R&D

Research and Development: U.S. Trends and International Comparisons

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Executive Summary

Key takeaways:

- In 2022, the United States performed an estimated $885.6 billion in research and development (R&D) in current U.S. dollars. This is an increase from 2021 of 12% in current (nominal) dollars and a 5% increase in constant (inflation-adjusted) dollars.
- The business sector is by far the largest performer of U.S. R&D. In 2022, this sector performed an estimated $692.7 billion in domestic R&D (current U.S. dollars), or 78% of U.S. R&D, a 14% increase from the $608.6 billion performed in 2021 (6% increase in constant dollars).
- The second-largest performing sector in 2022 was higher education, with $91.4 billion (or 10% of the U.S. R&D total). This represented a 7% increase from 2021 in current dollars, but performance stagnated in constant dollars (-0.4% change). In 2022, the federal government performed $73.3 billion, for an 8% share of U.S. R&D, compared with $66.8 billion in 2021, for a 10% increase (3% in constant dollars).
- In addition to being the largest performer, the business sector is also the largest R&D funder in the United States. In 2022, the sector funded $672.9 billion, or 76% of total U.S. R&D, up from 69% in 2000 and 61% in 2010.
- The federal government funded 18% of U.S. R&D ($159.8 billion dollars) in 2022 as the second-largest source. The federal government funds the largest proportion of U.S. basic research performance (40%). The largest recipient sector of federal R&D funding in 2022 was higher education (30%), followed by intramural federal R&D (29%).
- The United States has had an *R&D intensity*, a measure of R&D expenditures relative to gross domestic product (GDP), above 3.0% since 2019. In 2022, the United States had an R&D intensity of 3.4%, based on National Patterns of R&D Resources statistics.
- Five industries accounted for 79% of the $602.5 billion of U.S. business R&D performed by companies with 10 or more domestic employees in 2021: information (including software publishing) at 25%; chemicals manufacturing (including pharmaceuticals and medicines) at 18%; computer and electronic products manufacturing (including semiconductors) at 17%; professional, scientific, and technical services (including R&D services) at 11%; and transportation equipment manufacturing (including motor vehicles and aerospace products and parts) at 8%.
- U.S. semiconductor and other electronic components manufacturing was one of the most R&D-intensive industries in 2021 (20% R&D-to-sales ratio). That year, semiconductor business R&D increased 9.8% in current U.S. dollars to $47.4 billion, after increasing 22.8% in 2020.
- In FY 2022, the Department of Health and Human Services (HHS) and the Department of Defense together accounted for around three-fourths of the $196.6 billion in federal obligations for R&D and R&D plant.
- Across all agencies in FY 2022, 24% of federal R&D obligations were devoted to basic research ($45.4 billion), 25% to applied research ($48.4 billion), and 51% to experimental development ($96.6 billion).
- Federal research obligations (basic plus applied research) reached $93.8 billion in FY 2022 across all science and engineering (S&E) fields. Funding for life sciences research was the highest among S&E fields across agencies at $41.6 billion (44% of the total), primarily from HHS.
- The Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022 appropriated $52.7 billion to revitalize the U.S. semiconductor industry along the supply chain, including $13.7 billion supporting R&D, workforce development, and related programs.
- Based on internationally comparable estimates, the United States had the highest gross domestic expenditures on R&D (GERD) in 2021, at $806.0 billion, followed by China, with $667.6 billion in current U.S. purchasing power parity dollars. The top five R&D-performing economies (including Japan, Germany, and South Korea) accounted for 73% of the 2021 global R&D total.

Introduction

This report analyzes research and experimental development (R&D) trends in the United States and internationally. R&D refers to creative and systematic work aimed at increasing the stock of knowledge and is broken down into three categories: basic research, applied research, and experimental development (Moris and Pece 2022; OECD 2015). The **Glossary** section of this report summarizes key definitions.

R&D and other intangibles or intellectual property products (IPPs), such as software investment, contribute to innovation, output and productivity growth, competitiveness, and public policy goals across countries—from defense, cybersecurity, and information infrastructure to sustainable energy, environmental protection, and health (Baily, Bosworth, and Doshi 2020; CRS 2020a; NASEM 2020; Pece 2023b; OECD 2023d, 2023h). The COVID-19 pandemic impacted global science by highlighting the importance of resiliency and security in domestic and international global research networks (OECD 2022, 2023a, 2023b, 2023c, 2023d).

In the private sector, R&D is also a leading component of global value chains (GVCs) for industries at the forefront of advanced manufacturing, emerging and critical technologies, and high-technology services across the globe. International production arrangements and global R&D networks, built over the past decades (Kano, Tsang, and Yeung 2020; Papanastassiou, Pearce, and Zanfei 2020), have been challenged by pandemic-related and geopolitical factors that are impacting the organization of international R&D and economic activity and the role of critical or emerging technologies (IMF 2023; OECD 2023e).

This report is organized into four sections. The first covers U.S. R&D across the major performing and funding sectors, followed by a section on international comparisons. The last two sections focus on business R&D and federal R&D. The report also includes new information on semiconductor and other critical or emerging technologies R&D that feeds into business high-technology supply chains and public policy goals (CRS 2022a, 2022b; USG 2023).

Related *Science and Engineering Indicators 2024* reports include "**Academic Research and Development**" and the forthcoming "The STEM Labor Force: Scientists, Engineers, and Skilled Technical Workers." Three other related reports focus on production supply chains and other post-R&D activities: "**Publications Output: U.S. Trends and International Comparisons**," "**Invention, Knowledge Transfer, and Innovation**," and "**Production and Trade of Knowledge- and Technology-Intensive Industries**."

The principal data sources of this report are surveys and the National Patterns of R&D Resources (henceforth, National Patterns) database (NCSES 2024) from the National Center for Science and Engineering Statistics (NCSES), National Science Foundation (NSF). The Organisation for Economic Co-operation and Development (OECD) Main Science and Technology Indicators (MSTI) database (OECD 2023c) is the source for international R&D statistics. All amounts are reported in U.S. current dollars unless otherwise noted. All years are calendar years unless otherwise noted.

Trends in U.S. R&D Performance

U.S. R&D is performed and funded by businesses, governments, higher education, and nonprofit organizations. *R&D performance* refers to who conducts R&D, whether it is funded from internal funds or external financial sources (e.g., contracts, grants). From the perspective of R&D funding, funds may be devoted to own R&D or to pay for R&D in other sectors or organizations (private R&D services suppliers, academic or nonprofit grantees) (OECD 2015:126). Academic R&D is covered only briefly in this report given that the *Indicators 2024* report "**Academic Research and Development**" provides comprehensive information for this sector.

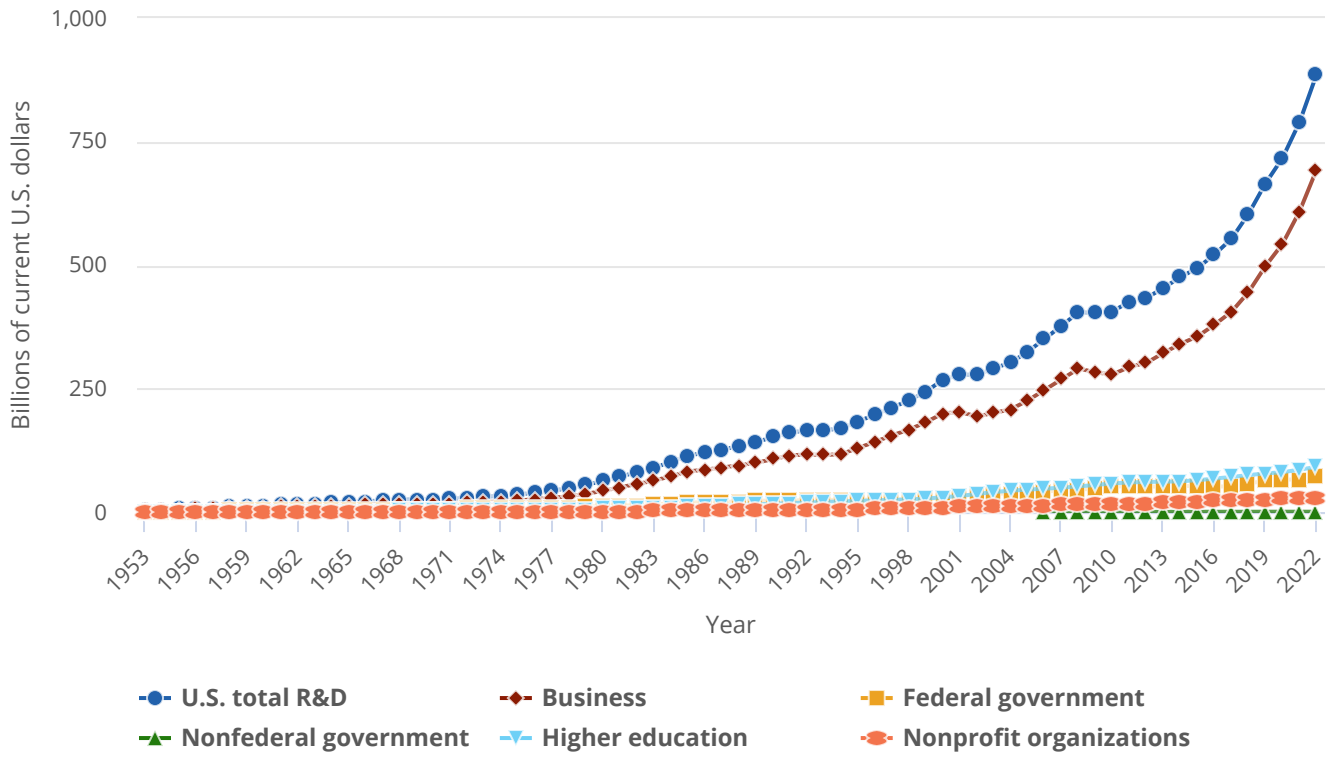
U.S. Total R&D and R&D Intensity

U.S. Total R&D

In 2022, the United States performed an estimated $885.6 billion in R&D in current (nominal) U.S. dollars (**Figure RD-1**, **Figure RD-2**; **Table RD-1**), based on National Patterns statistics (Anderson 2024; NCSES 2024).[1] This is an increase of 12% from 2021 but only of 5% in constant (inflation-adjusted) 2017 U.S. dollars.[2]

Figure RD-1

U.S. R&D, by performing sector: 1953–2022



Note(s):
Some data for 2021 are preliminary and may be revised later. The data for 2022 include estimates and are likely to be revised later. Federal performers of R&D include federal agencies and federally funded research and development 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 (2021–22 edition).

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

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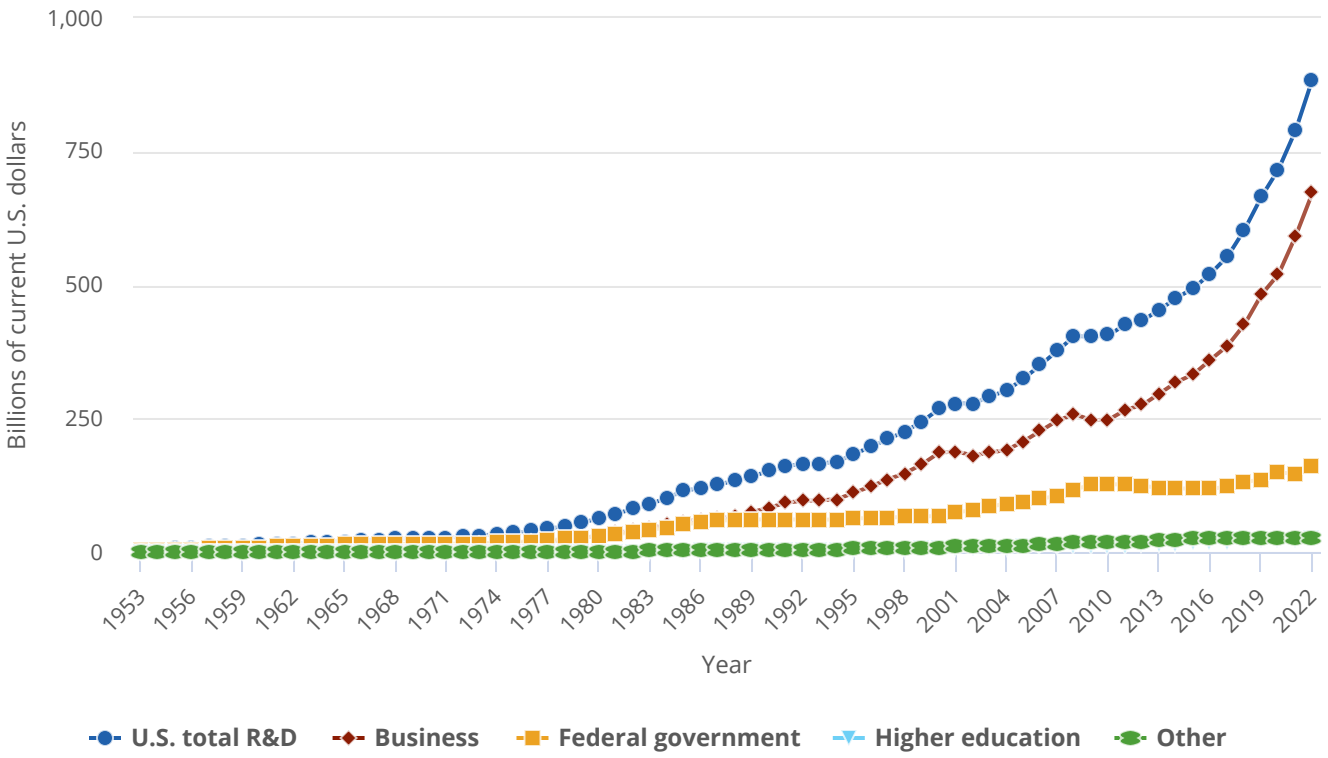
Figure RD-2

U.S. R&D, by source of funds: 1953–2022



Note(s):
Some data for 2021 are preliminary and may be revised later. The data for 2022 include estimates and are likely to later be revised. Federal performers of R&D include federal agencies and federally funded research and development centers. R&D funding listed as Other combines data from nonfederal governments (state and local) and nonprofit organizations. For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2020–21 edition).

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

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Table RD-1

U.S. R&D expenditures, by performing sector and source of funds: 2010–22

(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[a]	2022[b]
Millions of current dollars													
All performing sectors	406,599	426,214	433,698	454,232	475,938	494,470	521,686	553,612	604,028	665,557	716,870	789,072	885,563
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	692,748
Federal government	50,798	53,524	52,144	51,086	52,687	52,847	51,187	52,553	58,356	62,802	65,093	66,786	73,338
Federal intramural[c]	31,970	34,950	34,017	33,406	34,783	34,199	31,762	32,231	36,793	39,870	41,227	41,464	46,960
FFRDCs	18,828	18,574	18,128	17,680	17,903	18,649	19,424	20,322	21,563	22,932	23,866	25,322	26,378
Nonfederal government	691	694	665	620	583	595	620	632	643	675	683	685	697
Higher education	58,083	60,087	60,876	61,511	62,318	64,604	67,777	71,115	74,890	78,157	80,823	85,787	91,451
Nonprofit organizations	18,050	17,817	17,762	18,487	19,622	20,604	22,573	23,521	24,576	25,749	27,053	27,190	27,329
All funding sources	406,599	426,214	433,698	454,232	475,938	494,470	521,686	553,612	604,028	665,557	716,870	789,072	885,563
Business	248,126	266,426	275,728	297,188	318,410	333,242	360,290	386,538	426,488	482,227	520,364	591,009	672,868
Federal government	126,617	127,014	123,837	120,131	118,367	119,532	118,174	122,470	131,098	135,779	148,169	147,531	159,833
Nonfederal government	4,303	4,386	4,158	4,244	4,214	4,277	4,995	5,076	5,252	5,474	5,676	5,733	5,902
Higher education	12,262	13,103	14,282	15,341	16,176	17,260	18,729	19,880	20,989	21,885	22,560	23,783	25,514
Nonprofit organizations	15,292	15,284	15,694	17,327	18,771	20,160	19,497	19,648	20,201	20,193	20,102	21,017	21,447
Millions of constant 2017 dollars													
All performing sectors	453,632	465,903	465,418	479,297	493,603	508,109	531,028	553,612	590,500	639,911	680,262	715,953	750,649
Business	311,247	321,478	324,357	340,325	353,375	365,635	386,326	405,792	435,584	478,978	515,480	552,227	587,209
Federal government	56,674	58,508	55,958	53,905	54,642	54,305	52,103	52,553	57,049	60,382	61,769	60,597	62,165
Federal intramural[c]	35,668	38,205	36,504	35,250	36,074	35,142	32,331	32,231	35,969	38,334	39,121	37,621	39,806
FFRDCs	21,006	20,303	19,453	18,656	18,568	19,163	19,772	20,322	21,080	22,048	22,647	22,976	22,359
Nonfederal government	771	758	713	654	605	611	631	632	629	649	648	622	590
Higher education	64,802	65,682	65,328	64,905	64,631	66,386	68,991	71,115	73,212	75,145	76,695	77,838	77,519
Nonprofit organizations	20,138	19,476	19,061	19,507	20,350	21,172	22,977	23,521	24,026	24,757	25,671	24,670	23,165
All funding sources	453,632	465,903	465,418	479,297	493,603	508,109	531,028	553,612	590,500	639,911	680,262	715,953	750,649
Business	276,828	291,237	295,894	313,587	330,228	342,434	366,743	386,538	416,936	463,645	493,791	536,244	570,358
Federal government	141,263	138,842	132,894	126,760	122,760	122,829	120,290	122,470	128,162	130,547	140,602	133,860	135,482
Nonfederal government	4,800	4,795	4,462	4,478	4,370	4,394	5,084	5,076	5,135	5,263	5,386	5,202	5,003
Higher education	13,680	14,323	15,326	16,188	16,776	17,736	19,065	19,880	20,519	21,041	21,408	21,579	21,627
Nonprofit organizations	17,061	16,707	16,841	18,284	19,468	20,716	19,846	19,648	19,748	19,415	19,076	19,069	18,179

FFRDC = federally funded research and development center.

[a] Some data for 2021 are preliminary and may be revised later.

[b] The data for 2022 are estimates and are likely to be revised later.

[c] 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.

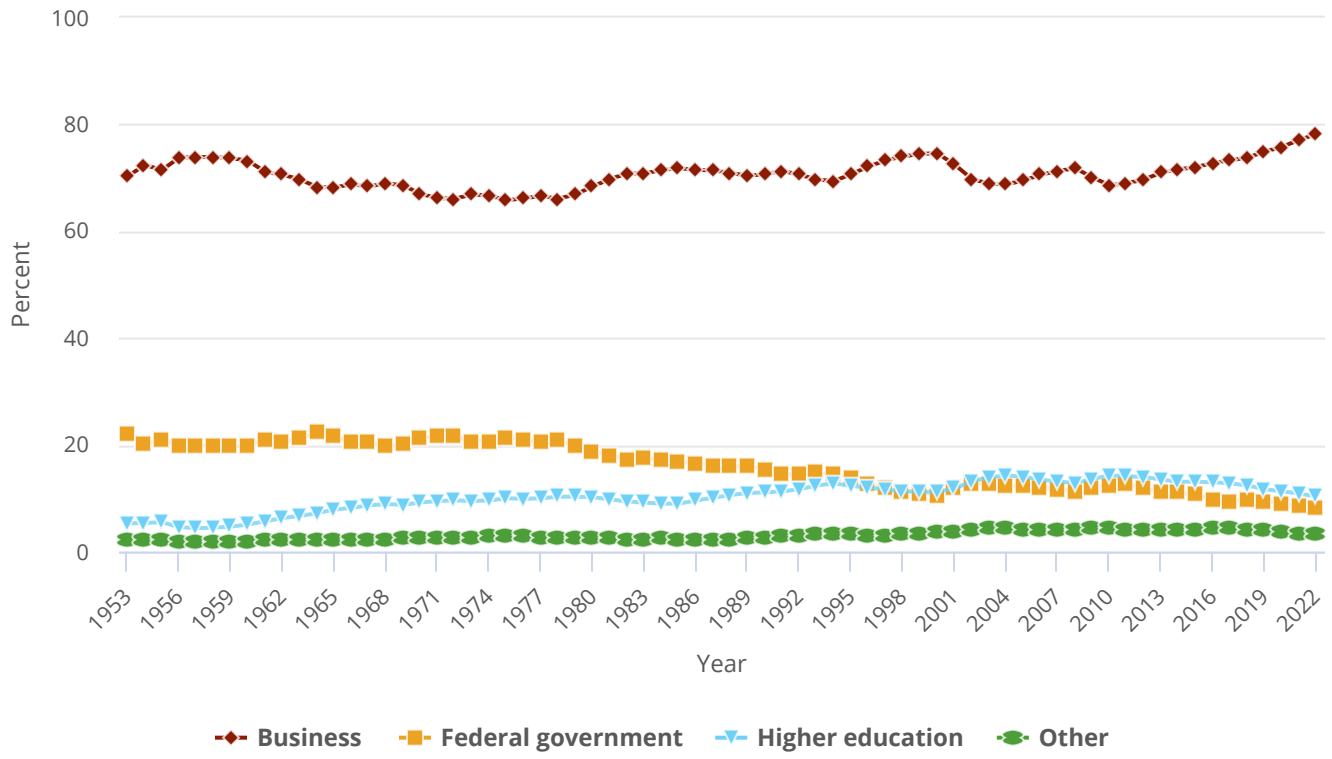
Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

Science and Engineering Indicators

U.S. R&D performance has been on a long-term growth trajectory since the post–World War II era, with a compound annual growth rate (CAGR) of 4% since 1953 in constant dollars (NCSES 2024, **Table 1**). The top three U.S. R&D-performing sectors are business, higher education, and the federal government (**Figure RD-3**), with business being the largest-performing sector by far, with a 78% share in 2022. The higher education sector has been the second-largest performer since 2002, remaining slightly ahead of the federal government sector since then. On the other hand, the federal government and business sectors have funded a combined share of over 90% of U.S. R&D since the 1950s, trading first and second place in 1980 when the business sector surpassed the federal government as the largest funder (**Figure RD-4**).

Figure RD-3

U.S. R&D expenditures, shares by performing sector: 1953–2022



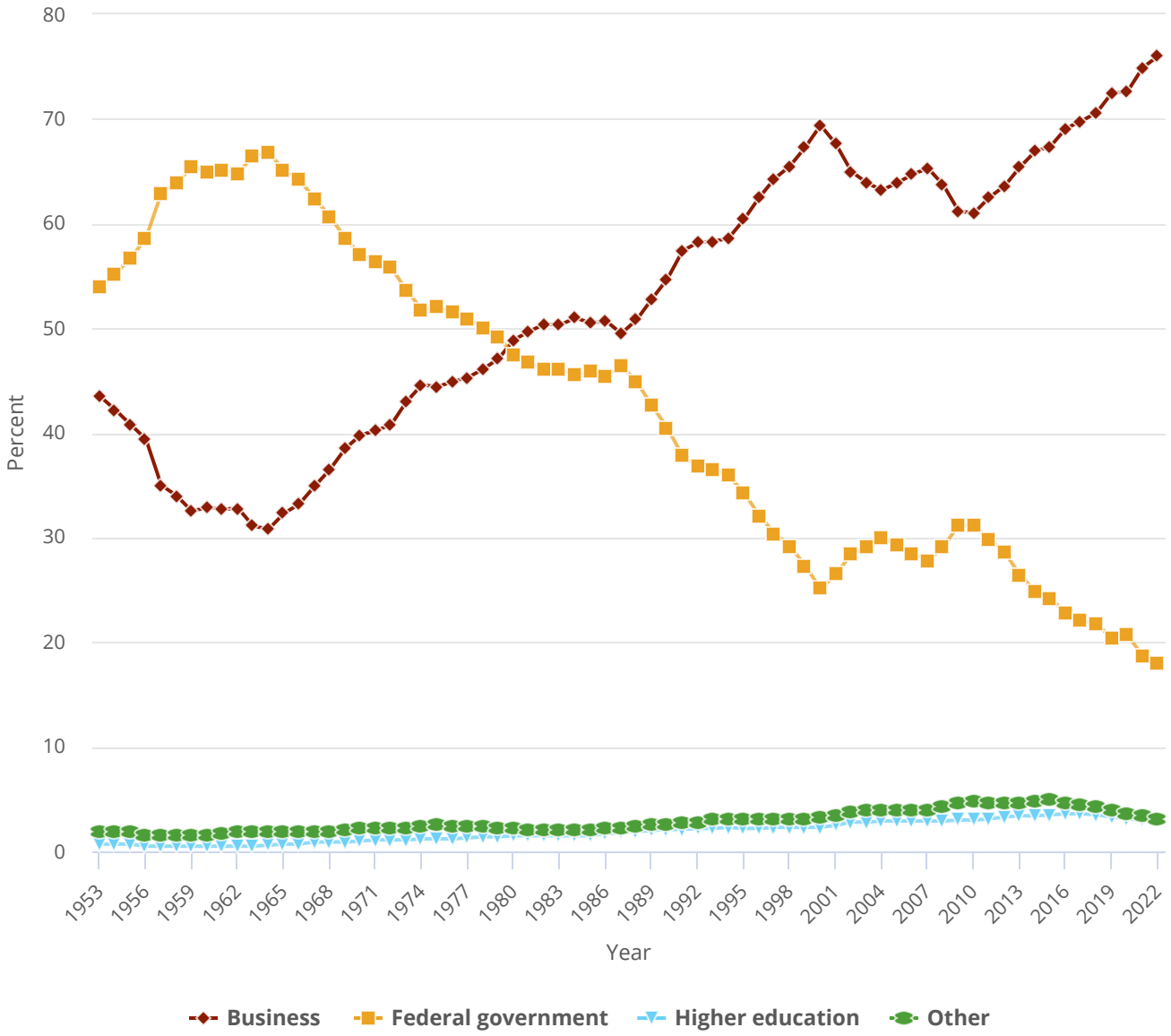
Note(s):
Some data for 2021 are preliminary and may be revised later. The data for 2022 include estimates and are likely to later be revised. Federal performers of R&D include federal agencies and federally funded research and development centers. R&D funding listed as Other combines data from nonfederal governments (state and local) and nonprofit organizations. For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2021–22 edition).

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

Science and Engineering Indicators

Figure RD-4

U.S. R&D expenditures, shares by funding sector: 1953–2022



Note(s):
Some data for 2021 are preliminary and may be revised later. The data for 2022 include estimates and are likely to later be revised. Federal performers of R&D include federal agencies and federally funded research and development centers. R&D funding listed as Other combines data from nonfederal governments (state and local) and nonprofit organizations. For more information, see Table 2 and Table 6 of National Patterns of R&D Resources (2021–22 edition).

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

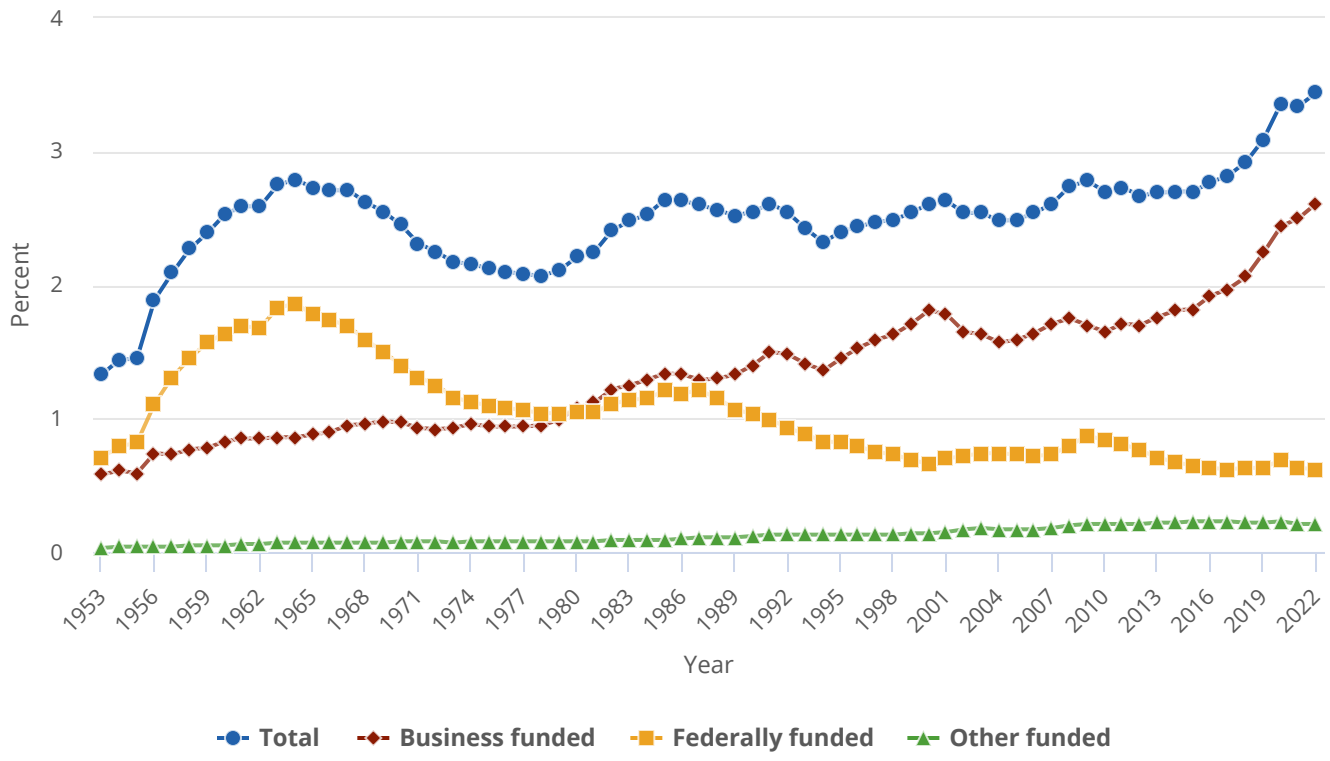
Science and Engineering Indicators

U.S. National R&D Intensity

The ratio of R&D expenditures to gross domestic product (GDP) is an intensity measure at the national level used for analysis and policymaking. For the United States, this measure has been above 3.0% since 2019 and was 3.4% in 2022, based on National Patterns statistics (**Figure RD-5**) (NCSES 2024, **Table 1**). Based on R&D funding measures, the ratio follows the pattern of relative shares of business versus federal sources (**Figure RD-4**), with the business R&D-to-GDP ratio being higher than the federal R&D-to-GDP ratio for the last few decades. The federal R&D-to-GDP ratio has declined since the last peak in 2009, associated with funds from the American Recovery and Reinvestment Act (ARRA).

Figure RD-5

Ratio of U.S. R&D to GDP, by funding source: 1953–2022



GDP = gross domestic product.

Note(s):
Some data for 2021 are preliminary and may be revised later. The data for 2022 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 as used in National Patterns of R&D Resources (2021–22 edition).

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

Science and Engineering Indicators

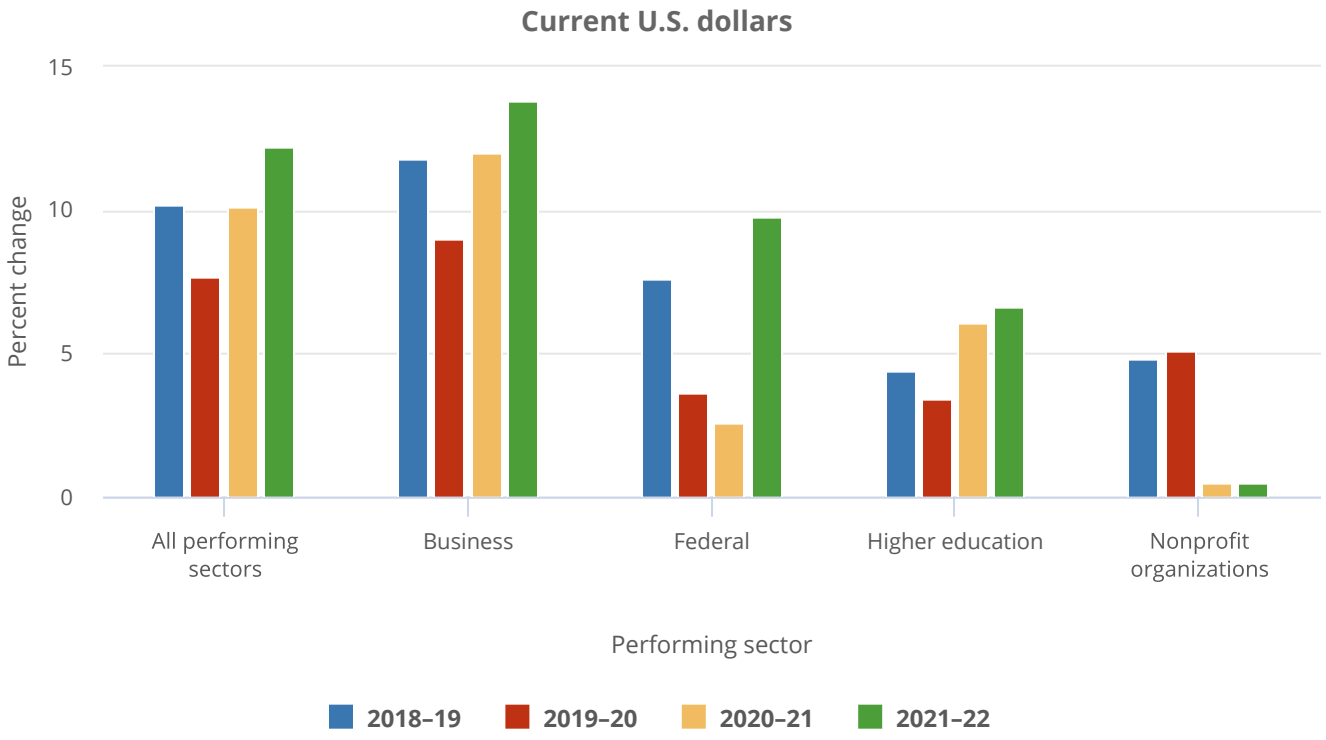
R&D-Performing Sectors

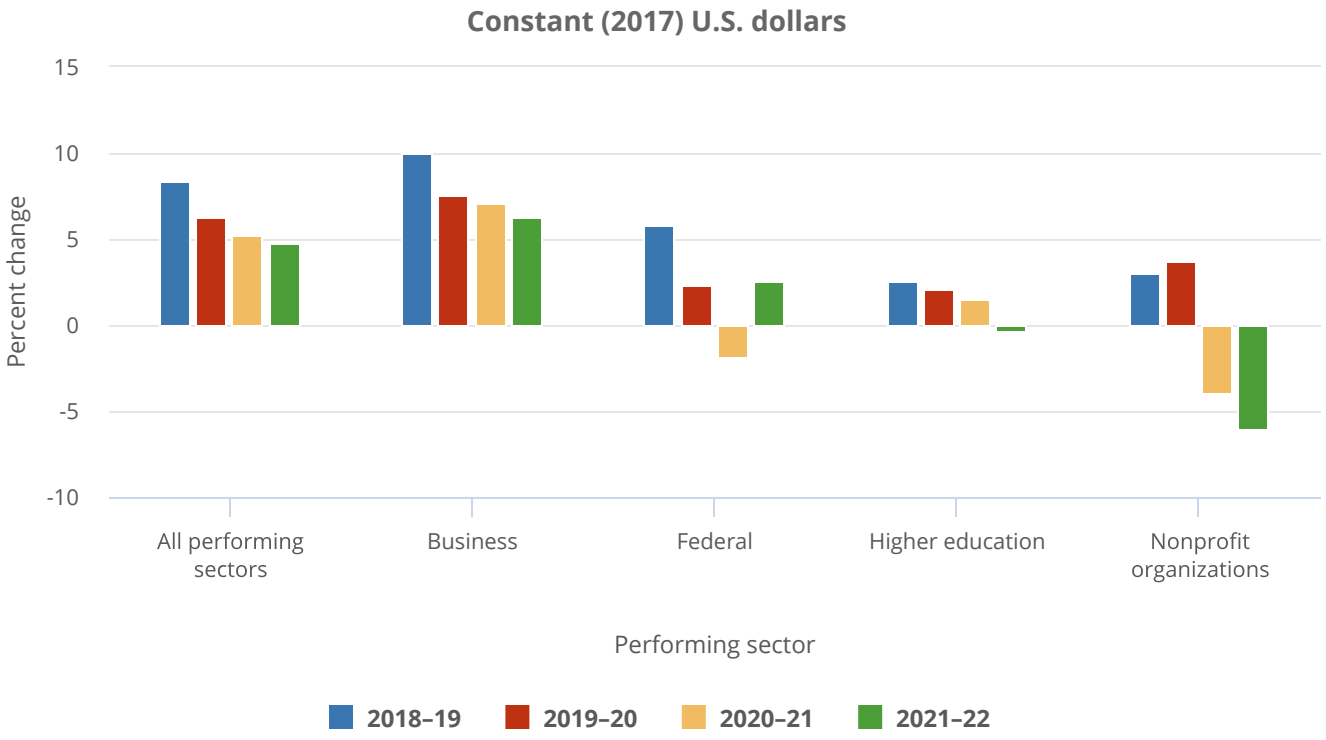
This section briefly describes U.S. R&D performance for all major sectors: business, higher education, federal and state government, and nonprofit. Later sections in this thematic report discuss additional details for business and the federal government.

The business sector is by far the largest performer of U.S. R&D. In 2022, this sector performed $692.7 billion in domestic R&D (current U.S. dollars), compared with $608.6 billion in 2021 for a 14% increase (6% in constant dollars) (**Figure RD-3**, **Figure RD-4**, **Figure RD-6**; **Table RD-1**, **Table RD-2**).[3] From 2010 to 2022, business R&D grew at an annual CAGR of 5% in constant dollars, the highest rate across all sectors. This growth was driven by several R&D-intensive industries, as discussed later in this thematic report.

Figure RD-6

Annual percent changes in U.S. R&D, by performing sector: 2018–22





Note(s):
Some data for 2021 are preliminary and may be revised later. The data for 2022 are estimates and are likely to be revised later. 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 (2021–22 edition).

Science and Engineering Indicators

Table RD-2

U.S. R&D expenditures, by performing sector, source of funds, and type of R&D: 2022

(Millions of dollars and percent)

Performing sector and type of R&D	Total	Source of funding					
		Business	Federal government	Nonfederal government	Higher education[a]	Nonprofit organizations	Percent by performer
R&D	885,563	672,868	159,833	5,902	25,514	21,447	100.0
Business	692,748	663,968	27,325	413	NA	1,042	78.2
Federal government	73,338	366	72,779	38	NA	155	8.3
Federal intramural	46,960	-	46,960	-	NA	-	5.3
FFRDCs	26,378	366	25,819	38	NA	155	3.0
Nonfederal government	697	NA	311	355	NA	NA	0.1
Higher education	91,451	5,493	47,738	4,766	25,236	8,219	10.3
Nonprofit organizations	27,329	3,026	11,679	NA	NA	12,019	3.1
Percent by funding source	100.0	76.0	18.0	0.7	2.9	2.4	-
Basic research	129,435	48,067	51,286	3,096	16,133	10,853	100.0
Business	46,287	43,466	2,676	41	NA	103	35.8
Federal government	13,202	55	13,118	6	NA	23	10.2
Federal intramural	7,959	-	7,959	-	NA	-	6.1

Table RD-2

U.S. R&D expenditures, by performing sector, source of funds, and type of R&D: 2022

(Millions of dollars and percent)

Performing sector and type of R&D	Total	Source of funding					
		Business	Federal government	Nonfederal government	Higher education[a]	Nonprofit organizations	Percent by performer
FFRDCs	5,244	55	5,159	6	NA	23	4.1
Nonfederal government	121	NA	54	62	NA	NA	0.1
Higher education	57,838	3,128	30,768	2,833	16,004	5,105	44.7
Nonprofit organizations	11,987	1,415	4,670	NA	NA	5,620	9.3
Percent by funding source	100.0	37.1	39.6	2.4	12.5	8.4	-
Applied research	159,927	98,768	46,068	1,975	6,744	6,373	100.0
Business	100,334	96,007	3,869	149	NA	310	62.7
Federal government	24,078	214	23,751	22	NA	91	15.1
Federal intramural	13,299	-	13,299	-	NA	0	8.3
FFRDCs	10,779	214	10,452	22	NA	91	6.7
Nonfederal government	536	NA	239	273	NA	NA	0.3
Higher education	24,951	1,583	13,103	1,427	6,656	2,182	15.6
Nonprofit organizations	10,028	952	5,106	NA	NA	3,780	6.3
Percent by funding source	100.0	61.8	28.8	1.2	4.2	4.0	-
Experimental development	596,199	526,035	62,478	831	2,637	4,220	100.0
Business	546,125	524,496	20,779	223	NA	627	91.6
Federal government	36,058	96	35,911	10	NA	41	6.0
Federal intramural	25,703	-	25,703	-	NA	0	4.3
FFRDCs	10,355	96	10,208	10	NA	41	1.7
Nonfederal government	40	NA	18	20	NA	NA	0.0
Higher education	8,663	782	3,867	505	2,576	932	1.5
Nonprofit organizations	5,314	659	1,904	NA	NA	2,619	0.9
Percent by funding source	100.0	88.2	10.5	0.1	0.4	0.7	-

NA = not available; amount not published in source data.

FFRDC = federally funded research and development center.

[a] Higher education totals for R&D, basic research, applied research, and experimental development are not published in the source data.

Note(s):
The data for 2022 are estimates and are likely to be revised later.

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

Science and Engineering Indicators

The second-largest performer sector was higher education, with $91.4 billion (or a 10% share) in 2022. This represented a 7% change from 2021 in current dollars but stagnated (-0.4% change) in constant dollars. Since 2010, the CAGR was 1.5% in constant dollars.[4]

In 2022, the federal government performed $73.3 billion, or an 8% share of U.S. R&D, compared with $66.8 billion in 2021 for a 10% increase (3% in constant dollars) (**Table RD-1**, **Table RD-2**). The 2022 number included $47.0 billion in intramural R&D and $26.4 billion performed by federally funded R&D centers (FFRDCs).[5] Nonfederal government R&D performance in 2022 was estimated to be $697 million, averaging $655 million from 2010 to 2022 in constant dollars. In 2022, it represented about 0.1% of the U.S. total (**Table RD-1**, **Table RD-2**).

Nonprofit organizations (excluding higher education institutions, the federal government, and nonfederal governments) performed $27.3 billion of R&D in 2022 ($23.2 billion in constant dollars) (**Table RD-1**, **Table RD-2**). Since 2010, the share of the sector has been between 3% and 4%.

Sources of R&D Funding

The business sector is the largest R&D funder in the United States. In 2022, the sector funded $672.9 billion ($570.4 billion in constant 2017 dollars), or 76% of total U.S. R&D (**Table RD-2**). Virtually all (99%) of the 2022 business R&D funding supported business R&D.[6]

The federal government funded another 18% ($159.8 billion, or $135.5 billion in constant dollars) in 2022 as the second-largest source of funding for U.S. R&D (**Figure RD-4**; **Table RD-1**). The largest recipient sectors of federal R&D funding in 2022 were higher education (30%), intramural federal R&D (29%), businesses (17%), and FFRDCs (16%) (NCSES 2024, Table 6). The remaining sectors funded another 6%: higher education (3%), nonprofit organizations (2%), and state and other local or nonfederal government (1%) (**Figure RD-4**; **Table RD-1**, **Table RD-2**).

Type of R&D

Most R&D performed in the United States is devoted to experimental development (hereafter, *development*), reflecting the large role of for-profit businesses in funding and performance. In 2022, development activities accounted for $596.2 billion in current dollars, or 67% of the $885.6 billion in total U.S. R&D performance. This was followed by applied research (18%) and basic research (15%). These relative shares have been stable for many years (**Table RD-3**). The higher education sector performs the largest share of basic research ($57.8 billion of $129.4 billion, or 45%), whereas the business sector performs 63% of applied research ($100.3 billion of $159.9 billion) and 92% of experimental development ($546.1 billion of $596.2 billion) (**Table RD-2**).

Table RD-3

U.S. R&D expenditures, by type of R&D: Selected years, 2000–22

(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[a]	2022[b]
Billions of current dollars														
All R&D	267.9	406.6	426.2	433.7	454.2	475.9	494.5	521.7	553.6	604.0	665.6	716.9	789.1	885.6
Basic research	42.0	76.5	73.7	74.0	79.3	82.9	84.4	87.5	90.2	97.9	105.0	111.8	118.6	129.4
Applied research	56.5	78.9	81.7	86.6	88.0	91.6	97.1	109.5	113.3	118.3	130.2	132.5	144.0	159.9
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	596.2
Billions of constant 2017 dollars														
All R&D	368.5	453.6	465.9	465.4	479.3	493.6	508.1	531.0	553.6	590.5	639.9	680.3	716.0	750.6
Basic research	57.8	85.3	80.6	79.4	83.6	86.0	86.8	89.1	90.2	95.7	101.0	106.1	107.6	109.7
Applied research	77.7	88.0	89.3	93.0	92.8	95.0	99.7	111.4	113.3	115.7	125.2	125.8	130.7	135.6
Experimental development	233.0	280.3	296.0	293.1	302.8	312.6	321.6	330.5	350.1	379.1	413.7	448.4	477.6	505.4
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
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
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	18.3	18.1
Experimental development	63.2	61.8	63.5	63.0	63.2	63.3	63.3	62.2	63.2	64.2	64.7	65.9	66.7	67.3

[a] Some data for 2021 are preliminary and may be revised later.

[b] The data for 2022 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's *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.

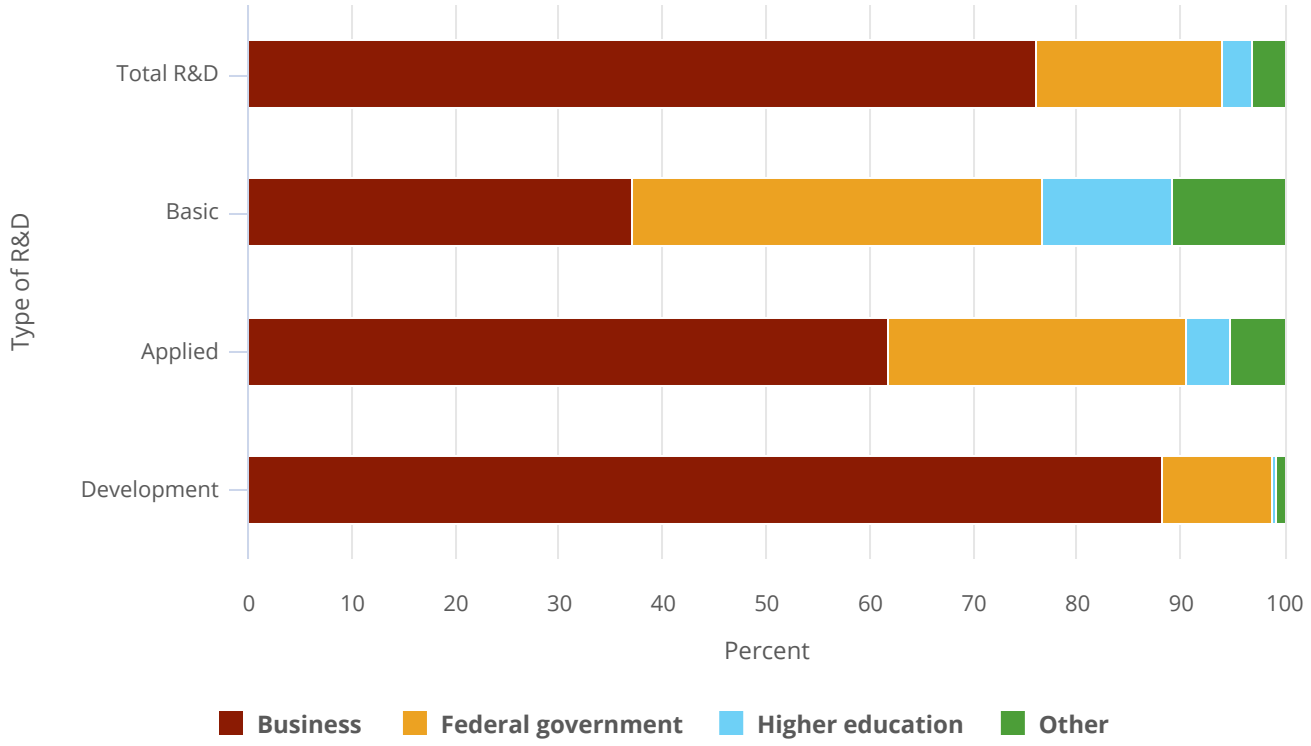
Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

Science and Engineering Indicators

U.S. businesses funded 88% of development expenditures in 2022, compared with 76% of overall U.S. R&D (**Figure RD-7**). Businesses also funded the largest share of applied research (62%). The federal government funded the largest proportion of total U.S. basic research (40%), followed by the business sector (37%) and the higher education sector (12%) (**Table RD-2**). For basic research performed by the higher education sector, 53% was funded by the federal government. For more information on long-term trends by type of R&D and on the higher education sector, see, respectively, Anderson (2024) and the *Indicators 2024* report "**Academic Research and Development**."[7]

Figure RD-7

U.S. R&D, by type and funding source: 2022



Note(s):
The data for 2022 are estimates and may be revised later. The Other category includes nonfederal government and nonprofit organizations.

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2021–22 edition).

Science and Engineering Indicators

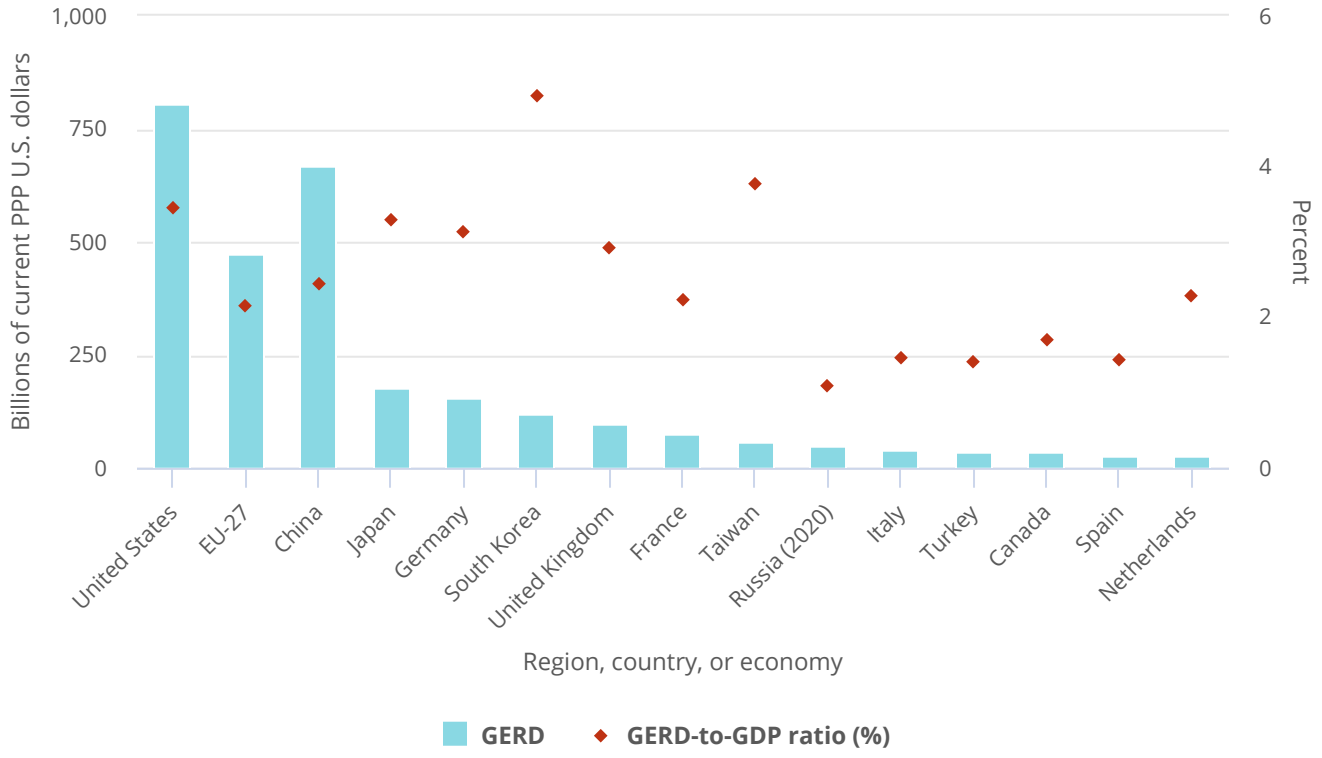
Cross-National Comparisons of R&D Performance

U.S. R&D expenditures can be compared with those of other countries to illustrate the relative position of the United States in this area and its impact on economic and other national goals noted earlier. Statistics in this section cover available data from MSTI (OECD 2023c) 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.

Based on internationally comparable estimates, the United States reached $806.0 billion in gross domestic expenditures on R&D (GERD) in 2021 ($709.7 billion in constant U.S. PPPs), up 10% from 2020 (6% in constant PPPs).[8] China, the second-highest performer of domestic R&D in recent years, totaled $667.6 billion in 2021 ($620.1 billion in constant PPPs), up 14% from 2020 (10% in constant U.S. PPPs) (OECD 2023c). Other top R&D performers include Japan ($177.4 billion), Germany ($153.7 billion), South Korea ($119.6 billion), the United Kingdom ($97.8 billion), and France ($77.2 billion) in current U.S. PPP dollars (**Figure RD-8**, **Figure RD-9**; Table SRD-1).

Figure RD-8

GERD and GERD-to-GDP ratio, by selected region, country, or economy: 2021 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 Russia was 2020.

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2020–21 edition); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators*, September 2023, https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

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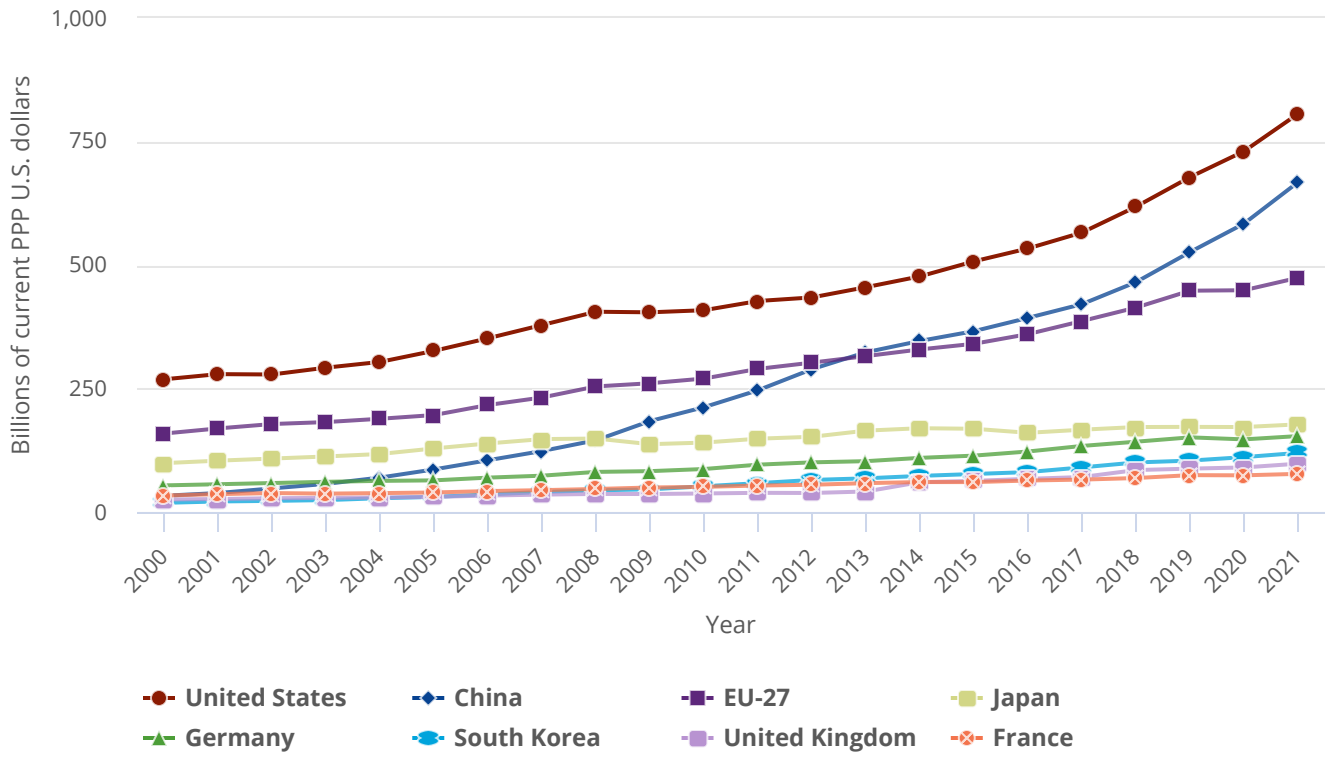
Figure RD-9

Gross domestic expenditures on R&D, by selected region, country, or economy: 2000–21



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 for 2021 are preliminary and may be revised later. Data for the United Kingdom dating back to 2014 are provisional and may be revised. U.S. data have been adjusted for international comparability.

Source(s):
OECD, *Main Science and Technology Indicators*, September 2023, https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

Science and Engineering Indicators

The distribution of R&D within countries presents some cross-sectional features. The business sector is the largest performer and funder of R&D across the top R&D-performing countries (**Table RD-4**). Across all countries with available statistics, Israel, Taiwan, and Ireland had the largest shares of R&D performed by the business sector (Table SRD-2). The government sector in many countries, including Germany and China, performed a higher share of R&D than the U.S. government sector (15% in Germany and China, compared with 8% in the United States, based on OECD GERD estimates). The R&D performance share of higher education was at least 20% in the European Union (EU-27), the United Kingdom, and France, compared with single-digit shares in China and South Korea. **Table RD-4** also shows that government funded approximately 30% of R&D in Germany and France, driving the EU-27 overall share funded by this sector to 31%, compared with 20% and 19%, respectively, for the United States and China.[9]

Table RD-4

GERD for selected region, country, or economy, by performing sector and source of funds: 2021

(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	Private nonprofit[a]	Business	Government	Other domestic	Rest of the world
United States[b]	806.0	77.6	8.3	10.4	3.7	67.9	19.9	5.5	6.7
EU-27	474.1	65.6	11.6	22.0	0.8	57.0	30.8	2.4	9.9
China	667.6	76.9	15.3	7.8	NA	78.0	19.0	NA	0.2
Japan	177.4	78.6	8.4	11.9	1.2	78.1	15.5	5.9	0.6
Germany	153.7	66.9	14.8	18.3	NA	62.8	30.0	0.3	6.9
South Korea	119.6	79.1	9.8	9.1	2.0	76.1	22.8	0.8	0.3
United Kingdom	97.8	70.9	5.1	22.5	1.5	58.5	19.4	11.4	10.6
France	77.2	65.7	11.7	20.5	2.1	55.4	32.5	4.4	7.7

NA = not available.

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

[a] The private nonprofit sector comprises all nonprofit institutions serving households except those classified as part of the higher education sector.

[b] 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. 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 (2020–21 edition); OECD, *Main Science and Technology Indicators,* September 2023, https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

Science and Engineering Indicators

Global R&D and Top R&D-Performing Countries

Based on available statistics across countries, the global total for R&D expenditures was $2.6 trillion in U.S. current PPP dollars in 2021. This includes all 37 OECD members plus another 7 economies (Argentina, China, Romania, Russia, Singapore, South Africa, and Taiwan) available in the OECD R&D database (Table SRD-1).[10] The global total for the same set of economies in 2018 was $2.1 trillion, for a CAGR of 7.8% in U.S. current PPP dollars from 2018 to 2021 (OECD 2023c).

Overall, the top 5 R&D-performing economies (the United States, China, Japan, Germany, and South Korea) accounted for 73% of the 2021 total, the top 10 for 85%, and the top 20 for 93% (**Figure RD-8**; **Table RD-5**; Table SRD-1).[11] The EU-27 accounted for 18% of global GERD in 2021 (OECD 2023c). China's GERD grew annually by double digits (nominal CAGR) in 2000–10 (20.5%) and in 2010–21 (11.0%), exceeding the rate of GDP growth over each of these periods, measured in U.S. current PPP dollars based on OECD MSTI statistics (**Table RD-5**). For the United States, the CAGR for GERD between 2000 and 2010 was 4.3%, compared with a growth rate of 3.9% for GDP over that period. For 2010–21, U.S. GERD grew 6.4% annually in nominal CAGR terms, faster than the nominal GDP growth rate of 4.1%.

Table RD-5

GERD, GDP, GERD-to-GDP ratio, and growth rates, by selected region, country, or economy: Selected years, 1990–2021

(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	2021[a]	1990	2000	2010	2021[a]	1990	2000	2010	2021[a]	1990–2000	2000–10	2010–21[a]	1990–2000	2000–10	2010–21[a]
United States	152.4	268.6	408.5	806.0	5,963	10,251	15,049	23,315	2.56	2.62	2.71	3.46	5.8	4.3	6.4	5.6	3.9	4.1
EU-27	NA	158.8	270.2	474.1	NA	9,479	14,512	21,988	NA	1.68	1.86	2.16	NA	5.5	5.2	NA	4.4	3.8
China	NA	32.9	212.2	667.6	1,114	3,683	12,380	27,446	NA	0.89	1.71	2.43	NA	20.5	11.0	12.7	12.9	7.5
Japan	65.4	98.9	140.5	177.4	2,459	3,461	4,525	5,383	2.66	2.86	3.10	3.30	4.2	3.6	2.1	3.5	2.7	1.6
Germany	36.0	53.9	87.0	153.7	1,380	2,237	3,185	4,913	2.61	2.41	2.73	3.13	4.1	4.9	5.3	4.9	3.6	4.0
South Korea	NA	18.5	52.1	119.6	358	871	1,573	2,426	NA	2.13	3.32	4.93	NA	10.9	7.8	9.3	6.1	4.0
United Kingdom	19.1	25.2	37.5	97.8	978	1,563	2,296	3,355	1.95	1.61	1.63	2.91	2.8	4.1	9.1	4.8	3.9	3.5
France	23.4	33.3	50.9	77.2	1,028	1,590	2,335	3,480	2.27	2.09	2.18	2.22	3.6	4.3	3.9	4.5	3.9	3.7
Taiwan	NA	9.1	25.0	55.6	204	478	890	1,472	NA	1.91	2.82	3.77	NA	10.6	7.5	8.9	6.4	4.7
Russia (2020)	24.1	10.5	33.1	48.0	1,275	1,074	3,144	4,367	1.89	0.98	1.05	1.10	-8.0	12.2	3.8	-1.7	11.3	3.3
Italy	12.7	15.5	25.4	40.1	1,057	1,542	2,084	2,761	1.20	1.00	1.22	1.45	2.0	5.1	4.3	3.8	3.1	2.6
Canada	8.3	16.7	24.9	34.4	560	901	1,364	2,027	1.48	1.86	1.83	1.70	7.3	4.0	3.0	4.9	4.2	3.7
Turkey	1.1	2.8	10.1	36.2	457	609	1,269	2,582	0.24	0.47	0.79	1.40	10.2	13.5	12.3	2.9	7.6	6.7
Spain	4.1	7.7	20.1	27.6	532	876	1,476	1,928	0.78	0.88	1.36	1.43	6.4	10.0	2.9	5.1	5.4	2.5
Netherlands	5.5	9.1	12.8	25.7	287	508	748	1,131	1.92	1.79	1.70	2.27	5.2	3.4	6.6	5.9	4.0	3.8

NA = not available.

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

[a] Data are for 2021 or the most recent year with GERD data available.

Note(s):
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 SRD-1.

Source(s):
National Center for Science and Engineering Statistics, National Patterns of R&D Resources (2020–21 edition); OECD, *Main Science and Technology Indicators*, September 2023, https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

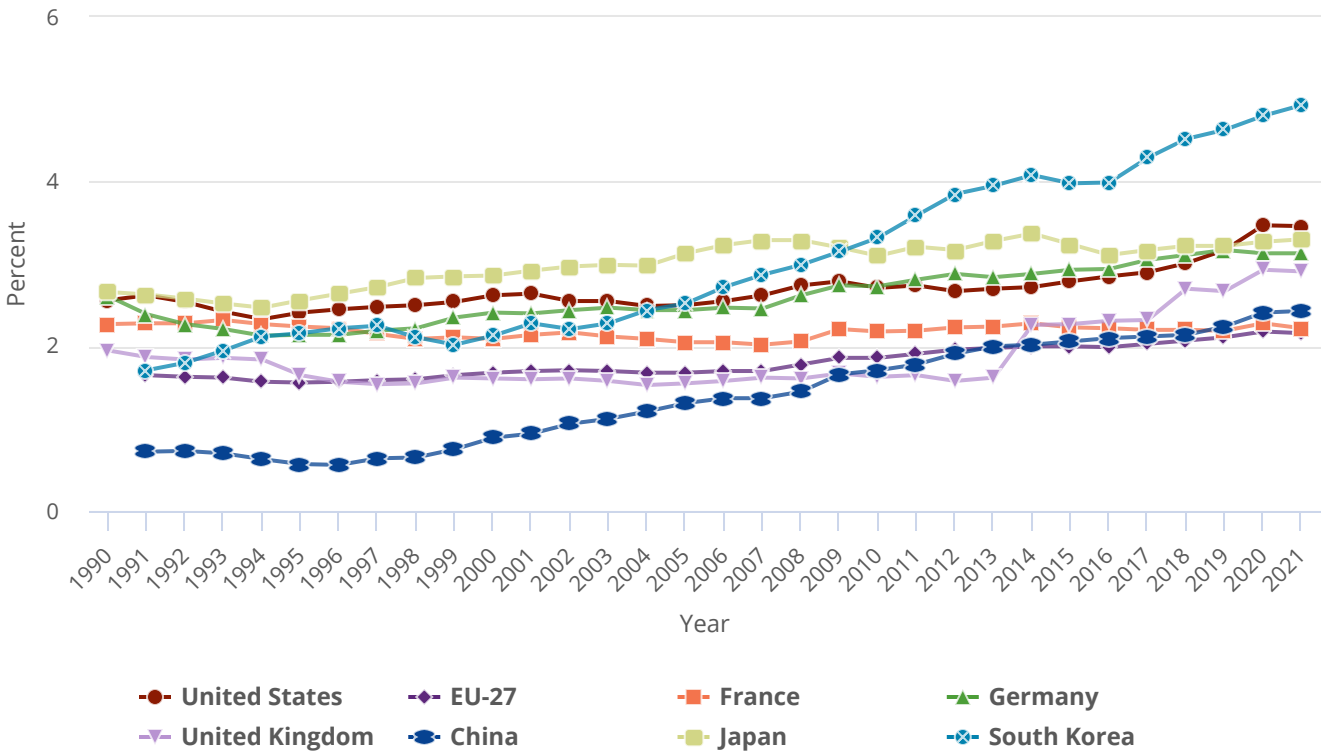
Science and Engineering Indicators

R&D Intensities

The GERD-to-GDP ratio facilitates comparisons of national investment in R&D relative to the size of the economy across countries and time (**Figure RD-8**, **Figure RD-10**). This indicator may be grouped into three size categories. Only two countries, Israel and South Korea, had R&D intensities above 4.0% in 2021 (Table SRD-1). Eight economies had intensities between 3.0% and 4.0%, including Taiwan (3.8%), the United States (3.5%), Japan (3.3%), and Germany (3.1%). And multiple countries had intensities above 2.0%, including the United Kingdom at 2.9%, China at 2.4%, France at 2.2%, and Singapore at 2.2%. The EU-27 had a ratio of 2.2% in 2021, compared with 1.9% in 2010.

Figure RD-10

GERD as a share of GDP, by selected region, country, or economy: 1990–2021



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. 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 (2020–21 edition); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators*, September 2023, https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

Science and Engineering Indicators

U.S. Business R&D

U.S. business R&D expenditures are measured as current costs, which include labor costs; materials and supplies; expensed equipment (not capitalized); leased facilities and equipment; and expenses for depreciation and amortization on property, plant, and equipment. These expenditures are dominated by labor costs, in comparison with current costs associated with facilities or equipment such as rental expenses or expensed equipment (Moris and Shackelford 2023b).[12]

Of the $608.6 billion of U.S. business R&D performed in 2021, $602.5 billion was performed by companies with 10 or more domestic employees, and $6.1 billion was performed by businesses with 9 or fewer domestic employees (or microbusinesses) (Kindlon 2023; Britt 2023).[13] Statistics are from NCSES's Annual Business Survey (ABS) for microbusinesses and the Business Enterprise Research and Development (BERD) Survey for the larger companies.[14]

The largest proportion of R&D by businesses with 10 or more domestic employees is performed by the manufacturing sector (54% in 2021) (**Table RD-6**),[15] whereas 88% of microbusiness R&D is performed by the nonmanufacturing sector (Kindlon 2023, Table 4). **Figure RD-11** shows the distribution of domestic R&D for the top 5 R&D-performing industries (based on North American Industry Classification System [NAICS] codes) for these two broad size categories. The dominance of nonmanufacturing for microbusinesses is largely driven by the 73% share of R&D by firms classified in professional, scientific, and R&D services (NAICS 54), whereas the share of information (NAICS 51) was 12% for microbusinesses compared with 25% for larger companies. (See Table SRD-3 and Table SRD-4 for detailed company size R&D distribution from these sources.)

Table RD-6

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: 2021

(Millions of dollars and percent)

Industry, NAICS code	Domestic net sales[a]	Domestic R&D[b]		R&D-to-sales ratio (%)
All industries, 21–33, 42–81	13,097,756	602,499		4.6
Manufacturing industries, 31–33	6,550,600	326,060		5.0
Chemicals, 325	1,309,684	109,490		8.4
Pharmaceuticals and medicines, 3254	624,341	100,220		16.1
Machinery, 333	427,096	17,730		4.2
Computer and electronic products, 334	778,262	101,063		13.0
Semiconductor and other electronic components, 3344	232,353	47,396		20.4
Electrical equipment, appliance, and components, 335	156,050	5,494		3.5
Transportation equipment, 336	1,014,159	50,760		5.0
Motor vehicles, bodies, trailers, and parts, 3361–63	623,254	26,391		4.2
Aerospace products and parts, 3364	311,988	21,468	i	6.9
Nonmanufacturing industries, 21–23, 42–81	6,547,157	276,439		4.2
Information, 51	1,703,835	147,855		8.7
Software publishers, 5112	303,134	39,049		12.9
Data processing, hosting, and related services, 518	562,172	45,192		8.0
Finance and insurance, 52	1,537,769	20,947		1.4
Professional, scientific, and technical services, 54	483,784	66,496		13.7
Computer systems design and related services, 5415	199,429	20,409		10.2
Scientific R&D services, 5417	82,907	34,142	i	41.2

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.

[a] 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.

[b] 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.

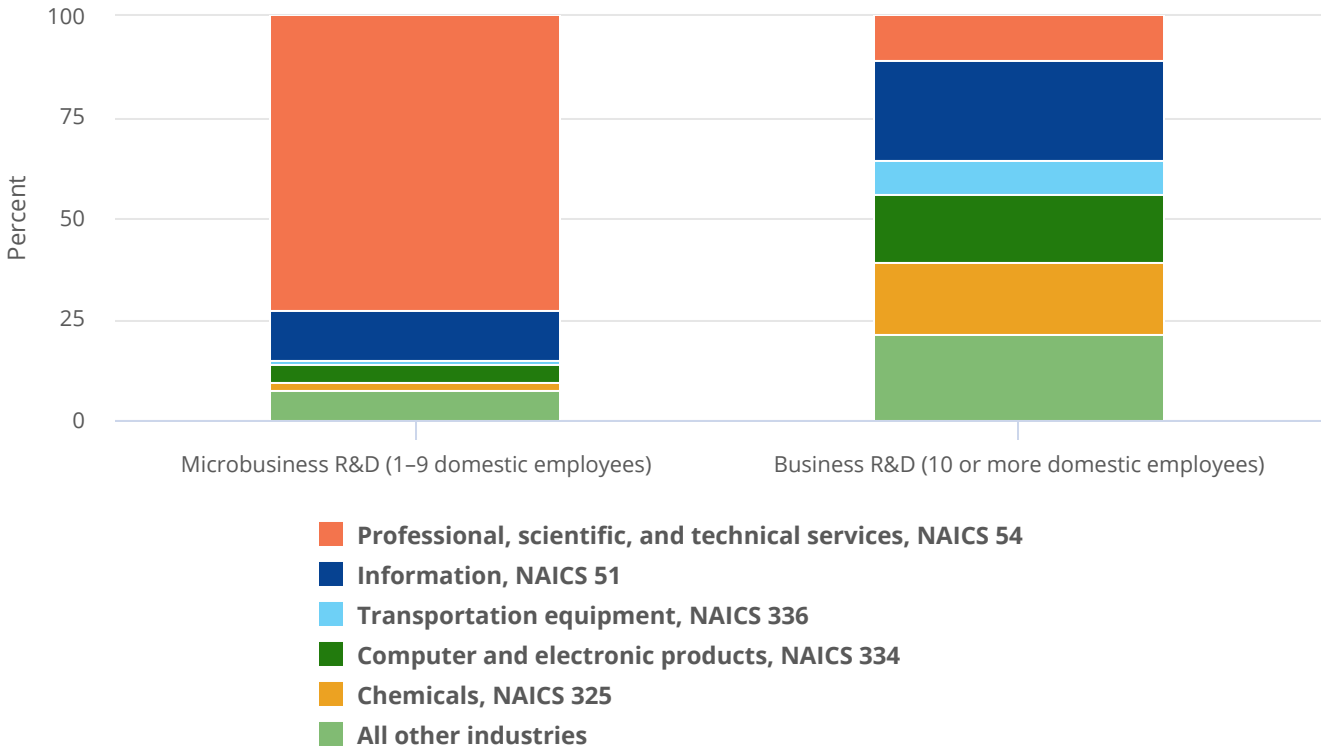
Note(s):
Data are for companies with 10 or more domestic employees. Detail may not add to total because of rounding. Industry classification was based on the dominant business code for domestic R&D performance, where available. For companies that did not report business codes, the classification used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

Source(s):
National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development (BERD) Survey, 2021.

Science and Engineering Indicators

Figure RD-11

U.S. business and microbusiness R&D distribution, by top industries: 2021



NAICS = 2017 North American Industry Classification System.

Note(s):
Details may not add to total because of rounding. NAICS industry classification is based on the dominant business code for domestic R&D performance. Statistics are representative of companies located in the United States that performed or funded R&D.

Source(s):
National Center for Science and Engineering Statistics and Census Bureau, 2022 Annual Business Survey (ABS): Data Year 2021, and 2021 Business Enterprise Research and Development (BERD) Survey.

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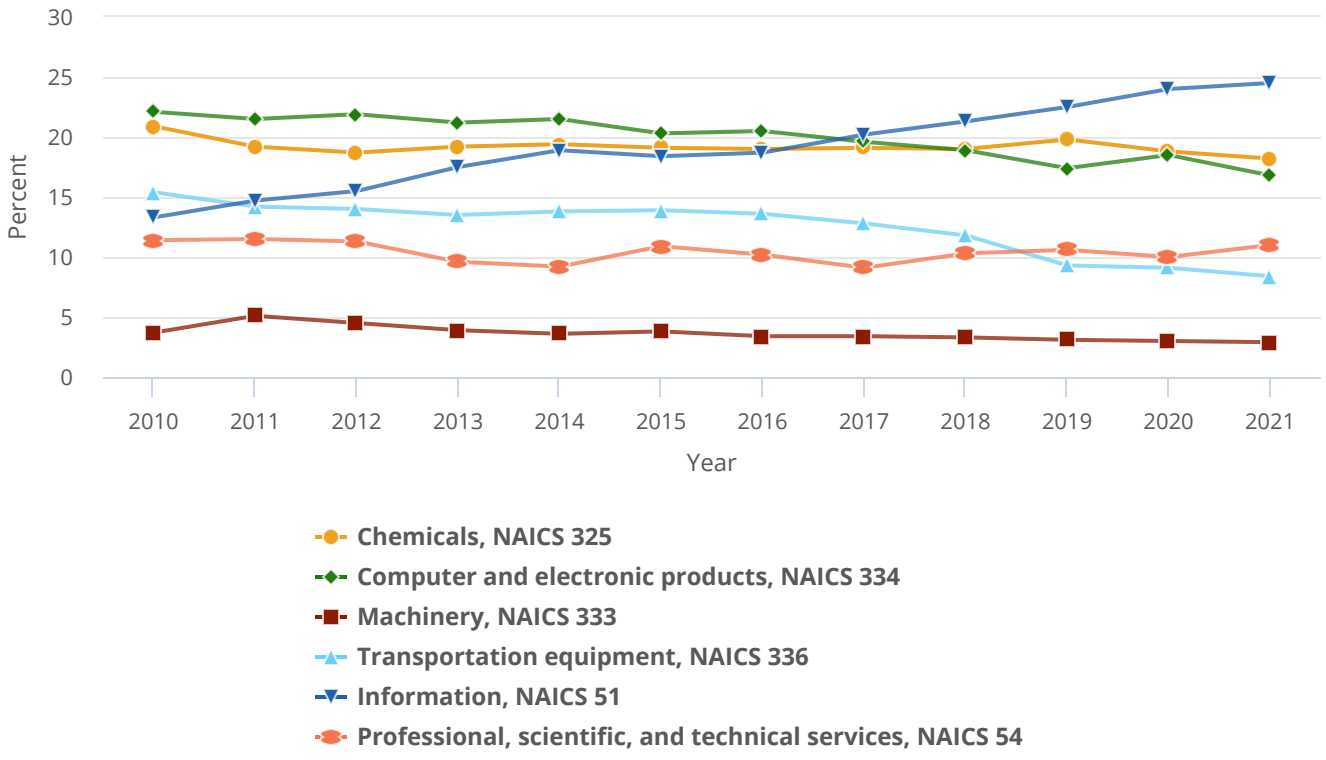
Industries That Perform the Most U.S. Business R&D

The rest of this section focuses on R&D activities by businesses with 10 or more domestic employees from the NCSES BERD Survey. Five industries accounted for 79% of the $602.5 billion of U.S. business R&D performed by these companies in 2021: information (including software publishing) at 25%; chemicals manufacturing (including pharmaceuticals and medicines) at 18%; computer and electronic products manufacturing (including semiconductors) at 17%; professional, scientific, and technical services (including R&D services) at 11%; and transportation equipment manufacturing (including motor vehicles and aerospace products and parts) at 8% (**Figure RD-12**; **Table RD-6**).[16] Machinery manufacturing companies performed another 3%. The latter six NAICS industries are major R&D-intensive or knowledge- and technology-intensive industries covered in the *Indicators 2024* report "**Production and Trade of Knowledge- and Technology-Intensive Industries**" with analysis of output, trade, and GVCs. Indeed, these six industries are among the largest R&D intensive as measured by domestic R&D-to-sales ratio (**Table RD-6**). At the four-digit NAICS level, the industries with the largest R&D intensities were scientific R&D services (41%), semiconductor and other electronic components manufacturing (20%), pharmaceuticals and medicines manufacturing (16%), and software publishers (13%).

Figure RD-12

Industry share of U.S. business R&D, by top R&D-performing industries: 2010–21



NAICS = 2017 North American Industry Classification System.

Note(s):
Industry classification is based on the dominant business code for domestic R&D performance, when available. For companies that did not report business codes, the classification used for sampling was assigned. Beginning in survey year 2018, statistics are representative of companies located in the United States that performed or funded $50,000 or more of R&D. The 2010–16 data come from the Business R&D and Innovation Survey and do not include companies with fewer than five domestic employees. Data for 2017–18 come from the Business Research and Development Survey, whereas data for 2019–21 come from the Business Enterprise Research and Development Survey; both surveys do not include companies with fewer than 10 domestic employees.

Source(s):
National Center for Science and Engineering Statistics and Census Bureau, Business R&D and Innovation Survey (BRDIS), Business Research and Development Survey (BRDS), and Business Enterprise Research and Development (BERD) Survey.

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Across industries, close to 90% of U.S. business R&D is funded by the performing company. In the information industry, this share is 99% (**Table RD-7**). At the other extreme, only 18% of R&D performed by the scientific R&D services industry is funded internally, reflecting contract R&D for other companies, domestic and foreign, and on behalf of the federal government. Domestic company customers funded 54% of the U.S. R&D of this industry, and the federal government funded another 12%. In the manufacturing sector, aerospace products and parts had one of the lowest shares of R&D funded internally (46%). For this industry, the federal government funded 49% of its domestic R&D.

Table RD-7

U.S. business R&D performance, by source of funds: 2021

(Millions of dollars)

Industry, NAICS code	All R&D[a]	Paid for by the company	Paid for by others				
			Total	Federal	Companies		All others
					Domestic	Foreign	
All industries, 21–33, 42–81	602,499	527,804	74,695	23,582	26,587 i	23,256	1,270
Manufacturing industries, 31–33	326,060	287,666	38,394	16,374	6,601	14,855	564
Chemicals, 325	109,490	97,097	12,393	1,223	2,654	8,418	98
Pharmaceuticals and medicines, 3254	100,220	88,524	11,697	1,194	2,631	7,777	95
Machinery, 333	17,730	16,726	1,003	503	211	278	11
Computer and electronic products, 334	101,063	94,211	6,852	2,828	1,650	2,290	84
Semiconductor and other electronic components, 3344	47,396	45,516	1,880	81	75	1,714	10
Electrical equipment, appliance, and components, 335	5,494	5,007	486	25	12	448	1
Transportation equipment, 336	50,760	34,405	16,356	11,670 i	1,534	2,870 i	282 i
Motor vehicles, bodies, trailers, and parts, 3361–63	26,391	22,754	3,637	48	808	2,713 i	68 i
Aerospace products and parts, 3364	21,468 i	9,900	11,568 i	10,527 i	724	129	189 i
Nonmanufacturing industries, 21–23, 42–81	276,439	240,138	36,300 i	7,207	19,986 i	8,400 i	707 i
Information, 51	147,855	146,488	1,366	377	271	694	24
Software publishers, 5112	39,049	38,441	608	13	240	336	19
Data processing, hosting, and related services, 518	45,192	44,585	607	338	16	250	4
Finance and insurance, 52	20,947	20,902	45	0	45	0	0
Professional, scientific, and technical services, 54	66,496	32,083	34,413 i	6,790	19,555 i	7,470 i	598 i
Computer systems design and related services, 5415	20,409	17,188	3,221	569	553	2,043	56
Scientific R&D services, 5417	34,142 i	6,123	28,019 i	4,106	18,420 i	5,163 i	330 i

i = more than 50% of the estimate or its component(s) is a combination of imputation and reweighting to account for nonresponse.

NAICS = 2017 North American Industry Classification System; nec = not elsewhere classified.

[a] 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. Beginning in survey year 2018, companies that performed or funded less than $50,000 of R&D were excluded from tabulation. These companies in aggregate represented a very small share of total R&D expenditures in prior years. Had the companies under this threshold been included in the 2018 estimates, they would have contributed approximately $90 million to overall R&D expenditures. 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 research and development centers.

Source(s):
National Center for Science and Engineering Statistics and Census Bureau, Business Enterprise Research and Development (BERD) Survey, 2021.

Science *and Engineering Indicators*

Geographical locations of the performance of U.S. business R&D are not evenly distributed among the states. Of the $602.5 billion of business R&D performed by businesses with 10 or more domestic employees in 2021, California accounted for $211.6 billion, or 35%, in 2021 (Table SRD-5).[17] The next-largest shares in 2021 were for Washington (8%); Massachusetts (7%); Texas (5%); and New York, New Jersey, and Michigan (4% each).[18]

U.S. Business R&D in Selected Critical and Emerging Technologies

R&D in critical and emerging technologies, such as semiconductors, artificial intelligence (AI), synthetic biology, biomanufacturing, and other advanced manufacturing processes, contribute to economic competitiveness and national security (DOD/DSB 2022; NSTC 2022).[19] This section covers U.S. business R&D by the semiconductor manufacturing industry, followed by analysis of software, AI, nanotechnology, and biotechnology R&D across industries.[20] (Federal R&D funding initiatives in some of these areas are covered in the next section.)

Semiconductors or computer chips are critical components for applications in AI, quantum computing, autonomous or electric vehicles, and 5G communications (CRS 2020b, 2023c). Semiconductor production occurs along GVCs comprising R&D, engineering, and design; fabrication; and assembly, testing, and packing stages (CRS 2023c). Modular production and cost advantages in Asia facilitated the separation of design and production starting in the late 1970s and early 1980s with the emergence of chip foundries in Taiwan and other Southeast Asian locations performing contract manufacturing for design-only or fabless companies in the United States and other countries (Kuan and West 2023).

In the United States, semiconductor and other electronic components manufacturing is one of the most R&D-intensive industries, as highlighted earlier. In 2021, semiconductor business R&D increased 9.8% in current U.S. dollars to $47.4 billion after increasing 22.8% in 2020 (**Table RD-8**). The share of semiconductor manufacturing within overall U.S. computer manufacturing R&D was 47% in 2021 after fluctuating around 40% since 2008.

Table RD-8

U.S. R&D performed, by semiconductor manufacturing and other selected industries: 2008–21

(Millions of current U.S. dollars)

Industry	NAICS code	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
All industries	21–23, 31–33, 42–81	290,680	282,505	279,289	290,240	302,759	323,107	340,539	355,671	378,590	396,979	443,633	491,434	538,870	602,499
Manufacturing industries	31–33	203,755	196,441	199,147	202,363	208,577	222,718	231,705	236,170	249,999	255,602	274,315	284,673	309,021	326,060
Computer and electronic products	334	60,464	55,856	61,623	62,438	66,290	68,629	73,256	72,182	77,451	78,003	83,948	85,571	99,523	101,063
Semiconductor and other electronic components	3344	22,324	20,023	23,011	24,237	28,218	30,176	31,668	30,451	31,413	30,373	30,232 - 43,377	35,178	43,184	47,396
Nonmanufacturing industries	21–23, 42–81	86,926	86,064	80,142	87,877	94,183	100,389	108,834	119,501	128,591	141,377	169,318	206,761	229,849	276,439

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. 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. For survey year 2008, industry classification was based on the 2002 NAICS. For survey years 2009–13, industry classification was based on the 2007 NAICS. For survey years 2014–19, industry classification was based on the 2012 NAICS. For survey years beginning in 2020, classification was based on the 2017 NAICS. Most statistics for years prior to 2020 have been revised since original publication. Revised statistics include adjustments based on information obtained after the original statistics were prepared. An estimate range may be displayed in place of a single estimate to avoid disclosing operations of individual companies.

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

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U.S. business R&D performance focuses on key areas of interest across a wide variety of industries (**Table RD-9**; Table SRD-6). Software R&D, over half of which is performed in the information services industry, is an increasingly large technology area of U.S. business R&D expenditures. In 2021, software R&D accounted for $257.0 billion, or 43% of $602.5 billion.[21] In 2021, a separate 5% ($28.9 billion) was classified by businesses as R&D specifically devoted to AI applications. The professional, scientific, and technical services industry, which includes scientific R&D services, performed 19% of U.S. business R&D in AI in 2021. Biotechnology R&D accounted for 17% of total U.S. business R&D in 2021. Within R&D performed by pharmaceuticals and medicine manufacturing, 79% was classified as biotechnology. For its part, nanotechnology R&D accounted for 5% of total U.S. business R&D. Within semiconductor manufacturing R&D and semiconductor machinery manufacturing R&D, however, nanotechnology focus accounted for 50% and 43%, respectively.

Table RD-9

U.S. business R&D performed, by industry and select technology focus: 2021

(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	602,499		257,030	i	102,513		32,718	i	28,875	i
Manufacturing industries	31–33	326,060		50,012		85,389		27,805	i	10,716	i
Chemicals	325	109,490		1,442		79,551		619		448	i
Pharmaceuticals and medicines	3254	100,220		1,290		78,889		292		397	i
Machinery	333	17,730		2,392		114	i	2,318		834	
Computer and electronic products	334	101,063		32,906		2,344	i	23,907	i	6,874	i
Semiconductor and other electronic components	3344	47,396		9,270	i	41		23,549	i	4,115	i
Electrical equipment, appliances, and components	335	5,494		1,200		54		16		321	i
Transportation equipment	336	50,760		7,717	i	9		226	i	1,525	
Motor vehicles, bodies, trailers, and parts	3361–63	26,391		4,254		0		3		1,147	
Aerospace products and parts	3364	21,468	i	3,363	i	9		223	i	373	i
Nonmanufacturing industries	21–23, 42–81	276,439		207,017	i	17,123	i	4,913	i	18,159	i
Information	51	147,855		134,216	i	198		3,417	i	9,982	i
Software publishers	5112	39,049		32,926		110		3,365	i	2,364	
Data processing, hosting, and related services	518	45,192		43,677		87		51		2,901	i
Finance and insurance	52	20,947		18,558		4		0		853	
Professional, scientific, and technical services	54	66,496		25,158	i	15,504	i	1,458	i	5,487	i
Computer systems design and related services	5415	20,409		12,875		39	i	758	i	1,717	i
Scientific R&D services	5417	34,142	i	5,733	i	15,190	i	518	i	2,739	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, 2021.

Science and Engineering Indicators

Federal Support for U.S. R&D

U.S. federal obligations for R&D and R&D plant are presented by fiscal year, through FY 2023, in current U.S. dollars. (FY 2023 data are preliminary and are subject to revisions.) Obligations offer a different and complementary perspective of federal R&D funding discussed earlier using National Patterns statistics. Obligations represent the monetary amount for orders placed, contracts awarded, services received, and other similar transactions by federal agencies, regardless of when the funds were appropriated and when future payments may be required. Funding may be devoted to internal or intramural R&D performance (agency laboratories and other facilities as well as FFRDCs) or to external performers, notably academic institutions for basic research, as well as businesses, state and local governments, and nonprofit organizations.

Federal funding for R&D has been a key feature of U.S. science and technology policy for decades, supporting national defense, space exploration, energy, health, general science, and other national goals (CRS 2022c; Mowery 1992; Pece 2023a; NASEM 2020). Since 2008, total obligations for R&D and R&D plant have fluctuated, with notable increases in FYs 2009–10 and further increases in 2019–21 (**Table RD-10**). These earlier fluctuations are partly due to the 2009 ARRA, which brought with it historical R&D funding peaks in FYs 2009 and 2010 (and relative drops in total R&D obligations in the following years). Later increases in FYs 2019–22 were the result of supplemental COVID-19-related appropriations like the Coronavirus Aid, Relief, and Economic Security (CARES) Act, which declined in FY 2023 (Pece 2023b, 2024). In addition to the CARES Act, a number of laws have been enacted that impact federal R&D obligations, including the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022 as well as the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA).[22] The last section summarizes information on several federal funding areas related to critical and emerging technologies.

Table RD-10

Federal obligations for R&D and R&D plant, by agency: FYs 2008–23

(Millions of dollars)

Agency	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016[a]	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023 (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	193,896	196,595	192,969
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	89,221
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	49,677
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	18,586
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	11,858
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	8,518
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	4,058
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	3,546
Department of Veterans Affairs	480	510	563	613	615	639	589	662	695	682	1,349	1,508	1,565	1,698	1,696	1,930
Department of Transportation	825	846	929	862	936	876	848	884	962	987	1,077	1,052	1,224	1,145	1,111	1,266
Department of the Interior	645	739	728	717	743	717	762	809	860	868	769	831	844	915	947	1,050
Department of Homeland Security	1,057	984	1,132	1,128	832	719	944	1,645	689	870	913	648	507	549	581	599
Environmental Protection Agency	532	553	572	582	581	530	538	521	513	498	492	490	493	526	531	574
Patient-Centered Outcomes Research Trust Fund	na	na	na	41	41	334	283	152	115	884	492	578	470	460	522	560
Department of Education	328	322	363	346	338	310	322	251	244	262	266	236	240	364	402	354
Smithsonian Institution	188	227	213	249	246	240	231	229	235	241	261	269	276	63	297	316
Agency for International Development	124	160	84	119	77	125	60	212	193	192	167	221	194	82	221	221
Department of Justice	114	103	125	102	85	119	161	150	208	127	107	121	96	85	111	139
Social Security Administration	54	68	63	53	65	57	60	59	129	110	72	146	70	105	79	106
All other agencies	220	213	248	303	284	248	239	279	294	250	332	327	233	255	245	390

na = not applicable.

[a] 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 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, Tennessee Valley Authority, RESTORE Act Centers, 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 72, FYs 2022–23.

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Federal Obligations for R&D and R&D Plant, by Major Agencies

Continuing an ongoing trend, a small number of agencies' FY 2022 R&D and R&D plant obligations constituted the majority of total federal obligations. The Department of Health and Human Services (HHS) ($74.4 billion, or 38% of total) and the Department of Defense (DOD) ($72.6 billion, or 37% of total) together accounted for around three-fourths of the $196.6 billion federal total. Other top agencies included the Department of Energy (DOE) ($18.0 billion, or 9% of total), the National Aeronautics and Space Administration (NASA) ($11.8 billion, or 6% of total), and NSF ($7.4 billion, or 4% of total) (**Table RD-10**).

In FY 2022, total obligations for R&D and R&D plant remained on par with FY 2021 ($196.6 billion and $193.9 billion, respectively). The CAGR from 2017 to 2022 was 10.1%, with preliminary estimates indicating FY 2023's funding obligations will decrease slightly to $193.0 billion. DOD R&D and R&D plant obligations increased 2% to $72.6 billion in FY 2022, from $70.9 billion in FY 2021. HHS funding decreased 3% in FY 2022 ($74.4 billion, down from $77.1 billion in FY 2021) following a 25% increase in the year prior (from $61.8 billion in FY 2020) and a 57% increase in FY 2020 (from $39.4 billion in FY 2019).

Distribution of Federal Obligations, by Performer and Type of R&D

Agencies obligate funds for R&D and R&D plant to intramural or extramural performers and for different types of R&D (basic research, applied research, or experimental development). R&D accounted for approximately 97% of the total R&D and R&D plant obligations in FY 2022 ($190.4 billion of the total $196.6 billion), with R&D plant (facilities and major equipment) accounting for the remaining 3% ($6.2 billion) (**Table RD-11**). For each of the top 15 agencies presented in **Table RD-11**, R&D plant accounted for a minority of overall R&D obligations, with DOE having the most R&D plant obligations ($4.3 billion of the total $6.2 billion across all agencies), followed by NSF with $529 million.

Table RD-11

Federal obligations for R&D and R&D plant, by agency and performer: FY 2022

(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	196,595	190,422	6,173	90,694	46.1	105,903	53.9
Department of Defense	72,608	72,352	256	29,899	41.2	42,709	58.8
Department of Health and Human Services	74,388	74,097	291	35,442	47.6	38,946	52.4
Department of Energy	17,977	13,697	4,280	13,156	73.2	4,821	26.8
National Aeronautics and Space Administration	11,750	11,623	127	4,053	34.5	7,697	65.5
National Science Foundation	7,425	6,896	529	425	5.7	7,000	94.3
Department of Commerce	2,390	2,011	379	1,820	76.2	570	23.8
Department of Agriculture	3,314	3,135	179	2,024	61.1	1,290	38.9
Department of Veterans Affairs	1,696	1,696	0	1,696	100.0	0	0.0
Department of Transportation	1,111	1,073	38	291	26.2	819	73.8
Department of the Interior	947	940	7	835	88.3	111	11.7
Department of Homeland Security	582	571	11	280	48.2	301	51.8
Environmental Protection Agency	531	525	6	274	51.6	257	48.4
Patient-Centered Outcomes Research Trust Fund	522	522	0	0	0.0	522	100.0
Department of Education	402	402	0	0	0.0	401	100.0
Smithsonian Institution	297	227	70	297	100.0	0	0.0
Agency for International Development	221	221	0	23	10.5	197	89.5

Table RD-11

Federal obligations for R&D and R&D plant, by agency and performer: FY 2022

(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
Department of Justice	111	111	0	8	7.2	103	92.8
Social Security Administration	79	79	0	47	59.5	32	40.5
All other agencies	244	244	0	123	49.0	128	51.0

Note(s):
Because of rounding in source tables, detail may not add to total. This table lists all agencies covered in Table RD-10 and as ranked there. 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 research and development 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. FY 2022 obligations include additional funding provided by supplemental COVID-19-related appropriations (e.g., Coronavirus Aid, Relief, and Economic Security [CARES] Act). All other agencies includes the 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, Tennessee Valley Authority, RESTORE Act Centers, Agency for Global Media, and Postal Service.

Source(s):
National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Volume 72, FYs 2022–23.

Science and Engineering Indicators

Extramural performers (businesses, higher education institutions, nonprofit organizations, state and local governments, and foreign organizations) accounted for 54% of R&D and R&D plant obligations ($105.9 billion) across all agencies in FY 2022, and intramural performers (which include both federal agencies' conduct of R&D as well as obligations to FFRDCs) accounted for 46% ($90.7 billion). Yet the percentage of FY 2022 federal R&D and R&D plant obligations for extramural recipients varied greatly among agencies. Extramural recipients accounted for 27% of the agency's total at DOE and 59% at DOD. At NSF and at the Patient-Centered Outcomes Research Trust Fund, extramural performers accounted for all or virtually all R&D and R&D plant funding, with 94% and 100%, respectively (**Table RD-11**).

Across all agencies, 24% of federal R&D obligations were devoted to basic research ($45.4 billion), 25% to applied research ($48.4 billion), and 51% to experimental development ($96.6 billion) in FY 2022 (**Table RD-12**). For DOD, 86% of total R&D was for experimental development ($62.2 billion), with 14% for applied research and basic research combined ($10.2 billion). In contrast, at NSF, 85% of R&D obligations were for basic research ($5.9 billion), with 15% ($1.0 billion) for applied research and no obligations for experimental development.

Table RD-12

Federal obligations for R&D, by agency and type of R&D: FY 2022

(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	190,422	45,393	48,414	96,615	23.8	25.4	50.7
Department of Defense	72,352	3,150	7,016	62,186	4.4	9.7	85.9
Department of Health and Human Services	74,097	22,411	25,861	25,825	30.2	34.9	34.9
Department of Energy	13,697	6,108	5,001	2,589	44.6	36.5	18.9
National Aeronautics and Space Administration	11,623	5,058	2,247	4,318	43.5	19.3	37.2

Table RD-12

Federal obligations for R&D, by agency and type of R&D: FY 2022

(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
National Science Foundation	6,896	5,863	1,033	0	85.0	15.0	0.0
Department of Commerce	2,011	273	1,417	321	13.6	70.4	16.0
Department of Agriculture	3,135	1,417	1,443	275	45.2	46.0	8.8
Department of Veterans Affairs	1,696	665	941	91	39.2	55.5	5.3
Department of Transportation	1,073	2	806	265	0.2	75.1	24.7
Department of the Interior	940	94	691	155	10.0	73.5	16.5
Department of Homeland Security	571	69	259	243	12.1	45.3	42.5
Environmental Protection Agency	525	0	406	119	0.0	77.3	22.7
Patient-Centered Outcomes Research Trust Fund	522	0	522	0	0.0	100.0	0.0
Department of Education	402	32	267	102	7.9	66.6	25.5
Smithsonian Institution	227	227	0	0	100.0	0.0	0.0
Agency for International Development	221	0	153	68	0.0	69.3	30.7
Department of Justice	111	17	86	8	15.2	77.4	7.4
Social Security Administration	79	0	79	0	0.0	100.0	0.0
All other agencies	243	7	187	49	2.9	76.8	20.3

Note(s):
This table lists all agencies covered in Table RD-10 and as ranked there. Because of rounding in source tables, detail may not add to total. FY 2022 obligations include additional funding provided by supplemental COVID-19-related appropriations (e.g., Coronavirus Aid, Relief, and Economic Security [CARES] Act). All other agencies includes the 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, Tennessee Valley Authority, RESTORE Act Centers, Agency for Global Media, and Postal Service.

Source(s):
National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, Volume 72, FYs 2022–23.

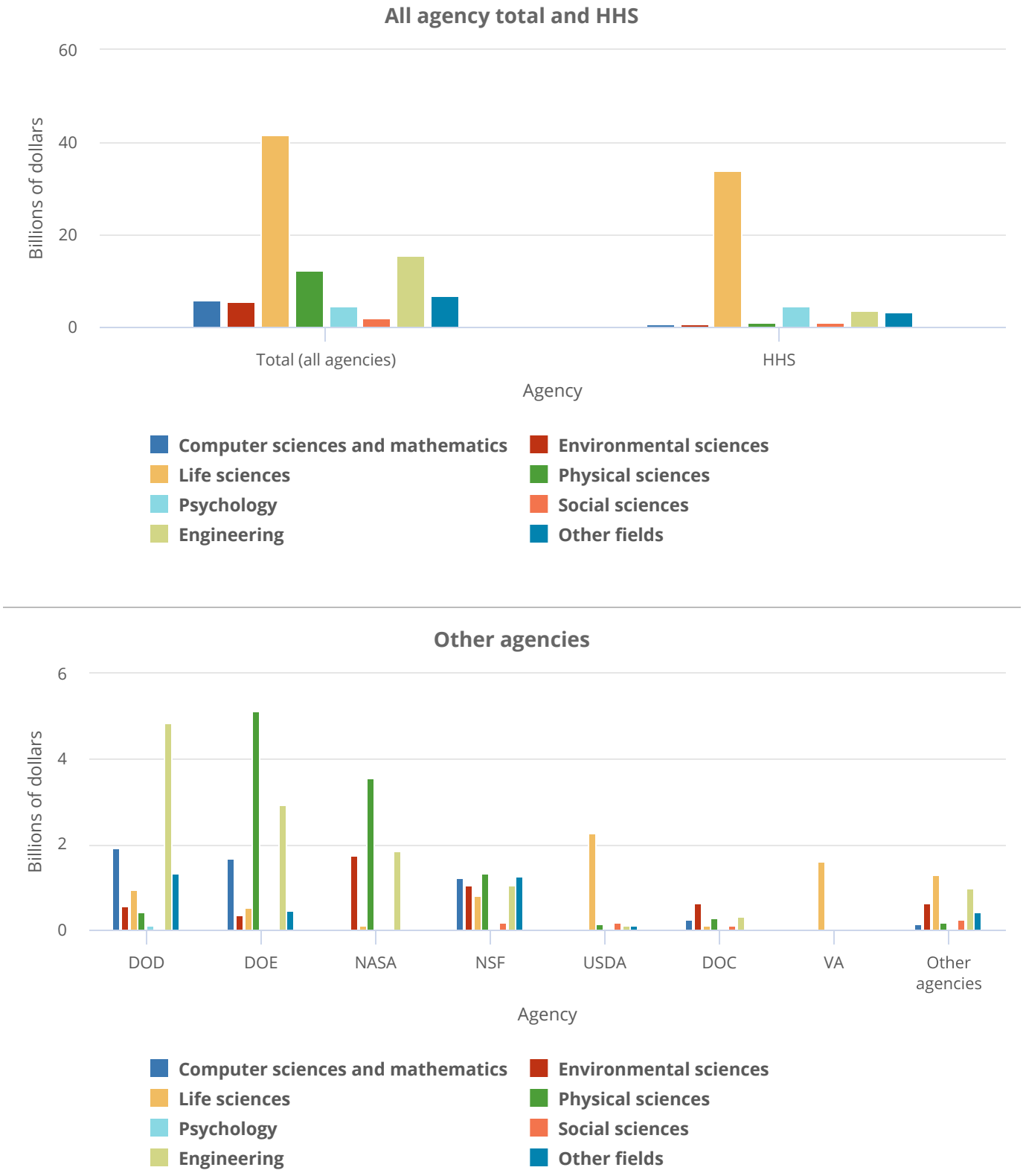
Science and Engineering Indicators

Distribution of Federal Obligations for Research, by S&E Fields

The government funds and performs research in a broad range of science and engineering (S&E) fields, including engineering, computer science and mathematics, environmental science, life sciences, physical sciences, and social sciences. Federal research obligations (basic plus applied research) reached $93.8 billion in FY 2022 across all S&E fields (**Figure RD-13**; Table SRD-7).

Figure RD-13

Federal obligations for research, by agency and major S&E field: FY 2022



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 72, FYs 2022–23.

Science and Engineering Indicators

Obligations for life sciences research were the highest among S&E fields, at $41.6 billion across all agencies (44% of total obligations) (**Figure RD-13**; Table SRD-7). This can primarily be attributed to HHS, which accounted for $34.0 billion, or 82% of total life science obligations. HHS funding also included $4.4 billion (96%) of the total $4.6 billion in psychology obligations across agencies. More broadly, $48.3 billion in overall HHS research obligations (across all S&E fields) accounted for around half of the total $93.8 billion of federal research obligations in FY 2022 (**Table RD-12**).

Other top agencies in research obligations include DOE, with $5.1 billion obligated for physical sciences (42% of the total $12.1 billion in that field) and $2.9 billion for engineering (19% of the total $15.5 billion across all agencies), and DOD, with $1.9 billion obligated for computer sciences and mathematics research (34% of the total $5.7 billion across all agencies) and $4.9 billion for engineering (31% of total) (**Figure RD-13**; Table SRD-7). NSF research obligations are spread rather evenly among major S&E fields. NSF funds between $1.0 billion and $1.3 billion in each of the computer sciences and mathematics, environmental sciences, physical sciences, and engineering fields and $792 million in life sciences (**Figure RD-13**; Table SRD-7).

Federal R&D Funding for Selected Critical and Emerging Technologies

The federal government has long supported semiconductor and information technology (IT) R&D (NRC 2003). More recently, the CHIPS and Science Act of 2022 appropriated $52.7 billion to revitalize the U.S. semiconductor industry through support of U.S. semiconductor fabrication and technology development along the supply chain, including $13.7 billion supporting R&D, workforce development, and related programs (CRS 2023a, 2023b; Zimmermann 2022). Several other recent federal initiatives related to critical and emerging technologies focus on quantum science, advanced IT and AI, and nanotechnology (CRS 2022a, 2022b; USG 2023). The National Quantum Initiative (NQI) Act became Public Law 115-368 in December 2018 to accelerate American leadership in quantum information science and technology.[23] Agencies with NQI activities reported $855 million in quantum information science R&D expenditures in FY 2021, up from $672 million in FY 2020 and $449 million in FY 2019 (SCQIS/NSTC 2023).

The Networking and Information Technology Research and Development (NITRD) Program coordinates federally funded R&D in advanced IT, networking, and AI. It was launched by the High-Performance Computing Act of 1991 and was most recently reauthorized in the 2017 American Innovation and Competitiveness Act (Public Law 114-329). Among agencies participating in the NITRD Program, $1.8 billion was budgeted in FY 2021 for R&D in nondefense AI (NITRD/NAIIO 2022).[24]

Last, the National Nanotechnology Initiative was launched by the 21st Century Nanotechnology Research and Development Act of 2003 (Public Law 108-153) to “invest in Federal R&D programs in nanotechnology and related sciences” and to “provide for interagency coordination.” Participating agencies budgeted $3.5 billion in FY 2020 (NSET/NSTC 2022) and $3.8 billion in FY 2021 on nanotechnology R&D and related workforce development (NSET/NSTC 2023). The latter included $1.7 billion for COVID-19 diagnostics and vaccine research by the Biomedical Advanced Research and Development Authority within HHS.[25]

Conclusion

U.S. GERD grew at a faster rate than GDP over 2010–21 on a compound annual growth rate basis. And while the United States remains the top R&D performer globally, other countries show continued growth in GERD and R&D intensity (R&D-to-GDP ratio). In 2021, the U.S. R&D intensity was 3.5%, based on internationally comparable OECD statistics. Other economies with R&D intensities above 3.0% include Israel and South Korea (both with intensities above 4.0%). Eight economies had intensities between 3.0% and 4.0%, including Taiwan, the United States, Japan, and Germany. Countries with intensities above 2.0% included the United Kingdom and China.

For the United States, the business sector continued to be the leading performer and funder of R&D. Manufacturing industries accounted for the largest proportion of R&D for companies with 10 or more employees, whereas the professional, scientific, and R&D services industry accounted for the largest proportion of R&D by microbusinesses. And U.S.-located companies continue to invest in software, AI, biotechnology, and nanotechnology R&D.

Consistent federal government support for R&D is a key feature of the U.S. R&D enterprise. The CHIPS and Science Act of 2022 appropriated $52.7 billion to revitalize the U.S. semiconductor industry along the supply chain, including $13.7 billion supporting R&D, workforce development, and related programs. More broadly, federal R&D funding constitutes the second-largest overall funding source and the largest source for U.S. basic research performance. The higher education sector was the largest performer of basic research and the largest recipient of federal R&D funding; in 2022, however, total R&D performance by the higher education sector did not increase after adjusting for inflation.

Glossary

Definitions

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, data on the EU include all 27 member countries.

Global value chain (GVC): Sequence of tasks or business functions needed to produce goods and services. These activities include R&D, engineering and design, production, marketing and sales, logistics, and customer service.

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

Gross domestic spending on R&D (GERD): Defined by the 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**).

Intangibles or intellectual property products (IPPs): IPPs are the result of R&D or innovation leading to knowledge that the developers can market or use to their own benefit in production because use of the knowledge is restricted by means of legal or other protection. They include R&D, mineral exploration and evaluation, computer software and databases, entertainment, literary and artistic originals, and other IPPs (OECD Glossary).

Knowledge- and technology-intensive (KTI) industries: Industries classified by the OECD as high R&D-intensive and medium-high R&D-intensive industries. OECD defines industry R&D intensity as the ratio of an industry's business R&D expenditures to its value added.

Organisation for Economic Co-operation and Development (OECD): An international organization of 37 countries, headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Colombia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Among its many activities, OECD compiles social, economic, and science and technology statistics for all member and selected nonmember 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).

Key to Acronyms and Abbreviations

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

KTI: knowledge- and technology-intensive

NAICS: North American Industry Classification System

NCSES: National Center for Science and Engineering Statistics

OECD: Organisation for Economic Co-operation and Development

PPP: purchasing power parity

R&D: research and experimental development

S&E: science and engineering

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Notes

1 For further background see Anderson, Jankowski, and Boroush (2023) and **https://ncses.nsf.gov/data-collections/national-patterns/2021-2022#methodology**.

2 For longer-term U.S. R&D trends, see Anderson, Jankowski, and Boroush (2023) and Anderson (2024). All comparative statements in this report have undergone statistical testing and are significant at the 90% confidence level except statements reliant on modeled estimates.

3 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 NCSES 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, and 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 $4 billion to $5 billion higher for 2016 and beyond as a result of microbusiness R&D being included.

4 The National Patterns statistics for higher education R&D appearing in this report adjust the academic fiscal year basis of NCSES's Higher Education Research and Development 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 report differ from those cited in the *Indicators 2024* report "**Academic Research and Development**." For further details, see **https://ncses.nsf.gov/data-collections/national-patterns/2021-2022#methodology**.

5 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. NCSES maintains a current Master Government List of Federally Funded R&D Centers available at **https://www.nsf.gov/statistics/ffrdclist/**.

6 Business funding refers to funding for domestic R&D performed by the business sector, higher education institutions, nonprofit organizations, and FFRDCs. 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.

7 Although key data features are noteworthy, care is needed in definitively identifying trends by type of R&D. Various methodological improvements in NCSES R&D performer surveys—but no material revisions in the type-of-R&D definitions (OECD 2015)—have been made over time, particularly before 2010, with the net implication that small percentage changes in the reported shares may not be meaningful.

8 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.

9 For international comparative measures of other forms of R&D support by governments such as tax incentives, see the OECD INNOTAX Portal (OECD 2023f).

10 The global total is based on 2021 or, for countries with missing data in the OECD database, the latest available year. In contrast with previous editions of this report, 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.

11 For methodological information on updated country statistics, see OECD (2023g).

12 Separately, businesses also have R&D capital expenditures—payments for long-lived assets to support R&D activities. Businesses that performed or funded U.S. R&D in 2020 had $32.5 billion in R&D capital expenditures (Moris and Shackelford 2023a).

13 For foreign R&D by multinational enterprises, see Bureau of Economic Analysis (2022) and Moris (2021).

14 For more information, see **https://ncses.nsf.gov/surveys/business-enterprise-research-development/2020#survey-info** for the BERD Survey and **https://ncses.nsf.gov/surveys/annual-business-survey/2021#survey-info** for the ABS. Microbusinesses are a small but important segment of business R&D and innovation. See Anderson and Kindlon (2019) and Knott and Vieregger (2020).

15 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://ncses.nsf.gov/surveys/business-enterprise-research-development/2021#data**.

16 Motor vehicle statistics include but do not separate out electric vehicles.

17 Statistics on U.S. state trends in R&D, S&E education, workforce, patents and publications, and knowledge-intensive industries are also available in the *Science and Engineering Indicators* **State Indicators data tool** at **https://ncses.nsf.gov/indicators/states**.

18 Selected below state–level statistics are also available from the NCSES BERD Survey (Shackelford and Wolfe 2019). For upcoming statistics on regional R&D within GDP accounts, see **https://www.bea.gov/data/special-topics**, and for more on R&D investment in U.S. GDP statistics, see Moris (2019) and Moylan and Okubo (2020).

19 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 President's Council of Advisors on Science and Technology (2020).

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

21 This share was 32% in 2016 and 20% in 2006 (Moris 2019).

22 For more information on CHIPS, IIJA, and IRA, see Pece (2024).

23 See **https://www.congress.gov/bill/115th-congress/house-bill/6227** (accessed 15 August 2023). Agencies participating in NQI efforts include the National Institute of Standards and Technology, NSF, DOE, DOD, NASA, the National Security Agency, and the Intelligence Advanced Research Projects Activity unit of the Office of the Director of National Intelligence. For more details, see (SCQIS/NSTC 2023). For related defense authorization legislation and possible technical applications in this area, see CRS (2022c).

24 See **https://www.congress.gov/114/plaws/publ329/PLAW-114publ329.pdf** and **https://www.nitrd.gov/** (accessed 15 August 2023). Participating agencies with a program component area for AI R&D in FY 2021 include Defense Advanced Research Projects Agency, Department of Homeland Security, DOD, DOE, Department of the Interior (DOI), Department of Transportation (DOT), Department of Education, NASA, HHS, Department of Justice (DOJ), Centers for Disease Control and Prevention, NSF, and Department of Agriculture (USDA). For more details, see (NITRD/NAIIO 2022).

25 See **www.congress.gov/108/plaws/publ153/PLAW-108publ153.pdf** and (NSET/NSTC 2023). Participating agencies in FY 2021 include Consumer Product Safety Commission, Department of Commerce, DOD, DOE, DOI, DOJ, DOT, Environmental Protection Agency, HHS, NASA, NSF, and USDA.

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