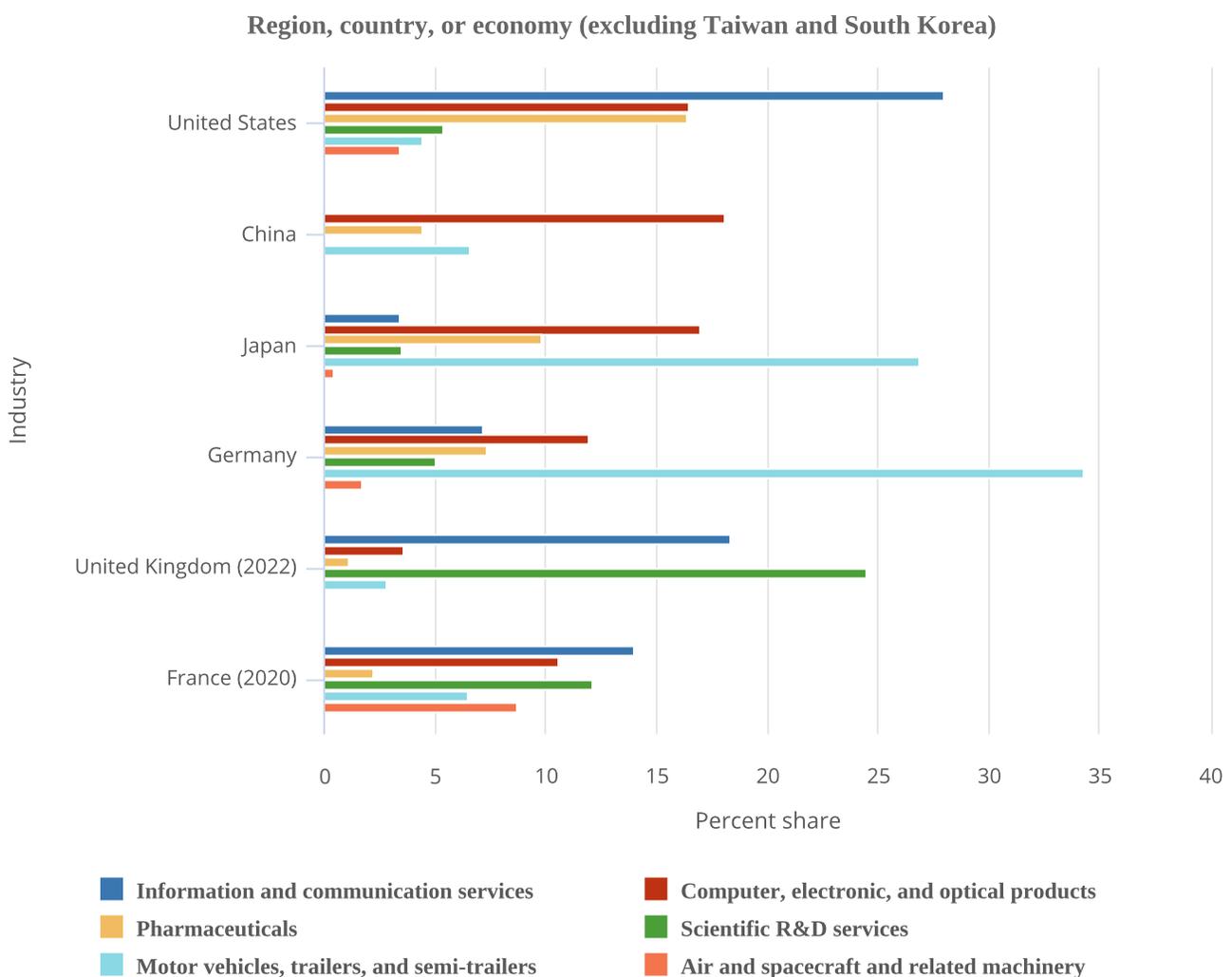
Some data are preliminary and may be revised later. Percentages may not add to 100% because of rounding. Germany's nonprofit sector expenditures are included in data for other performing sectors. The most recent year of GERD data for the United Kingdom was 2021. Classification of sectors follows Organisation for Economic Co-operation and Development (OECD) surveys. U.S. data have been adjusted for international comparability. Foreign currencies are converted by OECD to U.S. dollars using PPP.

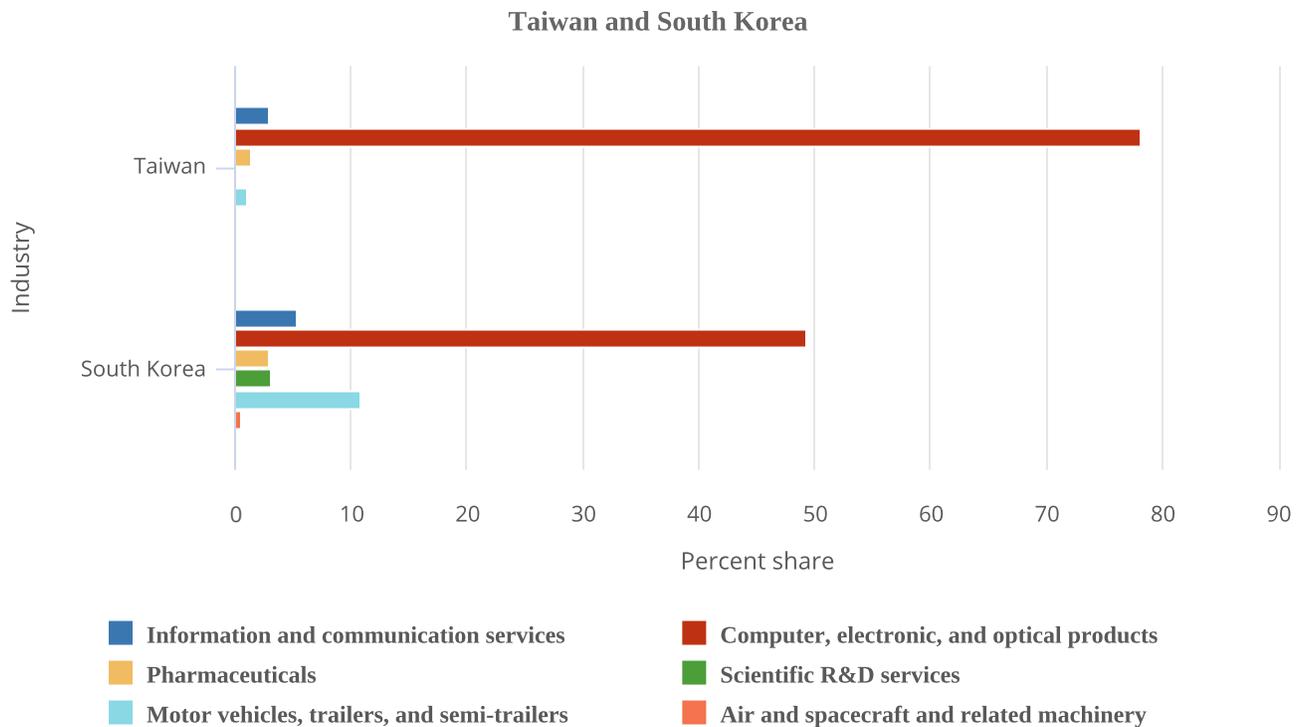
**Source(s):**National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition); OECD, Main Science and Technology Indicators, July 2024, [https://stats.oecd.org/Index.aspx?DataSetCode=MSTI\\_PUB](https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

Science and Engineering Indicators

IT-related industries (information and communication services and computer, electronic and optical products manufacturing) receive some of the largest shares of business R&D expenditures within top GERD economies, based on internationally comparable statistics from the OECD ANBERD database (OECD 2024a) (Figure DISC-21).<sup>24</sup> In 2021, information and communication industries (International Standard Industrial Classification of All Economic Activities [ISIC] 58-63) received the largest share of business R&D expenditures in the United States as well as France (28% and 14%, respectively), and the second-largest share in the United Kingdom (18%). Computer, electronic and optical products manufacturing (ISIC 26, which includes semiconductors) received the largest share of business R&D expenditures in Taiwan (78%) and in South Korea (49%); in the United States, it was the second-largest industry at 17%. However, in absolute terms, businesses in the United States funded the largest amount of business R&D in computer, electronic and optical products manufacturing among research-intensive economies at \$104.9 billion.

Figure DISC-21. Share of total R&D expenditures, by selected industry and selected region, country, or economy: 2021



**Note(s):**

Foreign currencies are converted by the Organisation for Economic Co-operation and Development (OECD) to U.S. dollars using purchasing power parity. U.S. R&D data have been adjusted for international comparability. Industry data are classified by OECD using the International Standard Industrial Classification of All Economic Activities (ISIC), Revision 4. Analytical Business Enterprise Research and Development (ANBERD) data for France are for 2020; ANBERD data for the United Kingdom are for 2022. For the information and communication services industries (ISIC 58-63), there are no 2021 ANBERD data for China. For the scientific R&D services industry (ISIC 72), there are no 2021 ANBERD data for China and Taiwan. For the air and spacecraft and related machinery industry (ISIC 303), there are no 2021 or 2022 ANBERD data for China, the United Kingdom, and Taiwan. Some data are preliminary and may be updated or revised later by OECD.

**Source(s):**

OECD, ANBERD, September 2024, available at <https://www.oecd.org/en/data/datasets/analytical-business-enterprise-research-and-development.html>, accessed 15 October 2024.

*Science and Engineering Indicators*

Other notable focus areas for business R&D expenditures in 2021 included the motor vehicles manufacturing (including electric vehicles), aerospace manufacturing, and pharmaceuticals manufacturing industries and R&D services. A third of business R&D expenditures in Germany and a quarter of business R&D expenditures in Japan were devoted to the motor vehicles manufacturing industry (ISIC 29). Among top GERD economies, the United States had largest share of business R&D expenditures in pharmaceuticals manufacturing (ISIC 21) with 16%, followed by Japan with 10%. Businesses in the United Kingdom (24%) and France (12%) invest the largest shares of R&D expenditures in scientific R&D services (ISIC 72).<sup>25</sup> Lastly, the largest shares of business R&D expenditures in the air and spacecraft and related machinery manufacturing industry (ISIC 303) were in France (9%) and the United States (3%).<sup>26</sup>

**SIDEBAR****Biotechnology R&D and Publications Output**

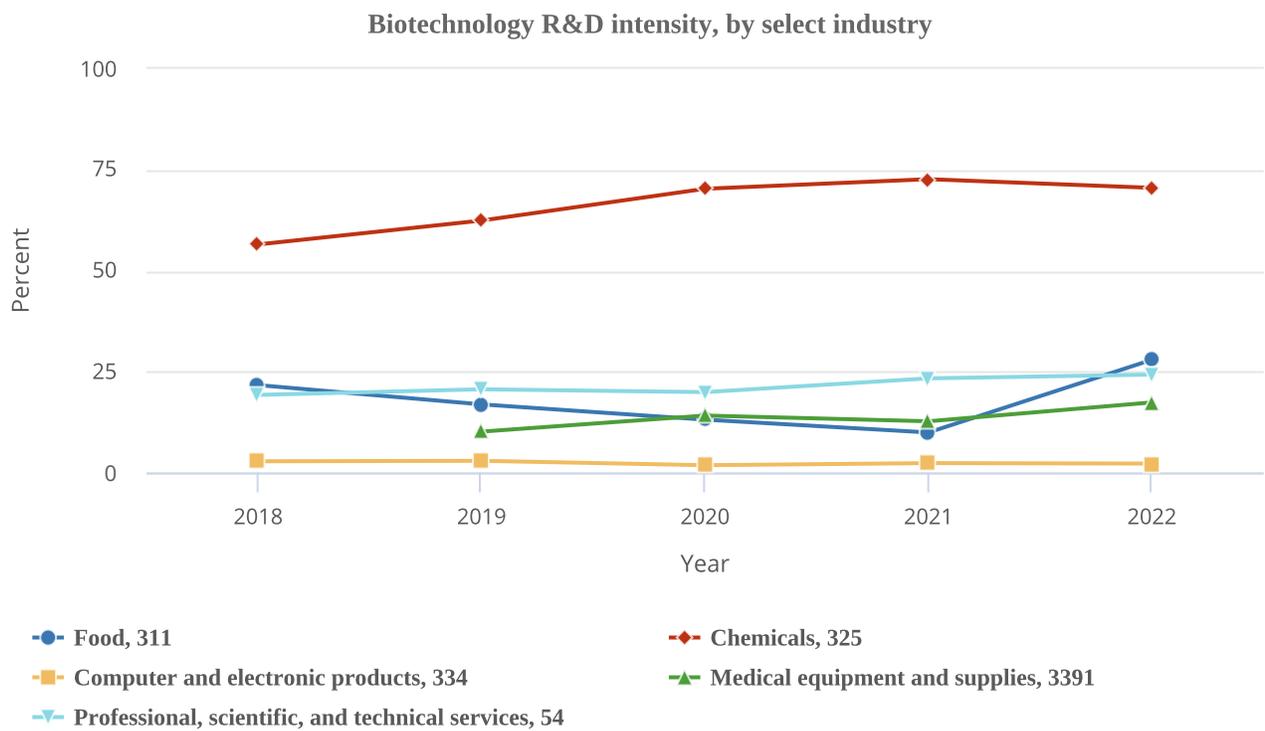
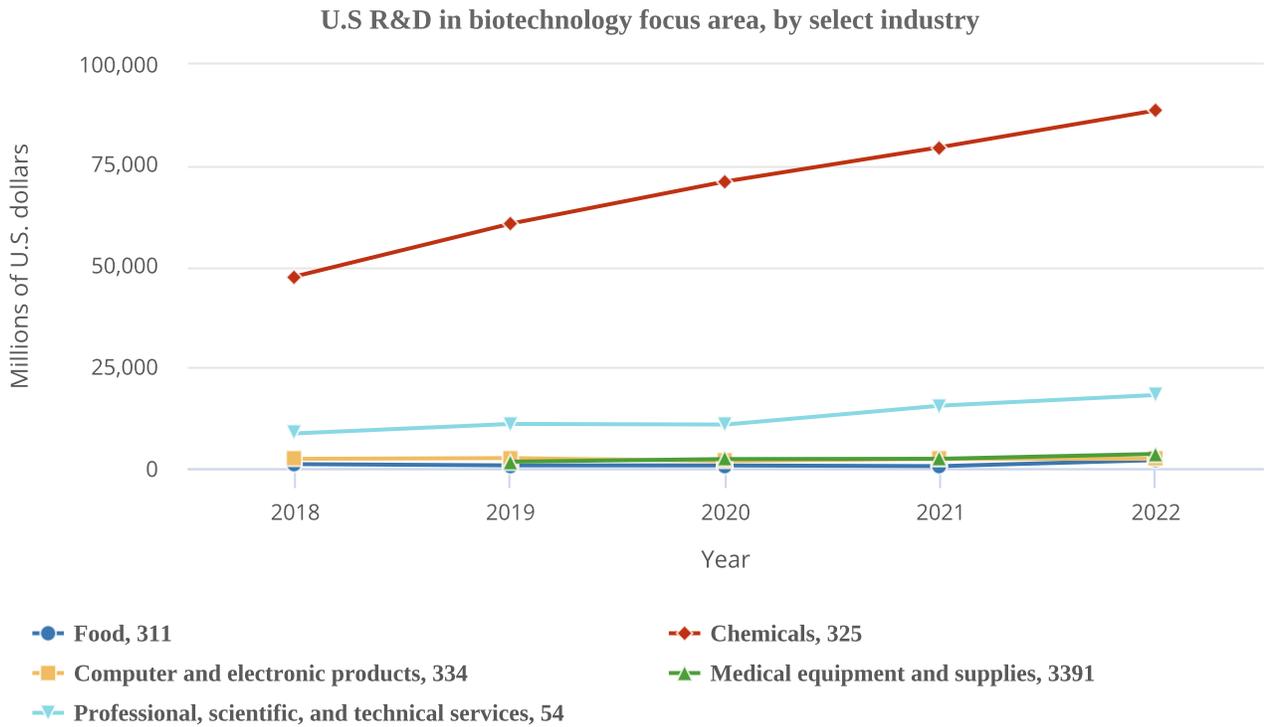
Biotechnology is one of several critical and emerging technologies areas (see the section [U.S. Business R&D by Technology Focus](#)) identified by the Department of Defense as contributing to economic competitiveness and national security. Biotechnology is considered an important contributor for applications ranging from agricultural production and health care to computing power and biosecurity (CRS 2025). This sidebar covers recent statistics on biotechnology R&D and publications output. The following sections of this report will cover broad trends in publications across all fields as described in the Introduction.

### **International and U.S. Biotechnology R&D**

The United States had the highest business sector biotechnology R&D expenditures in 2022 among economies reporting statistics to the Organisation for Economic Co-operation and Development (OECD) at \$117.1 billion (OECD 2024b, Table KBI 2).<sup>\*</sup> France, with the second-highest expenditures, reported \$6.3 billion in 2022 in current U.S. purchasing power parity dollars. Germany, the third-highest performer, reported \$4.6 billion in business biotechnology R&D expenditures.

In 2022, biotechnology R&D accounted for 17% of the total domestic R&D performed in the United States (\$117.1 billion of the \$691.5 billion total) (NCSES 2024a). Chemicals manufacturing (NAICS 325), which includes Pharmaceuticals and medicine manufacturing, has accounted for the majority of U.S. business R&D focused on biotechnology applications since 2018, reaching \$88.6 billion in 2022. Professional, scientific, and technical services (NAICS 54), which includes Scientific research and development services, has remained the second-highest-performing industry, with \$18.1 billion performed in 2022 ([Figure DISC-A](#)).

Figure DISC-A. Domestic business R&D paid for by the company and others and performed by the company in the biotechnology focus area, by selected industry: 2018–22



NA = not available.

NAICS = 2017 North American Industry Classification System.

**Note(s):**

Data for Medical equipment and supplies (NAICS 3391) are not available for 2018. Detail may not add to total because of rounding. Industry classification is based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used for sampling was assigned. Statistics are representative of companies located in the United States that performed or funded \$50,000 or more of R&D and are not comparable with estimates published for years prior to 2018. Companies could report R&D in one, more than one, or no application area. Beginning in survey year 2018, these statistics include an adjustment to the weight to account for unit nonresponse; beginning in survey year 2019, these company count estimates reflect a change in rounding methodology. The Business Enterprise Research and Development (BERD) Survey does not include companies with fewer than 10 domestic employees.

**Source(s):**

National Center for Science and Engineering Statistics and Census Bureau, Business Research and Development Survey (BRDS), 2018, and BERD Survey, 2019–22.

*Science and Engineering Indicators*

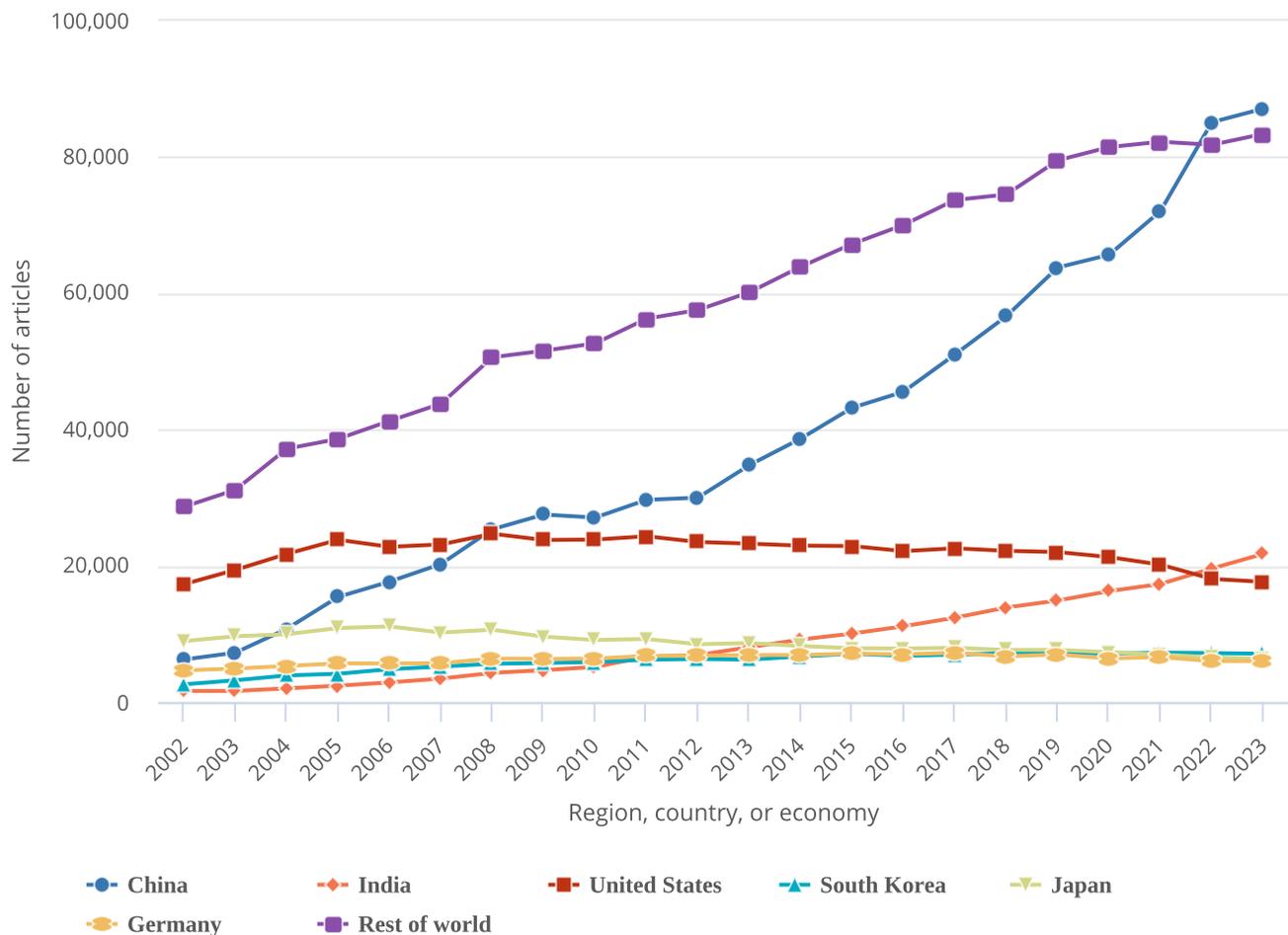
Chemicals manufacturing is also among the most biotechnology R&D-intensive industries in recent years, with 71% of its R&D reported as being in the Biotechnology application area in 2022 (\$88.6 billion out of the \$125.7 billion total within Chemicals). Health care services (NAICS 621–23) also reported a high biotechnology R&D intensity in 2022, with \$1.5 billion performed in the application area out of the total \$2.9 billion R&D performed across the industry in 2022 (NCSES 2024a: [Table 20](#)).

### **Business Use of Biotechnology by U.S.-Located Firms**

While only 1% of all U.S.-located companies reported using biotechnology at least “a little” in 2021, 32% of companies within Scientific research and development services (NAICS 5417) and 20% of companies within Pharmaceutical and medicine manufacturing (NAICS 3254) reported using biotechnology (Kindlon, Anderson, and Rhodes 2024, Figure 2).

### **International Biotechnology Publications**

International publication trends represent an early output from research in biotechnology across economies. The six countries that produced the highest total number of biotechnology publications from 2002 to 2023 are China, the United States, India, Japan, Germany, and South Korea ([Figure DISC-B](#)).<sup>†</sup> In 2002, researchers from the United States produced the most biotechnology articles of any nation, with 17,308 articles, followed by Japan with 8,957 articles. From 2002 to 2008, U.S. publication in biotechnology grew 43% but declined after 2008: gradually from 2008 to 2017 (down 9%) and then more rapidly from 2018 to 2023 (down 21%). In 2023, authors from the United States produced 17,649 biotechnology articles, the lowest level since 2002.

**Figure DISC-B. Biotechnology-related S&E articles, by selected region, country, or economy and rest of world: 2002–23****Note(s):**

Biotechnology article counts refer to publications algorithmically fingerprinted under "biotechnology" from conference proceedings and peer-reviewed journals in S&E fields in Scopus. Articles are classified by their year of publication and are assigned to a country on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles produced by authors from different regions, countries, or economies, each region, country, or economy receives fractional credit on the basis of the proportion of its participating authors). Data by all regions, countries, and economies are available in Table SDISC-78.

**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

Science and Engineering Indicators

From 2002 to 2023, publications from authors based in India grew 1,233% (from 1,633 to 21,761) and publications from authors based in China grew 1,292% (from 6,256 to 87,109). China overtook the United States as the top producer of biotechnology articles in 2008, and India overtook the United States as the second-largest producer in 2022. Biotechnology articles authored by Japanese researchers grew until 2006 before steadily decreasing (from 11,109 in 2006 to 6,333 in 2023). The number of biotechnology articles authored by German researchers gradually grew to a high of 7,255 articles in 2017 before gradually decreasing to 6,031 articles by 2023. South Korean authors have also produced an increasing number of biotechnology articles from 2002 to 2019 (up 178% to 7,265 articles in 2019) that remained between 7,100 and 7,300 through 2023. Outside of the top six producing countries, the combined biotechnology publications from authors from the rest of the world grew over this same period (up 191% to 83,399 in 2023).

\* Some countries differ in the characteristics of firms used to measure biotechnology R&D expenditures. Data on U.S. biotechnology R&D expenditures are limited to businesses with 10 or more employees. International data on biotechnology R&D are limited to OECD member countries as reported to OECD. Data for China and other nonmember economies are not available for this indicator.

† A data set of biotechnology-related publications was generated using Elsevier's existing Omniscience taxonomy, which fingerprints the entire Scopus database under an array of concepts. Of these concepts, 24 concepts were classified under "biotechnology." This approach helps ensure that a wide range of biotechnology research is included but prevents a too-extensive list of publications in which biotechnology may play a more removed role or appear as a minor application. Under this classification, materials research in biotechnology was the most represented, followed by a generic biotechnology classification. There were smaller but notable groupings of publications of industrial biotechnology and animal biotechnology included as well.

## Publication Output by Geography and Scientific Field

Research publications are an early output of R&D activity, especially academic R&D, and an important medium for disseminating and sharing scientific discoveries. The bibliometric analysis presented in this section includes papers with English-language titles and abstracts published in conference proceedings and research articles with English-language titles and abstracts published in peer-reviewed scientific and technical journals (collectively referred to as *articles*). The analysis excludes PhD dissertations, working papers, and preprints. It also excludes editorials, errata, letters, and other materials that do not typically present new scientific data, theories, methods, apparatuses, or experiments. The analysis also excludes articles published in journals that lack substantive peer review, sometimes referred to as predatory journals (Grudniewicz et al. 2019).

When aggregated, bibliometric indicators shed light on countrywide priorities across scientific fields. The scientific impact of publications through widely cited papers is an indicator of research quality. International collaborations in scientific publications show how researchers from different geographic locations pool resources and expertise to produce cutting-edge research or address global scientific challenges.

### Output by Geography, S&E Field, and Sector

Worldwide S&E publication output totaled 3.3 million articles in 2023, based on entries in the Scopus database.<sup>27</sup> In 2023, four countries each produced more than 100,000 articles: China, the United States, India, and Germany. Together, they accounted for over 50% of the worldwide total in 2023 (Table DISC-12).<sup>28</sup> The majority of the growth in worldwide annual publication output from 2.2 million in 2014 to 3.3 million in 2023 was driven by authors from two countries: China (51% of additional publications during that period) and India (13%) (Figure DISC-22). Articles from the United States and the EU-27 grew modestly from 2014 to 2023, but both have since decreased from their peak years in 2021. Publications from the United Kingdom and Japan decreased since 2021.

**Table DISC-12. S&E publications in all fields for the 15 largest producing regions, countries, or economies: 2013 and 2023**

(Number and percent)

Rank	Region, country, or economy	2013	2023	2023 world total (%)
na	World	2,129,076	3,275,079	na
1	China	351,526	932,712	28.48
2	United States	427,373	430,843	13.16
3	India	80,195	228,174	6.97
4	Germany	104,396	108,782	3.32
5	United Kingdom	98,613	97,536	2.98
6	Japan	106,968	96,543	2.95
7	Russia	38,167	85,558	2.61
8	Italy	66,221	82,771	2.53
9	South Korea	56,751	71,724	2.19
10	Canada	59,396	63,720	1.95
11	France	71,475	62,180	1.90
12	Spain	53,215	60,304	1.84
13	Brazil	45,991	58,292	1.78
14	Iran	31,025	55,085	1.68
15	Australia	50,403	54,589	1.67

na = not applicable.

**Note(s):**

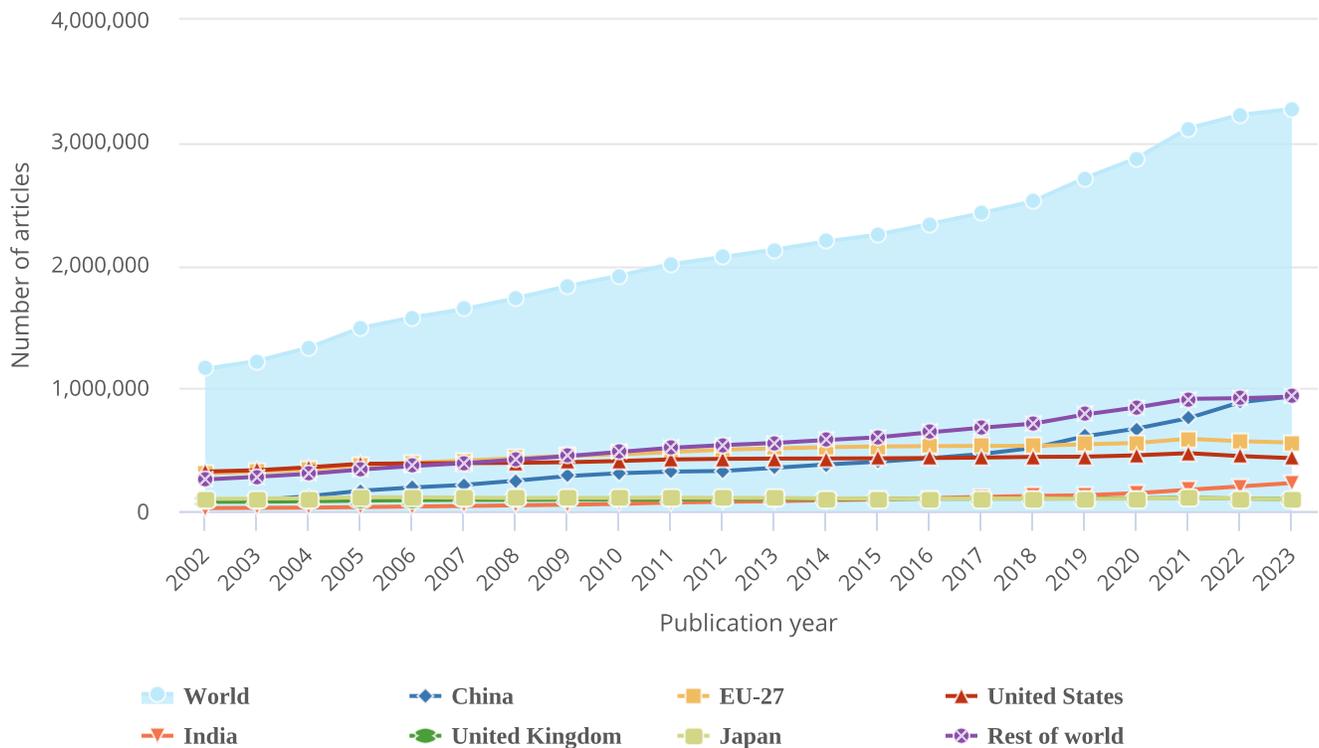
The countries or economies are ranked based on the 2023 total. Article counts refer to publications from conference proceedings and peer-reviewed journal articles in S&E and indexed in Scopus (see "Technical Appendix" for more details). Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles from multiple regions, countries, or economies, each country, region, or economy receives fractional credit on the basis of the proportion of its participating authors). Detail may not add to total because of regions, countries, or economies that are not shown. Proportions are based on the world total excluding unclassified addresses (data not presented). Data were extracted in February 2025. See Table SDISC-5 for groupings of regions, countries, or economies. Data by all regions, countries, and economies are available in Table SDISC-6.

**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

Science and Engineering Indicators

**Figure DISC-22. S&E publications, by selected region, country, or economy and rest of world: 2002–23**



EU-27 = European Union.

**Note(s):**

Article counts refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles produced by authors from different regions, countries, or economies, each region, country, or economy receives fractional credit on the basis of the proportion of its participating authors). See Table SDISC-5 for countries included in the EU-27. Data for all regions, countries, and economies are available in Table SDISC-6.

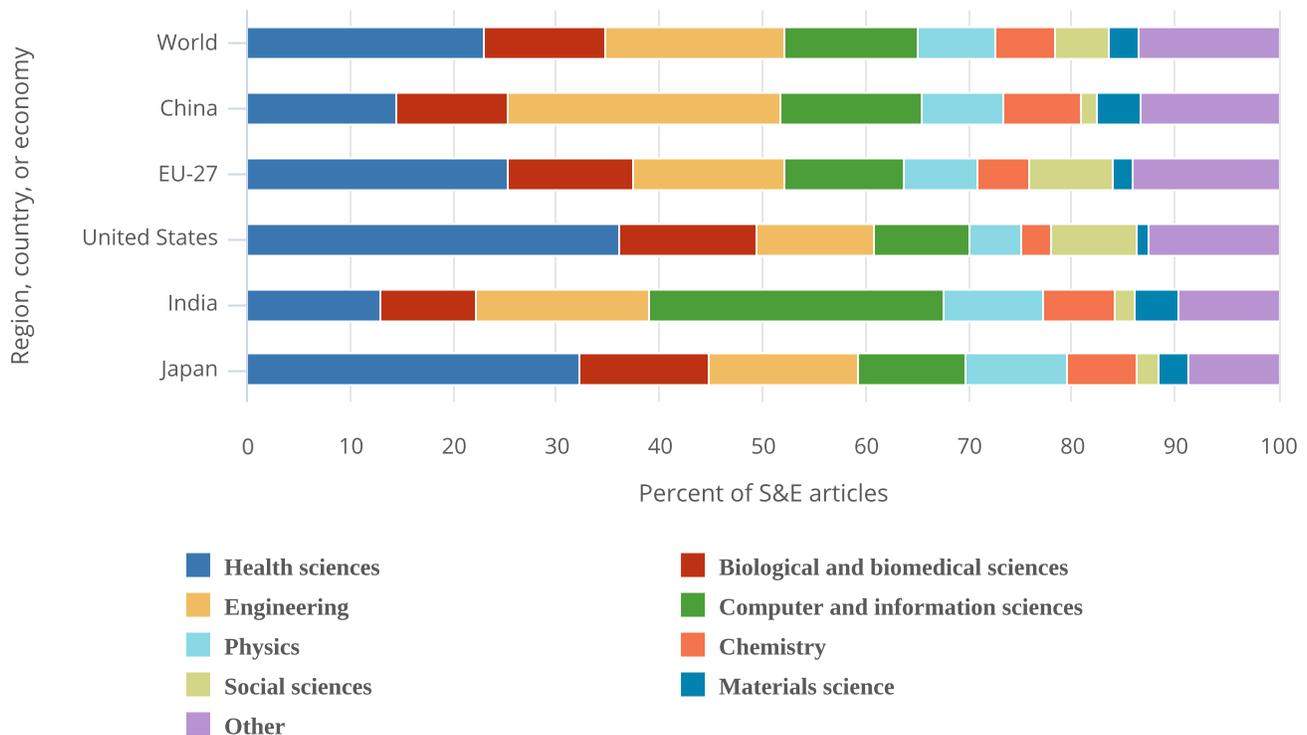
**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

Science and Engineering Indicators

The distribution of publications by field of science across geographies may indicate research priorities and capabilities. Globally, health sciences represented 23% of all publications in 2023, the highest output of any field (Figure DISC-23). Other fields with large numbers of publications included engineering (17% of publications in 2023), computer and information sciences (13%), and biological and biomedical sciences (12%). Among top producers, authors in three regions, countries, or economies had their highest concentration of publications in health sciences in 2023: the United States (36% of its total publications), Japan (32%), and the EU-27 (25%). Meanwhile, authors from China had the most publications in engineering (26%), and authors from India had the most publications in computer and information sciences (28%).

Figure DISC-23. Distribution of national S&E research portfolios across S&E fields, by selected region, country, or economy: 2023



EU-27 = European Union.

**Note(s):**

Articles refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles from multiple regions, countries, or economies, each region, country, or economy receives fractional credit on the basis of the proportion of its participating authors). See Table SDISC-5 for countries included in the EU-27. See Table SDISC-6 for all S&E fields. See Table SDISC-7–Table SDISC-20 for data for all regions, countries, and economies and all fields of science.

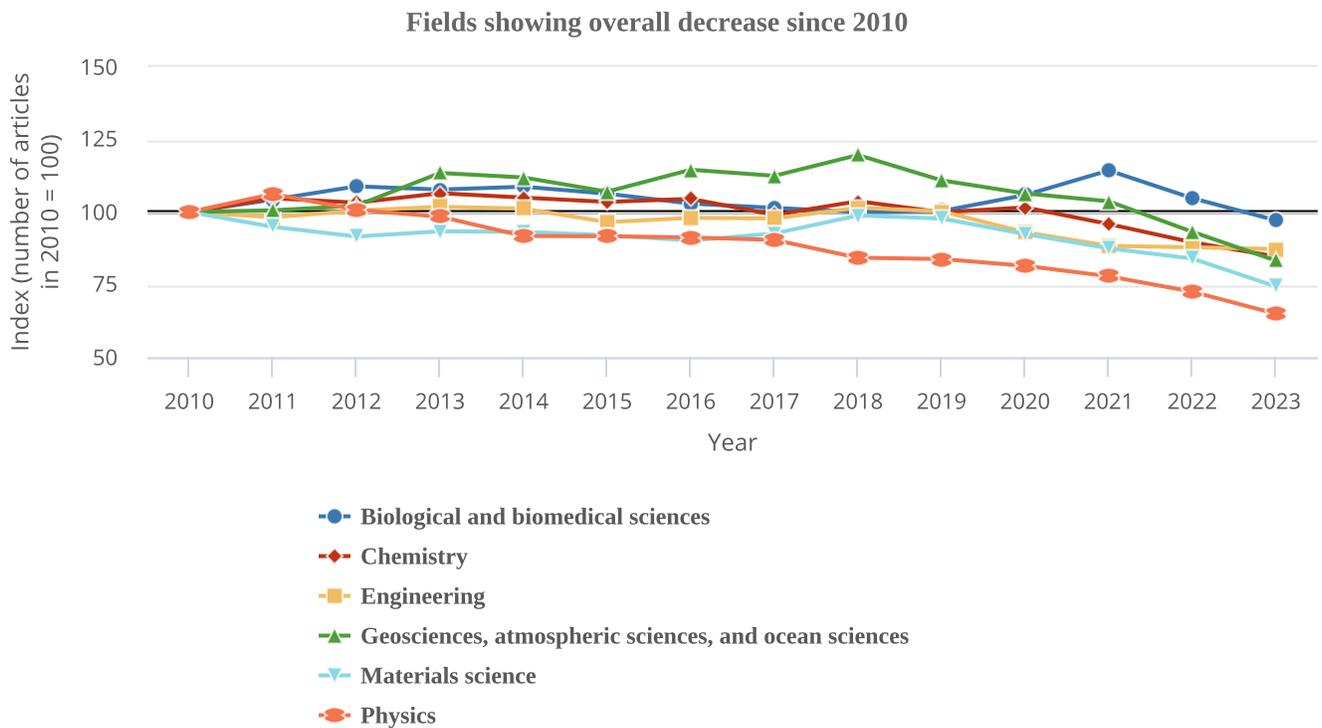
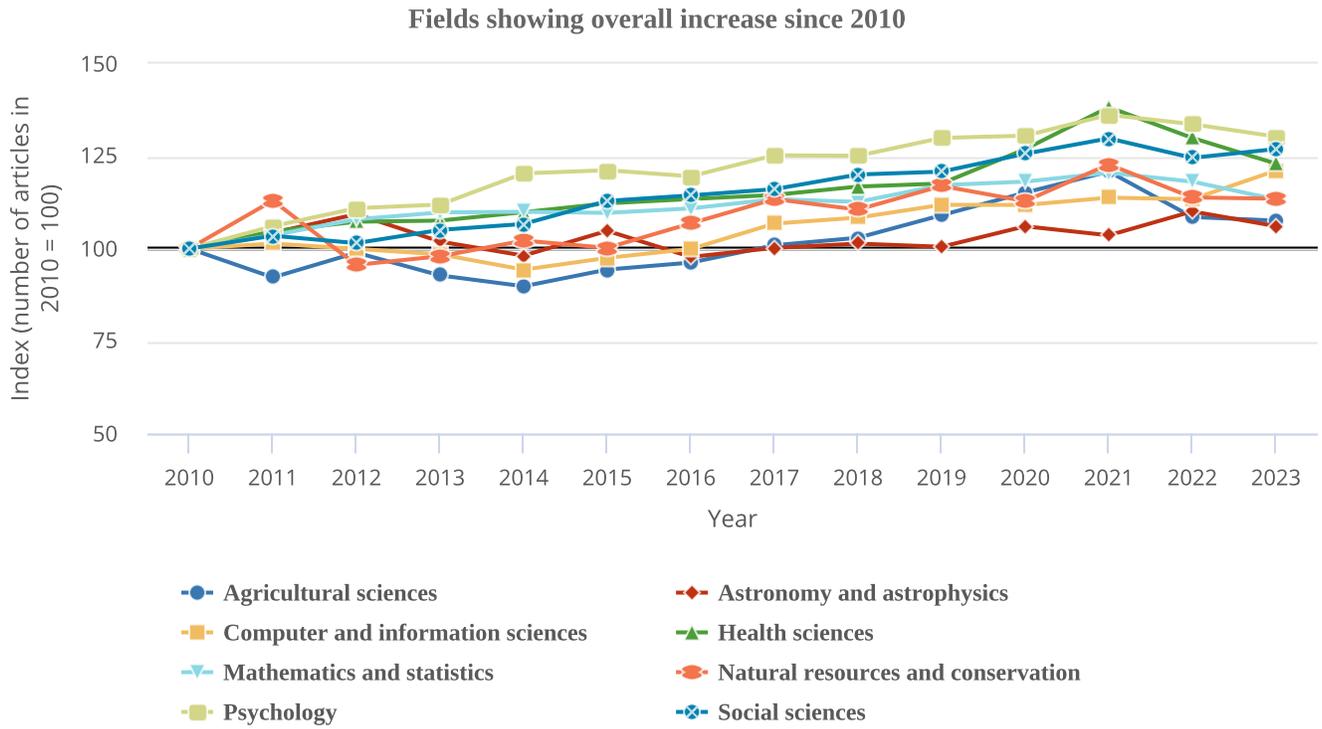
**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

*Science and Engineering Indicators*

Within the United States, the fastest-growing scientific fields from 2010 to 2023 were psychology (up 30%), social sciences (up 27%), and health sciences (up 23%) (Figure DISC-24). Meanwhile, fields with the largest decreases in U.S. publications included physics (down 35% from 2010 to 2023), materials science (down 26%), and geosciences, atmospheric sciences, and ocean sciences (down 17%).

Figure DISC-24. Index of U.S. publications, by S&E field: 2010–23



**Note(s):**

Articles refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles from multiple regions, countries, or economies, each region, country, or economy receives fractional credit on the basis of the proportion of its participating authors). See Table SDISC-7–Table SDISC-20 for data on all regions, countries, and economies by each S&E field.

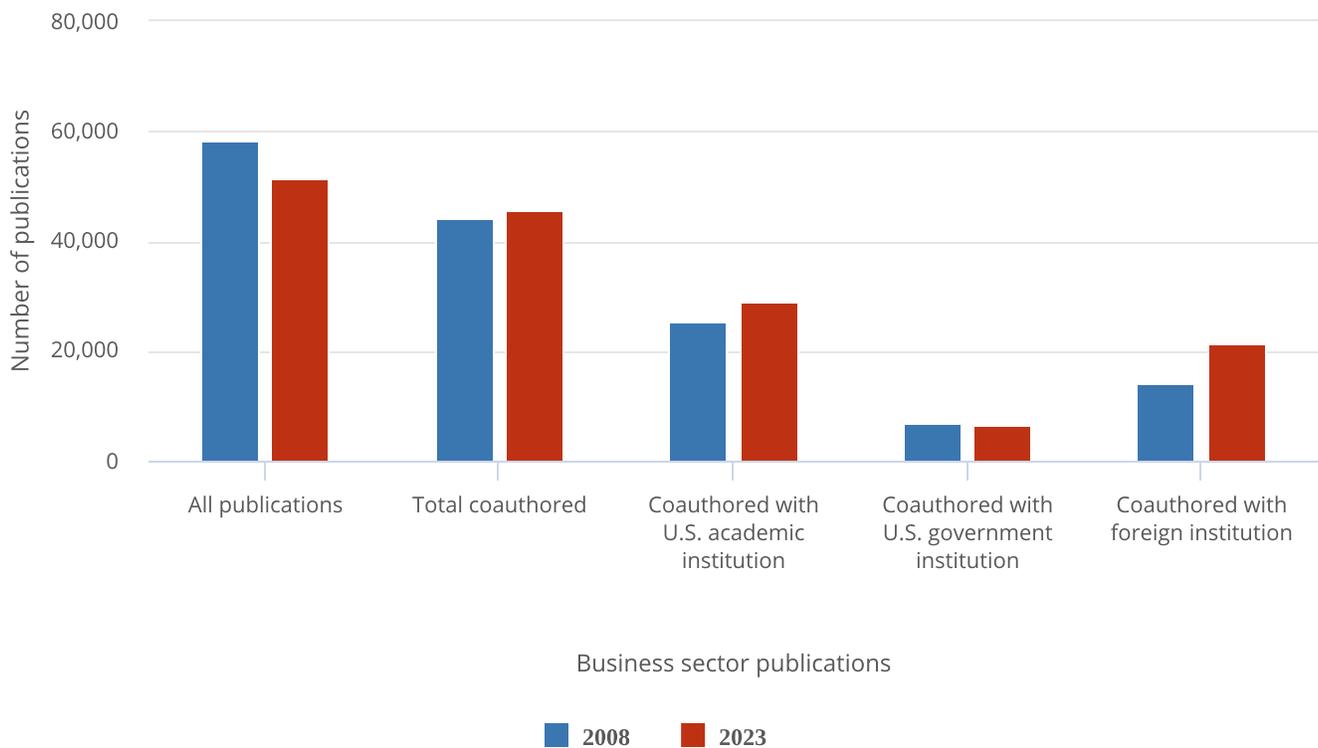
**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

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Research can be conducted in different sectors—such as academia, business, or government—with publication output serving as an indicator for resulting discoveries and collaboration. While students, faculty, and other academic staff may be more incentivized to produce peer-reviewed articles than authors from the business sector (Hicks 1995; Simeth and Raffo 2013), companies do benefit from publications by their scientists and engineers (Rotolo et al. 2022) resulting from their R&D activities (see section [U.S. Business R&D](#)), along with other research outputs such as patenting and licensing (see *Indicators 2026* report “Translation to Impact: U.S. and Global Science, Technology, and Innovation Output” [NSB forthcoming]). In the United States, the overall number of publications with business sector authors decreased from 2008 (58,346 articles) to 2023 (51,293). At the same time, an increasing share of articles with business sector authors were published collaboratively with authors outside the business sector. Coauthorship with colleagues from U.S. academic institutions produced the highest business publications output in 2023 (28,956), followed by collaboration with foreign (21,306) and U.S. government institutions (6,509) ([Figure DISC-25](#)).

**Figure DISC-25. U.S. business sector publications coauthored with academic, government, and foreign institutions: 2008 and 2023**



**Note(s):**

Publications are classified by their publication year and are assigned to a sector based on the institutional address(es) listed within the author information. Each publication is credited to a sector based on the institution type. Each collaborating institution is credited as coauthoring in this table when the listed authors come from different sectors. The publication is counted as one count in the sector (whole counting). Publications can be authored by collaborators in multiple sectors; thus, the sum of publications coauthored with various sectors can exceed the total. Publications from unknown U.S. sectors are not shown.

**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

*Science and Engineering Indicators*

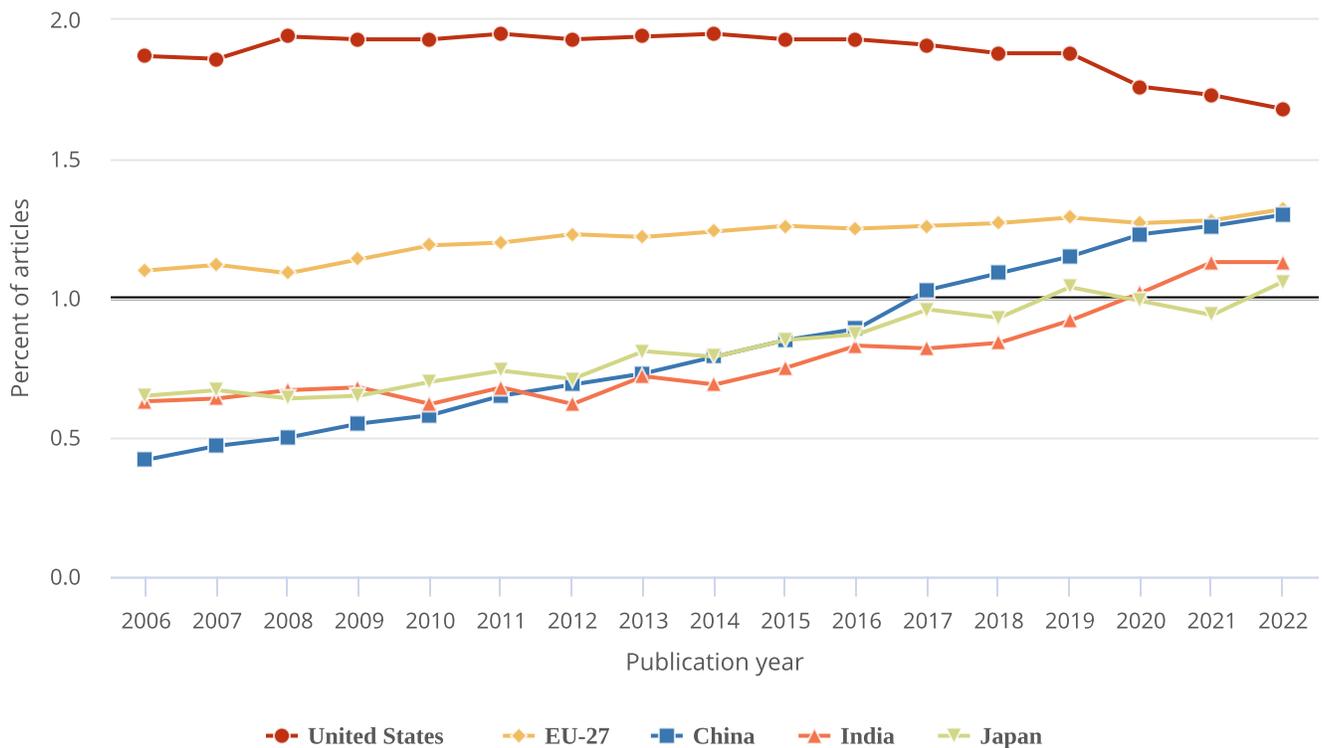
## Impact of Published Research

In addition to the total production of articles, indicators gauging the significance of published articles help assess the vitality and competitiveness of the U.S. S&E enterprise. Generally, authors of scientific articles cite previously published articles that influenced or informed their own research (Merton 1973; Tahamtan and Bornmann 2018). Thus, when an article is cited by many other articles, it is deemed to have scientific impact (Garfield 1973). Articles may accumulate citations over time, and although most scientific articles garner few or no citations, a small share receives hundreds or thousands of citations (Van Noorden, Maher, and Nuzzo 2014). Counting the citations earned by an article at least 2 years after publication provides sufficient time for high-impact articles to receive a distinguishing number of citations, although only articles published in the same field and the same year may be compared (Wang 2012). For this reason, the most recent available year for HCA-rated indicators is 2022.

Articles in the top 1% of all published articles in a given year and field are designated as highly cited articles (HCAs). For each geographic location (region, country, or economy), the proportion of HCAs relative to its total publication output is called its HCA share, and this indicator of scientific impact relative to total publication is comparable across different-sized producers. An HCA share above 1.00 means that more than 1% of the country's articles achieved HCA status, indicating that the country's published research has disproportionately higher impact given the overall number of articles its researchers produce.<sup>29</sup>

In 2022, 1.7% of peer-reviewed publications with U.S. authors were on the HCA list, showing that authors from the United States generate a disproportionate share of influential articles (Figure DISC-26). The HCA share for the United States had stayed above 1.9% in each year from 2008 through 2017 but has steadily declined since 2014. As of 2022, the U.S. HCA share stands at its lowest level throughout the period from 2006 to 2022. In contrast, China's HCA share has increased in each year from 2006 to 2022, rising from 0.4% in 2006 to 1.3% in 2022 (Figure DISC-26). The disparity in HCA shares between the United States and China has decreased steadily since 2008. Given that China produced more scientific articles than the United States in 2022, this convergence appears to represent a consistent increase in the scientific impact of publications with Chinese authors that is not outpaced by its overall publication growth (Table SDISC-6). The collective HCA share for the EU-27 has stayed at or above 1.2% since 2011 (Figure DISC-26). The HCA share for Japan, another major contributor to the world's scientific literature, has tended to lag behind the overall global HCA share. Japan's HCA share reached its highest level (1.1%) in 2022. India's HCA now exceeds the global HCA share, reaching 1.1% in 2022.

**Figure DISC-26. S&E publications in the top 1% most-cited journal articles as a share of all S&E journal articles, by selected region, country, or economy: 2006–22**



EU-27 = European Union.

**Note(s):**

Articles refer to articles from peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Citation data are based on all citations made to articles in their publication year and all following years and are normalized by subfield and publication year to allow for comparisons across subfields and over time, resulting in the world level standing at 1.00 for each subfield and year. A minimum 2-year citation window is needed for a highly cited article (HCA) score to be computed. This results in scores regarding HCA not being computed after 2022 because the citation window for more recent years is not yet complete. The share of articles in the top 1% is computed as follows:  $S_x = HCA_x / A_x$ , where  $S_x$  is the share of output from country  $x$  in the top 1% most-cited articles;  $HCA_x$  is the number of articles from country  $x$  that are among the top 1% of most-cited articles (using whole counting, with the exception of articles at the limit of the top 1%, which are fractioned so the world average can stand at 1%); and  $A_x$  is the total number of articles from country  $x$  with a relative citation score, which excludes articles released after 2022 and unclassified publications. The world average is 1.00 for each year. For more details, see Table SDISC-53. See Table SDISC-5 for countries included in the EU; beginning in 2020, the United Kingdom was no longer a member of the EU.

**Source(s):**

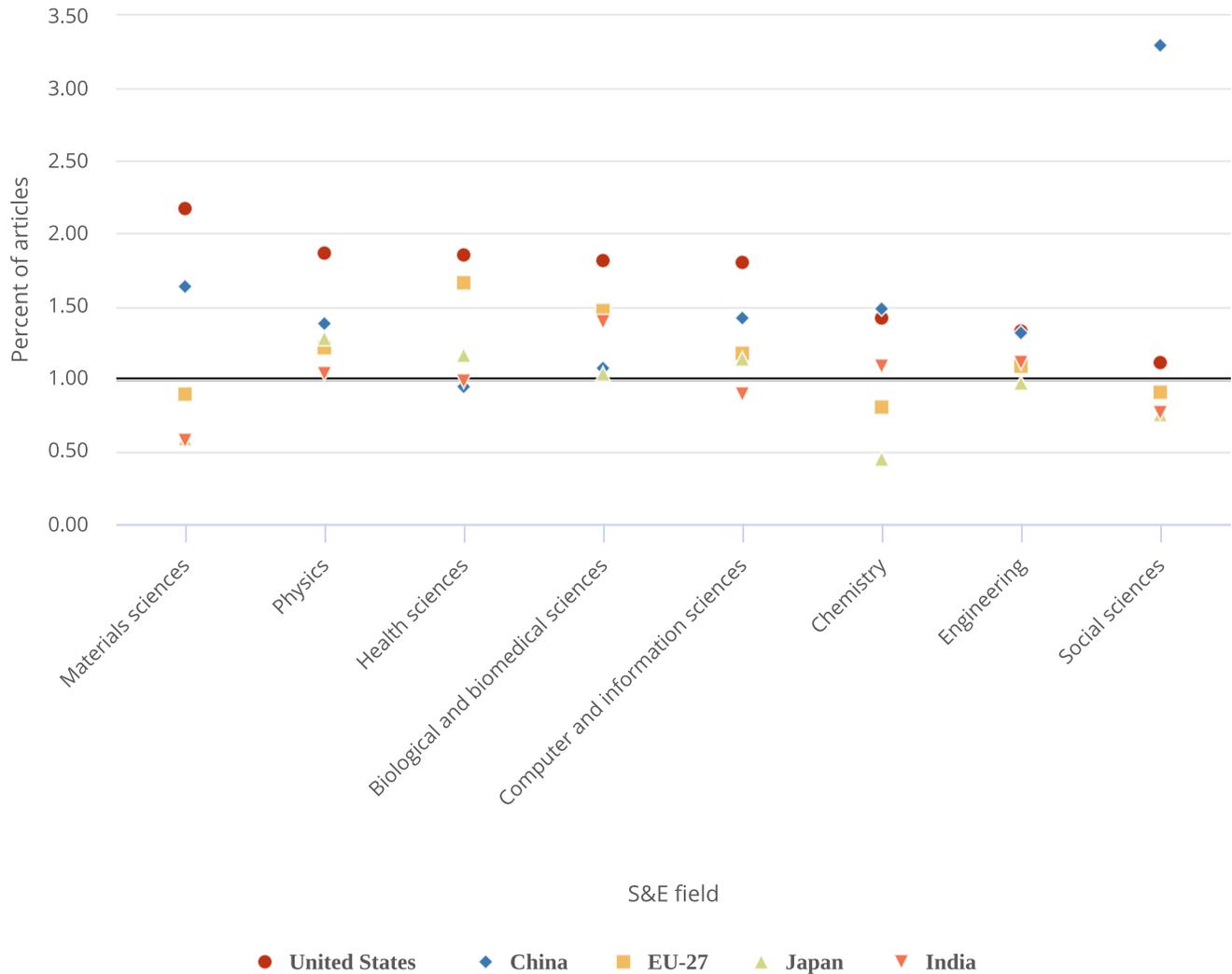
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

*Science and Engineering Indicators*

The HCA share of each country also varies between fields, reflecting research specializations or differences in the country's prominence in particular research fields or topics. In the United States, the HCA shares of 2022 publications in all selected fields also exceeded the baseline 1% HCA share (Figure DISC-27). In particular, 2.2% of materials science, 1.9% of physics, 1.8% of health science, 1.8% of biological and biomedical sciences, and 1.8% of computer and information sciences publications authored in the United States were HCAs in those respective fields.<sup>30</sup> Further, this was a higher HCA share in each of these fields compared to China, the EU-27, Japan, and India. The HCA shares of U.S.-authored publications in each selected field peaked between 2014 and 2019, whereas the HCA shares of publications by Chinese authors reached their highest level in 2020 or later (Table SDISC-53–Table SDISC-68). For HCAs in engineering, in 2022, the United States (1.3%)

and China (1.3%) had similar shares of the top articles in that field. The HCA shares of chemistry publications in China (1.5%) and the United States (1.4%) were also close. In 2022, for authors based in China, the top scientific field by impact was the social sciences, in which 3.3% of social sciences publications were HCAs, which was higher than the social sciences HCA share for the United States, EU-27, Japan, and India.

**Figure DISC-27. S&E publications in the top 1% most-cited journal articles as a share of all journal articles for selected S&E fields, by selected region, country, or economy: 2022**



EU-27 = European Union.

**Note(s):**

Articles refer to articles from peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are allocated to a region, country, or economy on a whole-count basis. Citation data are based on all citations made to articles in their publication year and all following years and are normalized by subfield and publication year to allow for comparisons across subfields and over time, resulting in the world level standing at 1.00 for each subfield and year. A minimum 2-year citation window is needed for a highly cited article (HCA) score to be computed. This results in scores regarding HCA not being computed after 2020 because the citation window for more recent years is not yet complete. The share of articles in the top 1% is computed as follows:  $S_x = HCA_x / A_x$ , where  $S_x$  is the share of output from country  $x$  in the top 1% most-cited articles;  $HCA_x$  is the number of articles from country  $x$  that are among the top 1% of most-cited articles (using whole counting); and  $A_x$  is the total number of articles from country  $x$  with a relative citation score, which excludes articles released after 2020 and unclassified publications. The world average is 1.00 for each year. For more details, see Table SDISC-54–Table SDISC-68. See Table SDISC-5 for countries included in the EU-27.

**Source(s):**

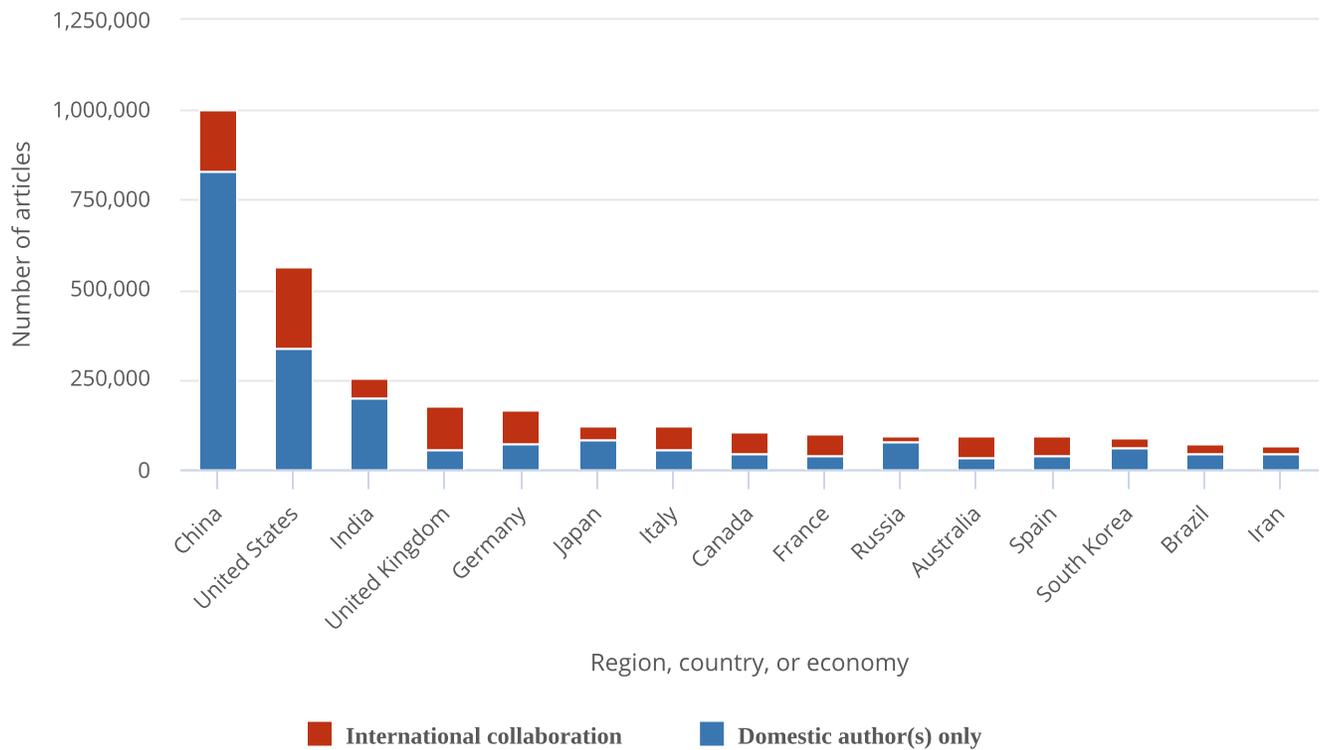
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025; World Bank Country and Lending Groups, accessed February 2025.

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## International Collaboration in Published Research

International collaborations can build a robust S&E workforce, increase scientific capabilities and cooperation (Lyons et al. 2016), including in emerging and critical technologies (see sidebar [Biotechnology R&D and Publications Output](#), and see sidebar [Semiconductor Research Publication Output and International Collaboration](#) at the end of this section). An article is classified as an international collaboration if at least two authors are located in different countries, as determined by their organizational affiliation on the article. Researchers may collaborate for several reasons, including to develop a scientific relationship with another researcher or to gain access to costly or shared equipment. They may also work together to meet conditions attached to research funding that require international collaboration (Wagner 2018). S&E research has become more global—a trend evidenced cross-nationally (Glänzel and Schubert 2005; Luukkonen et al. 1993; Royal Society 2011; Wagner, Park, and Leydesdorff 2015).

In 2023, researchers in the United States contributed to the largest number of articles involving international coauthorship (225,565 articles, representing 32% of all internationally coauthored articles) ([Figure DISC-28](#); Table SDISC-69). The most frequent partners for the United States were China, the United Kingdom, Canada, and Germany (Table SDISC-71). Elsewhere, the percentage of worldwide S&E articles produced with international collaboration has grown over time, increasing from 19% in 2012 to 22% in 2023 (Table SDISC-69).<sup>31</sup> Each region, country, or economy leading in publications showed increases in international collaboration rates ([Figure DISC-29](#)). United Kingdom researchers had international coauthors on 32% of their articles in 2002 and on 68% of their articles in 2023. Similarly, Germany's international collaboration rate increased from 35% to 56% over the same period. The United States and Japan both saw notable increases in international collaborations between 2003 and 2022 (from 20% to 40% and from 16% to 32%, respectively), whereas there were smaller increases for India (from 16% to 23%) and China (from 13% to 17%). China is the only selected country that shows a decrease in international collaboration since its peak in 2018 (22%).

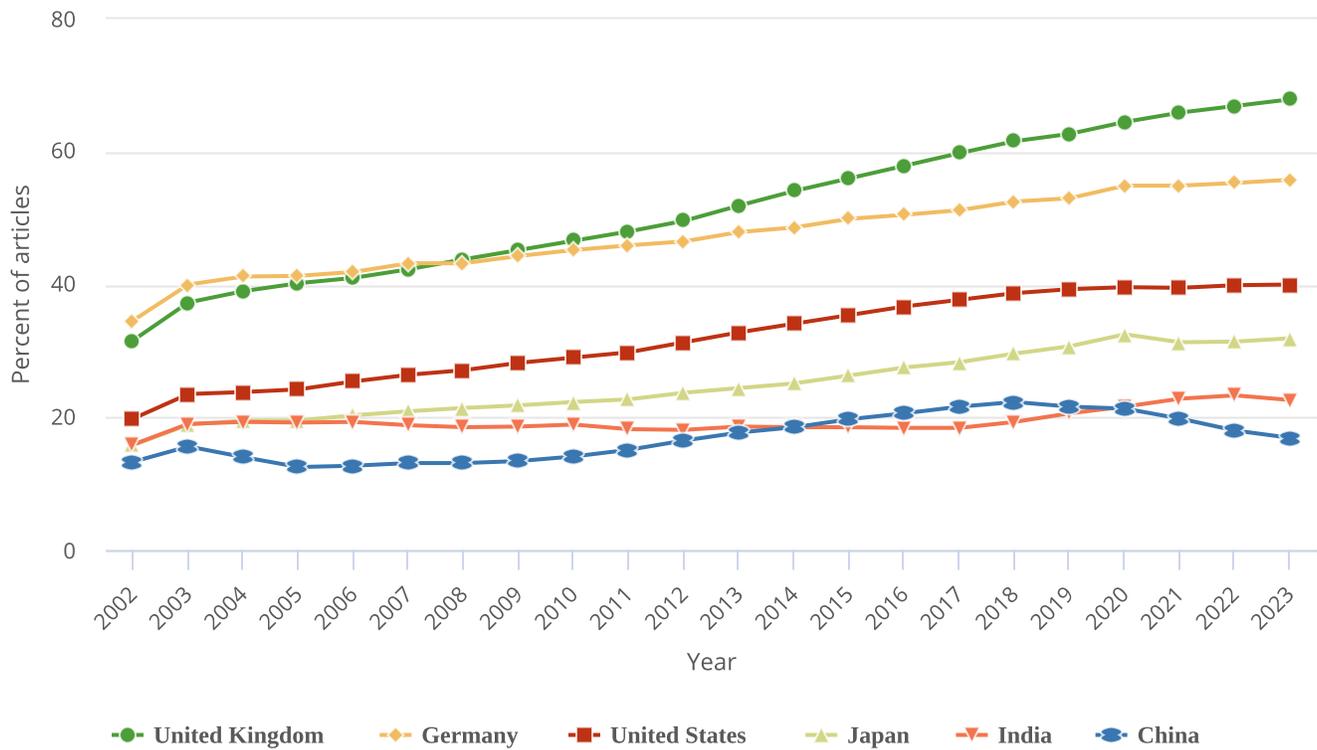
**Figure DISC-28. International coauthorship of S&E publications for the 15 largest producing regions, countries, or economies of S&E publications: 2023****Note(s):**

Articles refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating region, country, or economy is credited with one count). Articles without international coauthorship are counts of articles with one or more institutional addresses all within a single region, country, or economy, which include single-author articles and articles coauthored under the same institutional address. International articles are articles with institutional addresses from more than one region, country, or economy. The numbers of articles from the international collaboration and domestic author(s) only categories may not sum to the total article number because some coauthored publications have incomplete address information in the Scopus database. These publications often cannot be reliably identified as international or domestic collaborations. For this reason, they are not included in either subcategory but are still counted toward the total number of articles. For more detail, see Table SDISC-69.

**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

Figure DISC-29. Selected leading regions, countries, or economies with publications with international coauthors: 2002–23

**Note(s):**

Articles refer to publications from a selection of journals and conference proceedings in S&E from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating region, country, or economy is credited with one count). Articles with international institutions are counts of articles with institutional addresses from more than one region, country, or economy. For additional countries, see Table SDISC-69.

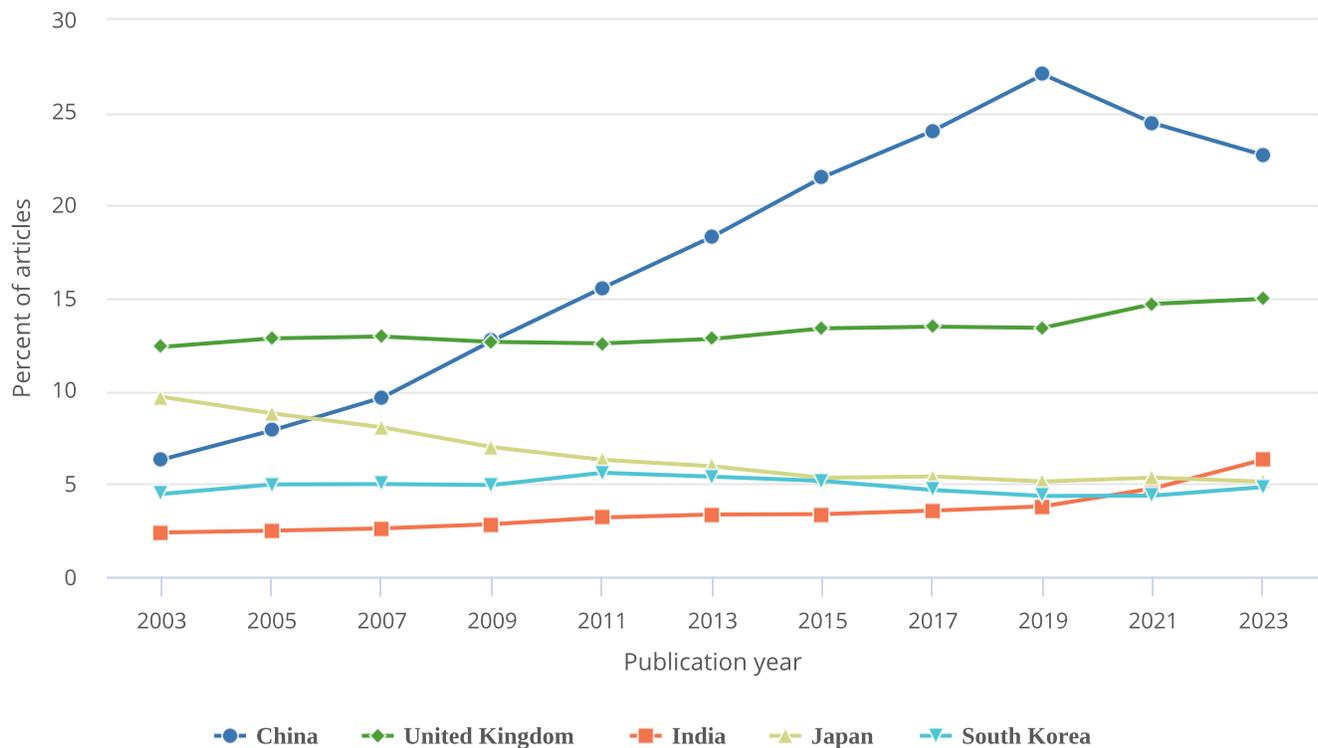
**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

*Science and Engineering Indicators*

Over time, the top countries with authors collaborating with U.S. researchers have changed. In 2003, partnerships with authors in the United Kingdom accounted for 12% of articles coauthored with U.S. collaborators—the highest percentage of any partner region, country, or economy (Figure DISC-30; Table SDISC-71). By 2009, China had overtaken the United Kingdom as the origin of the greatest percentage of coauthors with U.S. researchers and has remained in first place since that time. The increasing share of global publications from authors in China over the same period may have contributed to this increase in collaboration. In 2023, 23% of internationally coauthored U.S. articles have a Chinese coauthor, although this represents a decline from 27% in 2019. Meanwhile, the percentage of U.S. internationally coauthored articles with the United Kingdom increased slightly over this period to 15% in 2023. Since 2019, authors from India (from 4% to 6%) passed those from Japan (steady at 5%) and South Korea (from 4% to 5%) in collaborations with U.S. partners.

Figure DISC-30. U.S. international S&E publications with coauthor(s) from the United Kingdom and Asian countries: Selected years, 2003–23



**Note(s):**

Articles refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a whole-count basis (i.e., each collaborating region, country, or economy is credited with one count). Articles with international institutions are counts of articles with institutional addresses from more than one region, country, or economy. For more detail, see Table SDISC-71.

**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

*Science and Engineering Indicators*

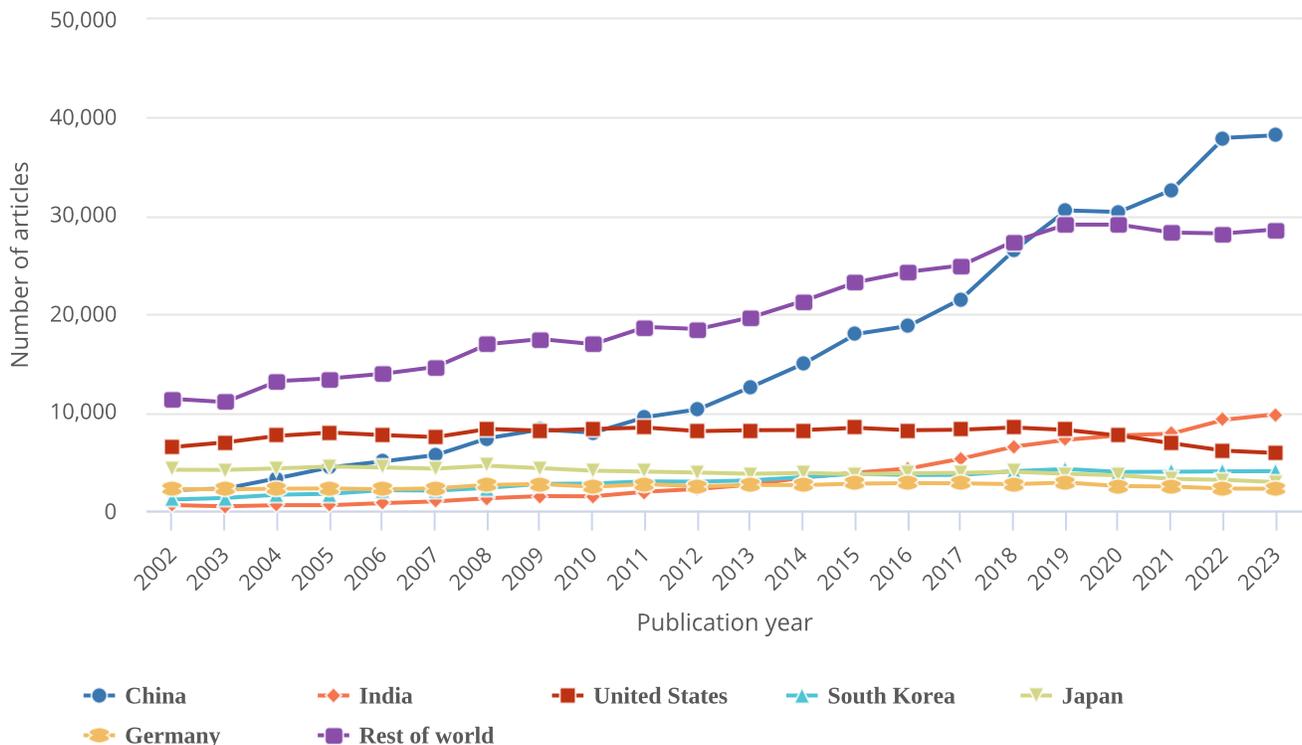
**SIDEBAR**

## Semiconductor Research Publication Output and International Collaboration

Basic research and applied research on semiconductors help power an important critical and emerging field in S&E (White House 2025), and international collaborations in this field can allow cutting-edge research to draw on the expertise of researchers from an array of backgrounds. This sidebar uses a data set of semiconductors research to present analysis on the yearly output of publications in semiconductor research and an international research network of collaboration on semiconductor research between authors from different countries.\* These analyses build on information presented in R&D on semiconductors (see the section [U.S. Business R&D](#)), the *Indicators 2026* report “Translation to Impact: U.S. and Global Science, Technology, and Innovation Output” (NSB forthcoming), and work on other critical and emerging fields, such as artificial intelligence (AI) (Boothby and Schneider 2024; NSB 2023: [Artificial Intelligence Publication Output and International Collaboration](#)) and COVID-19 (NSB 2021c: [Coronavirus Publication Output and International Collaboration](#)).

The worldwide output of publications on semiconductor research has increased by 228% over the past 20 years, from 27,963 articles in 2002 to 91,631 articles in 2023 (Table SDISC-77). The six countries whose authors published the most semiconductor research publications between 2002 and 2023 (China, the United States, Japan, India, Germany, and South Korea) together produced about 69% of semiconductor publications in 2023 (Figure DISC-C; Table SDISC-73). Publications by authors from China account for 42% of the world's semiconductor publication output in 2023, with 38,209 fractionally counted articles. Semiconductor research publications by authors from India (9,813 articles, 11%) and from the United States (5,857 articles, 6%) comprise the next-largest shares of semiconductor articles in 2023.

Figure DISC-C. Semiconductor-related S&E articles, by selected region, country, or economy and rest of world: 2002–23



**Note(s):**

Semiconductor article counts refer to publications algorithmically fingerprinted under "semiconductors" from conference proceedings and peer-reviewed journals in S&E fields in Scopus. Articles are classified by their year of publication and are assigned to a country on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles produced by authors from different regions, countries, or economies, each region, country, or economy receives fractional credit on the basis of the proportion of its participating authors). Data by all regions, countries, and economies are available in Table SDISC-76.

**Source(s):**

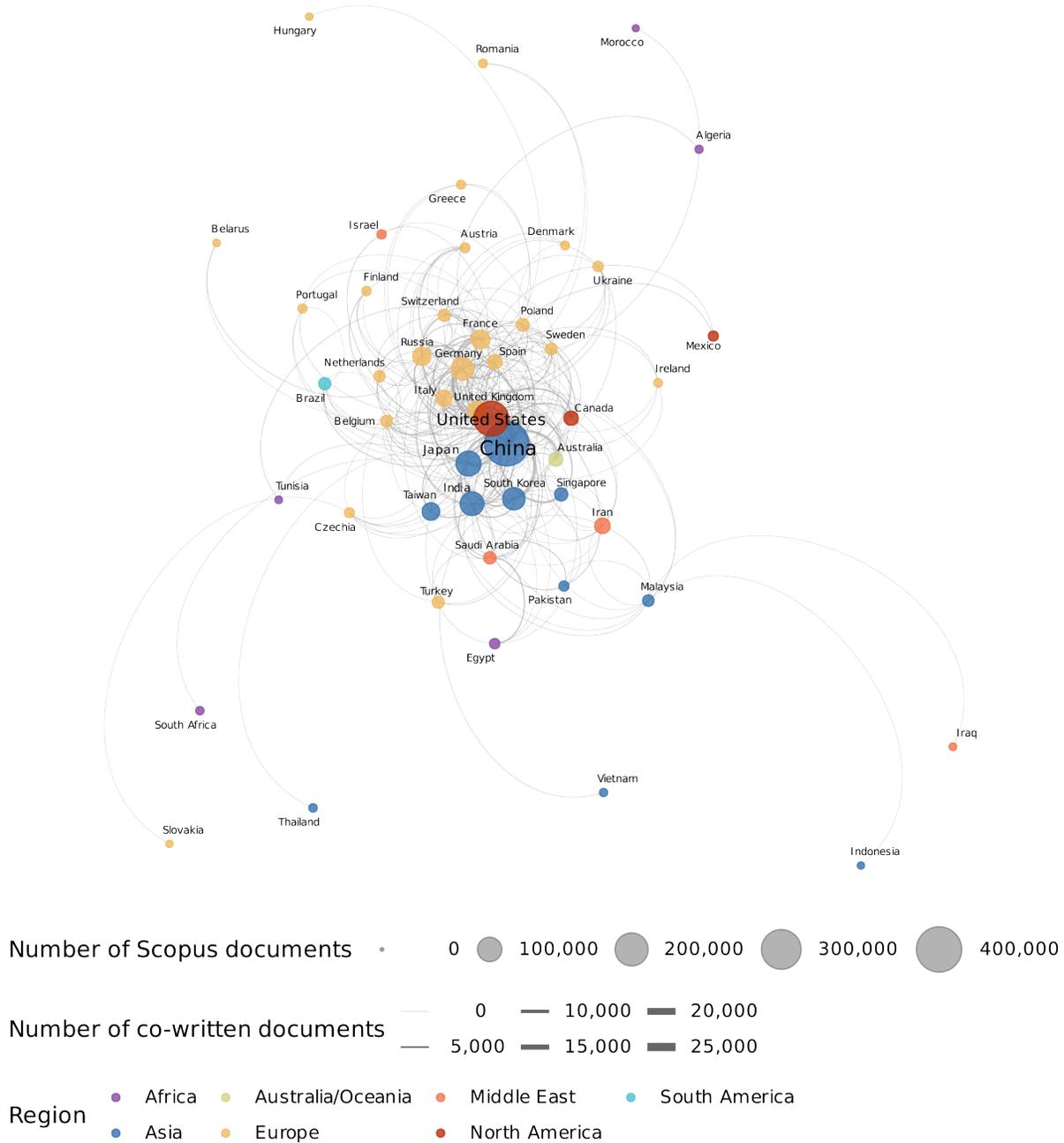
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

Science and Engineering Indicators

The output of semiconductor publications by Chinese authors increased by 1,720% between 2002 (2,099 articles) and 2023 (38,209 articles) and has exceeded the output of U.S. authors since 2011. The output of semiconductor publications by authors from India also rapidly increased by 1,665%, from 556 articles in 2002, and surpassed the semiconductor research publication output of U.S. authors in 2020. The output of semiconductor research articles by U.S. authors grew gradually (31%) from 6,467 articles in 2002 to a maximum of 8,460 articles in 2018, before decreasing 31% to 5,857 articles in 2023. See SDISC-76 for the output of semiconductor articles for additional countries.

The international research network on semiconductors helps illustrate collaborative relationships between authors from respective countries from 2002 to 2023 (Figure DISC-D). The top-producing countries all are central to the international network, and of the top 20 country pairs with the most prolific collaborative relationship between their authors, each pair included at least one of the top 6 countries, and in 9 pairs, both were in the top 6. The top-producing pairs were the United States and China (25,530 coauthored publications as a whole count), the United States and South Korea (9,605), and the United States and Germany (9,477). In 2023, 51% of semiconductor publications by U.S. authors were international collaborations, while 17% from China were international collaborations (Table SDISC-77); these shares in semiconductor research are higher than the U.S. shares of internationally collaborative publications and commensurate with China's (Figure DISC-29).

Figure DISC-D. Semiconductors collaboration network, by selected region, country, or economy pairs: 2002–23

**Note(s):**

This network diagram shows the number of coauthored articles by all pairs of regions, countries, or economies within the top 60 producers of semiconductor-related research based on whole counting for those pairs that cowrote 400 articles or more. Semiconductor article counts refer to publications algorithmically fingerprinted under "semiconductors" from conference proceedings and peer-reviewed journals in S&E fields in Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Links are only shown in a single direction, dictated by alphabetical order. Tied pairs are listed alphabetically. The size of the nodes is proportional to the total number of semiconductor-related articles written by each region, country, or economy. The width of the links between nodes is proportional to the quantity of articles that both regions, countries, or economies have coauthored. Positioning of nodes is defined using the Kamada-Kawai algorithm. For the list of regions, countries, and economies and their respective geographic regions in this figure, see Table SDISC-73.

**Source(s):**

National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed February 2025.

The research network is tightly distributed around the top producers similarly to past network diagrams of research publications in COVID-19 and AI (NSB 2021c: [Coronavirus Publication Output and International Collaboration](#); NSB 2023: [Artificial Intelligence Publication Output and International Collaboration](#)). The tight center cluster in the network may indicate that research collaborations on semiconductors are more extensive between researchers from already central countries than with researchers from countries with lower semiconductor publication counts and those outside the center cluster. Simultaneously, the network shows some regional collaboration patterns with continental clustering, such as the top producers from Asia being tightly distributed with other more peripheral collaborators like Indonesia, Thailand, and Vietnam on that same side of the network. Similar patterns were present for Europe and the Middle East and some African countries, and a similar distribution was present for AI in past analyses (NSB 2023: [Artificial Intelligence Publication Output and International Collaboration](#)).

\* A data set of semiconductors publications was generated using Elsevier's existing Omniscience taxonomy, which fingerprints the entire Scopus database under an array of concepts. Of these concepts, 89 included the term "semiconductors." This approach helps ensure that a wide range of semiconductor research is included but prevents a too-extensive of a list of publications in which semiconductors may play a more removed role or appear as a minor application.

## Conclusion

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The top 8 R&D-performing economies accounted for 82% of global R&D expenditures in 2022, with the United States (30%) and China (27%) together accounting for over half, based on comparable OECD statistics. As a region, the EU-27 performed 18%. The U.S. global R&D share declined from 39% in 2000 to 31% in 2010, remaining stable at 30% by 2022. China's share has increased steadily since 2000, with contemporaneous declines in the shares of Japan and the EU-27. The business sector accounted for more than 75% of R&D expenditures for 5 of the top 8 R&D-performing economies (including for the United States and China).

In the United States, the business sector dominates R&D funding and performance, and the majority of both are devoted to experimental development. The federal government is the second-largest source of R&D funding. The federal government funds the majority of academic R&D performance, over 60% of which is devoted to basic research. At the same time, R&D performance by institutions of higher education, the second-largest sector overall—but the largest basic research performer—grew less than 3% (CAGR in constant dollars) since 2013, compared with 6% growth (CAGR in constant dollars) for the business sector over the same period.

Top R&D-performing economies dominate S&E scientific publication output. The United States remains highly influential based on its publication output (ranking second globally) and its relative impact, as measured by citations to its S&E publications (ranking first globally), although there has been a decrease in impact since 2014. China's publication output has grown rapidly since 2003 and is now nearly double that of the United States. In terms of impact among S&E publications, China has increased rapidly in the last decade, overtaking the EU-27 to rank second behind the United States.

Health science publications comprised the largest share of global S&E publication output in 2023, but publication patterns by field were varied across individual countries and economies. Among top publication producers, the United States, the EU-27, and Japan published 36%, 25%, and 32% of their respective output in the health sciences. The U.S. share of health sciences publications is consistent with both federal and academic R&D obligation patterns discussed in this report. China's top publications field was engineering (26%), while India's was computer and information sciences (28%). International research collaboration has increased over the last two decades, reflecting traditional ties among regions, countries, and economies; new relationships that reflect growing global S&E capacity; and an increasingly networked research ecosystem.

# Glossary

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## Definitions

**ANBERD:** Analytical Business Enterprise Research and Development (OECD database).

**Applied research:** Original investigation undertaken to acquire new knowledge. It is directed primarily toward a specific practical aim or objective. See 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. See OECD (2015).

**Citations:** Citations document prior research relied on for science and engineering (S&E) publications. Thus, citations provide an indication of the flow and possible impact of new knowledge within and across scientific fields, sectors or institutions, and geographic locations.

**Coauthorship:** When more than one author is listed on a publication. An article is considered to contain an international coauthorship when institutional addresses for its authors are located in two or more different regions, countries, or economies. Publication counts of coauthorship use whole counting, so each location contributing to the article receives credit for that article. This indicator can be used to measure collaboration across geographies.

**European Union (EU-27):** The EU comprises 27 member nations: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. The United Kingdom withdrew from the EU on 1 February 2020. Unless otherwise noted, EU data include all current 27 member countries.

**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. See OECD (2015).

**Fractional counting:** A method of counting S&E publications in which credit for coauthored publications is divided among the collaborating institutions or regions, countries, or economies based on the proportion of their participating authors. Fractional counting allocates the publication count based on the proportion of the coauthors named on the article with institutional addresses from each region, country, or economy. Fractional counting enables the counts to sum up to the number of total articles.

**Gross domestic product (GDP):** The market value of all final goods and services produced within a country in a given period.

**Gross domestic expenditures on R&D (GERD):** Defined by OECD as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, and university and government laboratories in a country. It includes R&D funded from abroad but excludes domestic funds for R&D performed outside the domestic economy (<https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm>).

**Highly cited article (HCA):** An HCA ratio provides an indication of scientific impact (Waltman, van Eck, and Wouters 2013). The HCA ratio for a country or other geographic location is calculated as the share of all articles published in a given year by authors with institutional addresses within that location that fall within the top 1% by citation count of all articles published that year, measured for each research field. The HCA ratio is indexed to 1.00, so a location whose authors produce highly cited articles at the expected (i.e., global average) rate has an HCA ratio of 1.00—that is, 1% of the location's articles are among the top 1% of the world's highly cited articles. A location with an HCA ratio greater than 1.00 is producing a disproportionately high level of articles with exceptional scientific impact, whereas a location whose authors produce relatively fewer influential articles will have an HCA ratio below 1.00.

**Main Science and Technology Indicators (MSTI):** An OECD database.

**Organisation for Economic Co-operation and Development (OECD):** An international organization of 38 countries, headquartered in Paris, France (<https://www.oecd.org/en/about.html>). Among its many activities, OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

**Purchasing power parity (PPP):** Currency conversion rates that try to equalize the purchasing power of different currencies by eliminating the differences in price levels between countries.

**Research and experimental development (R&D):** R&D comprises creative and systematic 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).

**R&D plant:** Spending on R&D facilities and major equipment. Includes physical assets, such as land, structures, equipment, and intellectual property (e.g., software or applications).

**Whole counting:** This measure (also called *full counting* or *integer counting*) assigns one count to each region, country, or economy or institutional sector involved in coauthoring the article, irrespective of its proportionate involvement in authorship. Although fractional counting aims to assess the proportionate contributions of regions, countries, or economies or institutional sectors, whole counting aims to assess the participation of regions, countries, or economies or institutional sectors. One result of this difference is that the sum of articles from regions, countries, or economies or institutional sectors will exceed the total number of articles when whole counting is used. In the full-counting method, each publication is counted once for each entity listed in the address field.

## Key to Acronyms and Abbreviations

**CAGR:** compound annual growth rate

**EU-27:** European Union

**FFRDC:** federally funded research and development center

**FY:** fiscal year

**GDP:** gross domestic product

**GERD:** gross domestic expenditures on R&D

**ISIC:** International Standard Industrial Classification of All Economic Activities

**KTI:** knowledge- and technology-intensive

**NAICS:** North American Industry Classification System

**NCSES:** National Center for Science and Engineering Statistics

**NSF:** National Science Foundation

**OECD:** Organisation for Economic Co-operation and Development

**PPP:** purchasing power parity

**R&D:** research and experimental development

**S&E:** science and engineering

**TOD:** Taxonomy of Disciplines

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## Notes

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- 1** Research publications are often used as an output metric in R&D efficiency or R&D productivity studies, especially for academic research (Rotolo et al. 2022; Shelton 2008; Thomas, Sharma, and Jain 2011; Tijssen and Winnink 2018).
- 2** It is important to note that scientific papers do not represent all types of early research products, which also include PhD dissertations and research data sets (Aksnes et al. 2017; Arora et al. 2023; Sugimoto and Larivière 2018).
- 3** Estimated 2023 national R&D performance is based in part on 2023 projected R&D reported on the 2022 Business Enterprise Research and Development (BERD) Survey, preliminary information from the 2023 BERD Survey, and trends for business R&D performance. Every survey year, some of the variation in BERD estimates is due to changes in individual respondent reporting practices. For details, see NCSSES (2024a).
- 4** For longer-term U.S. R&D trends, see Anderson, Jankowski, and Boroush (2023) and NCSSES (2025d). All comparative statements in this report have undergone statistical testing and are significant at the 90% confidence level, except for statements reliant on modeled estimates.
- 5** Starting in 2016, the business R&D data reported by the National Patterns series include the R&D expenditures reported by microbusinesses (generally, companies with fewer than 10 employees). These new statistics come from NCSSES surveys fielded for 2016 and onward: the 2016 Business R&D and Innovation Survey–Microbusiness, which collected statistics on the R&D activities of businesses with 1–5 employees; for 2017–18, the Annual Business Survey (ABS), which collected statistics on the R&D activities of businesses with 1–9 employees. The totals for business R&D performance are from \$4 billion to \$5 billion higher for 2016 and beyond as a result of microbusiness R&D being included.
- 6** The National Patterns statistics for higher education R&D appearing in this section adjust the academic fiscal year basis of NCSSES’s Higher Education Research and Development (HERD) Survey data to calendar year and net out pass-throughs of research funds to remove double counting in the national totals. Accordingly, the higher education statistics included in this section differ from those based on fiscal year from the HERD Survey discussed further below. For further details, see <https://nces.nsf.gov/data-collections/national-patterns/2021-2022#methodology>.
- 7** U.S. R&D funded and performed by the business sector (by far the largest component as noted above) comprises own company funds of domestic R&D-performing businesses, funds from other domestic businesses, and funds from foreign businesses.
- 8** FFRDCs are R&D-performing organizations that are exclusively or substantially financed by the federal government. An FFRDC is operated to provide R&D capability to serve federal agency mission objectives or, in some cases, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered by an industrial firm, a university, a nonprofit institution, or a consortium. NCSSES maintains a current Master Government List of Federally Funded R&D Centers, which is available at <https://www.nsf.gov/statistics/ffrdclist/>.
- 9** For more information on R&D performed by businesses with 10 or more employees, see the Business Enterprise Research and Development (BERD) survey at <https://nces.nsf.gov/surveys/business-enterprise-research-development/2022>. For information on R&D performed by microbusinesses (1–9 employees), see the ABS at <https://nces.nsf.gov/surveys/annual-business-survey/2023>. Microbusinesses are a small but important segment of business R&D and innovation (Anderson and Kindlon 2019; Knott and Vieregger 2020).
- 10** For foreign R&D by multinational enterprises, see Bureau of Economic Analysis (2024) and Moris (2021).
- 11** At the same time, the U.S. R&D manufacturing share has declined over the years. See BERD Survey Table 59, Domestic R&D paid for by the company and others and performed by the company, by industry and company size: 2008–21, available at <https://nces.nsf.gov/surveys/business-enterprise-research-development/2021#data>.

**12** See <https://nces.nsf.gov/surveys/business-enterprise-research-development/2022#data>. For new statistics on state R&D value added in the context of U.S. GDP accounts, see <https://www.bea.gov/data/special-topics/research-and-development-satellite-account>. See also Moris (2019) and Moylan and Okubo (2020) for R&D investment measures in U.S. GDP statistics.

**13** R&D-intensive manufacturing industries may engage in advanced manufacturing and intelligent manufacturing. Examples include additive or nano-based manufacturing and biotechnology and biomanufacturing. For additional information, see Brocal, Sebastián, and González (2019) and the President's Council of Advisors on Science and Technology (2020).

**14** Companies could report expenditures on the same R&D project in one, more than one, or no technology category.

**15** The share of software-focused R&D was 32% in 2016 and 20% in 2006 (Moris 2019).

**16** HERD Survey data in this section are collected and reported by academic fiscal year, which runs from July through June. The NCSES HERD Survey collects data on universities' annual R&D spending, the sources of funds supporting that spending, and how the spending is distributed across types of R&D, fields of research, and institutions with specific features. Academic institutions that had \$150,000 or more in separately budgeted R&D expenditures for the previous year and were geographically separate campuses headed by a president, chancellor, or equivalent were included in the survey. For further details, see <https://nces.nsf.gov/surveys/higher-education-research-development/2022#methodology>.

**17** Institutional funds include institutionally financed research (all R&D funded by the institution from accounts that are only used for research, excluding institution research administration and support), cost sharing (committed), and unrecovered indirect costs (the portion of indirect costs associated with a sponsored project that was not reimbursed by the sponsor in accordance with the institution's negotiated indirect cost rate). For further details, see <https://nces.nsf.gov/surveys/higher-education-research-development/2023#methodology>.

**18** Many R&D activities require dedicated research space. In FY 2023, academic institutions reported allocating 240.2 million square feet of space to S&E research, up from 236.1 million in 2021 and 226.9 million in 2019 (Gibbons 2024b). The three S&E research components with the highest amount of S&E research space in 2023 are biological and medical sciences (61.2 million square feet), medical school spaces (52.2 million square feet), and engineering (42 million square feet) (NCSES *Facilities 2023: Table 1*).

**19** Data in this section are reported by federal fiscal years. For additional information on the impact of supplemental appropriations on federal R&D obligations, including Public Law (P.L.) 111-5, P.L. 117-58, P.L. 117-167, and P.L. 117-169; see Pece (2023, 2024) and NCSES (2025c: [Figure 1](#)).

**20** The global total is based on 2022 or, for countries with missing data in the OECD database, the latest available year. Comparable data on R&D were not available from the United Nations Educational, Scientific and Cultural Organization database, where most non-OECD R&D statistics were obtained in previous reports.

**21** U.S. GERD as reported by OECD differs slightly from the U.S. total domestic R&D performance tabulated earlier in this report. For consistency with international standards for the measurement of GERD, OECD includes U.S. domestic expenditures on capital for R&D, excludes depreciation on U.S. domestic R&D capital, and makes certain adjustments for foreign sources of funding of domestic R&D.

**22** United Kingdom GERD data are for 2021. Statistics in this section cover available data from MSTI (OECD 2024d) and are reported in U.S. dollars using purchasing power parity (PPP). PPP converts different currencies to a common currency while adjusting for differences in price levels between economies, allowing for cross-country comparisons.

**23** For international comparative measures of other forms of R&D support by governments such as tax incentives, see the OECD INNOTAX Portal (OECD 2024c).

**24** OECD ANBERD data are classified according to the International Standard Industrial Classification of All Economic Activities (ISIC 4), Revision 4. Data for France are for 2020, and data for the United Kingdom are for 2022. For the information and communication services industries (ISIC 58-63), there is no 2021 information in the OECD ANBERD database for China.

**25** For the scientific R&D services industry (ISIC 72), there is no 2021 information in the OECD ANBERD database for China and Taiwan.

**26** For the air and spacecraft and related machinery industry (ISIC 303), there is no 2021 or 2022 information in the OECD ANBERD database for China, the United Kingdom, and Taiwan. All top six industries highlighted here account for about three-fourths of U.S. and South Korea BERD expenditures based on OECD/ISIC data, close to two-thirds for Germany and Japan BERD expenditures, and 83% for Taiwan BERD expenditures. Other countries have missing data as noted earlier.

**27** Publication output includes only those indexed in the Scopus database. The publication output discussion uses fractional counting, which credits coauthored publications according to the collaborating institutions or regions, countries, or economies based on the proportion of their participating authors. Country assignments refer to the institutional address of authors, with partial credit given for each international coauthorship. As part of the data analysis, filters were employed on the raw Scopus S&E publication data to remove publications with questionable quality, which appear in what are sometimes called predatory journals (NSB *Indicators 2018: Bibliometric Data Filters*).

**28** The proportion of output attributable to the large producers is consistent whether using fractional counting, as in [Figure DISC-22](#) and [Table DISC-12](#), or whole counting, as in [Table SDISC-21](#). There is a slight difference between the United States and China when looking at the whole-counting total production numbers. Using whole counting for 2023, the United States had 568,973 articles, whereas China had 1,003,473. A whole-counting measure allocates one full count to each region, country, or economy with an author contributing to the article; in fractional counting, each region, country, or economy receives a proportion of the count based on the number of authors from that region, country, or economy. For example, if an article had four authors—two from the United States, one from China, and one from Brazil—the fractional scores would be half for the United States, a quarter for China, and a quarter for Brazil. The use of whole counting or fractional counting to tally the publication output of countries can change the calculated publication count based on the degree to which a country is involved in international collaborations.

**29** In mathematical terms, a region, country, or economy's HCA ratio (the share of the articles ranked in the highest 1% based on citations) is computed as follows:  $S_x = HCA_x / A_x$ , where  $S_x$  is the share of output from country  $x$  in the top 1% most-cited articles,  $HCA_x$  is the number of articles from country  $x$  that are among the top 1% of most-cited articles, and  $A_x$  is the total number of articles from country  $x$  with a relative citation (RC) score.  $HCA_x$  and  $A_x$  are based on whole counting. The RC score is a normalized citation score assigned to a publication and is used to rank articles into the top 1%. The RC score takes into consideration the citation behavior between fields and years of publication. Based on the observation that distinct differences in the citation rates of articles appear 2 years or more after publication, the HCA ratio is calculated with a time lag of at least 2 years (meaning that in 2024, the HCA ratios were calculated based on publications issued in 2022).

**30** The unrounded HCA share of U.S. health science articles in 2023 was 1.8499%.

**31** The total international collaboration rate differs from the rate of co-publications of individual regions, countries, or economies. Individual scores use whole counting, in which each geographic location with an institutional address on the publication receives 1 point. Therefore, the count for individual regions, countries, or economies will be larger than the number of publications that have authors with institutional addresses from two or more regions, countries, or economies, which is the basis for computing the total international collaboration rate.

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## Correction(s)

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**10 September 2025:** The tabular data view of [Figure DISC-D](#) has been corrected to add Ireland-France collaboration data. The original omitted this data from the tabular view only; the chart view is unaffected by the correction. (2 Sept. 2025)  
Table SDISC-75 has been replaced; the corrected version reflects analysis based on counts of co-publications. (2 Sept. 2025)  
[Table DISC-11](#) column headings previously labeled “Domestic” and “World” have been corrected to “Other domestic” and “Rest of world” to accurately describe the data and match related table SDISC-4. (10 Sept. 2025)