CHAPTER 7

Science and Technology: Public Attitudes and Understanding

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Highlights

Interest, Information Sources, and Involvement

About 4 out of 10 Americans say they are "very interested" in new scientific discoveries, and 6 out of 10 Americans say they are "very interested" in new medical discoveries.

- Other science-related issues also interest many Americans, with 4 in 10 interested in environmental pollution and in the use of new inventions and technologies.

The Internet continues to grow as Americans' primary source for science news and information seeking.

- The Internet has become Americans' primary source of science and technology (S&T) information, with more than 5 in 10 Americans citing it as their primary source in 2016, compared with about 1 in 10 in 2001.
- Television and newspapers continued to be used less often as sources of S&T news and information in 2016.

Americans' attendance at traditional informal science sites is down or stable in recent years.

- About 5 in 10 Americans said they had visited a zoo or aquarium in 2016, similar to 2012 but down from nearly 6 in 10 in 2001.
- Smaller percentages of Americans, about 3 in 10, said they had visited a natural history museum in 2016 compared to previous years, and a similar proportion said they had visited an S&T center.

Public Knowledge about S&T

Americans correctly answered an average of 5.6 of 9 factual knowledge questions in 2016, a score similar to those in recent years.

- Americans with more formal education tend to provide a greater number of correct answers on science knowledge questions.
- About half of Americans agreed that human beings "developed from earlier species of animals," the highest percentage seen for this question since 2001. Younger generations are more likely to answer the evolution question correctly.

About 6 in 10 Americans continue to correctly answer two multiple-choice questions dealing with probability in the context of medical treatment.

- About half of Americans could describe the best way to conduct a drug trial.
- About 3 in 10 Americans said they had a clear understanding of what is meant by a "scientific study" in 2016.

Public Attitudes about S&T in General

Public support for science appears to be stable. Americans continue to perceive far more benefits than harms from science and want government to fund scientific research.

- Most Americans, about 7 in 10, say they believe the benefits from science are greater than the harms, and almost all agree that S&T will create more opportunities for future generations.
- About half of Americans express concern that science is making life “change too fast.” This is similar to past highs.
- More than 8 in 10 Americans continue to say the government should fund basic scientific research, and about 4 in 10 continue to say we are spending “too little” to support such research.

Americans are more likely to have “a great deal of confidence” in leaders of the scientific community than in leaders of any group except the military.

- About 4 in 10 Americans express high levels of confidence in the scientific community, and more than 9 in 10 agree that scientists are helping to solve challenging problems facing the world.
- Since 2001, the percentage of Americans “strongly” agreeing that scientists are solving problems has risen from fewer than 2 in 10 Americans to almost 3 in 10.
- Although the medical community remains the third most respected group in America, the percentage of respondents who express “a great deal of confidence” in it has decreased (alongside confidence in most other institutions) since the 1970s and is now at a low of 36%.

Public Attitudes about Specific S&T-Related Issues

While Americans express less personal interest in the topic of environmental pollution, there is increasing concern about many specific environmental issues.

- Stated personal interest in environmental pollution has slowly declined since 1990, when more than 6 in 10 Americans said they were “very interested” in the topic. Only about 4 in 10 Americans gave this response in 2016.
- Despite the relatively low interest in the topic of environmental pollution in general, concern about specific environmental issues was high in 2016. Almost 8 in 10 Americans say they see water pollution as “extremely” or “very dangerous,” and more than 7 in 10 Americans say they see industrial air pollution as “extremely” or “very dangerous.” (Note that level of interest and level of concern are not necessarily equivalent. Individuals can be concerned about a particular issue but not be highly interested in that topic, especially in cases in which the topic has been on the public agenda for many years.)
- Levels of perceived danger from water and industrial pollution are substantially higher than they were in previous surveys.

Americans are divided on the severity and cause of climate change but concern has returned to previous highs.

- More than 6 in 10 Americans said they worried a “great deal” (45%) or a “fair amount” (21%) about “global warming.” Similar high levels of worry occurred in the early to mid-2000s.
- The highest recorded proportion of Americans ever—more than 6 in 10—say they believe that “global warming” is likely caused by humans.

- While 7 in 10 Americans recognize that "most" scientists believe warming is due to human activities, fewer than 2 in 10 know that almost all climate scientists attribute warming to human activity.
- Fewer than half of Americans think that "global warming" will pose a serious threat during their lifetime.

When given the choice, a majority of Americans say they would prefer to focus on non-fossil fuel alternatives.

- About 6 in 10 Americans say they would prioritize conservation over fossil fuel development; about 7 in 10 would focus on alternative energy over fossil fuel development.
- About 6 in 10 Americans in 2010 said they supported nuclear energy as one way to provide electricity in the United States. By 2016, about 4 in 10 expressed this view.

A substantial minority of Americans think genetically engineered foods are not safe, despite scientific consensus that such foods are no more dangerous than other foods.

- A recent consensus report by the National Academies of Sciences, Engineering, and Medicine concluded there is no substantiated evidence that current foods with genetically engineered ingredients are less safe than other foods.
- Despite the scientific consensus, more than 4 in 10 Americans say that "modifying genes" in crops is "extremely" or "very dangerous," a percentage that is higher than previous surveys. About 4 in 10 Americans also see genetically modified foods as less safe than other foods.

Many Americans view using stem cells from human embryos in medical research as "morally acceptable."

- Six in 10 Americans (60%) see using stem cells from human embryos as acceptable. This number has been relatively stable in recent years but is higher than earlier surveys.

Americans' views about animal testing have become less favorable over time.

- Gallup found that about 5 in 10 Americans now see animal testing as morally acceptable, down from more than 6 in 10 in 2010.

Introduction

Chapter Overview

The advancement and use of science and technology (S&T) are central to American life; S&T shapes what we do at home, at work, and in our communities. Many Americans produce new S&T at work (see Chapter 3), while others use S&T-based innovations to produce the goods and services that improve and reshape our lives. S&T gives us new opportunities to get healthy and stay healthy, including by influencing what and how we eat. It provides technologies that keep us connected and entertained. S&T often enters our conversations about daily life decisions and may stimulate us intellectually and emotionally. The centrality of S&T to American life means that Americans' attitudes about and understanding of S&T can reflect and affect the country's culture, well-being, and economy.

All technologies involve risks and benefits that may take time to become apparent. S&T discussions often center on these potential risks and benefits, as well as on moral issues raised by adopting scientific processes and technologies. Societies can do a better job of addressing potential concerns when the nature of these concerns is well understood and discussed (e.g., [NRC 1996, 2008]; [NASEM 2016a]). Americans' desire to seek potential benefits from S&T and deal with potential risks may affect what kinds of S&T are developed or used. For example, Americans must collectively decide how much of society's resources to devote to S&T research and development and where to devote those resources. Individuals may also choose where to focus their careers based on both their personal interests and their understanding of where they can make a meaningful contribution. Family members can also make decisions that may shape what young people learn, think, and feel about science.

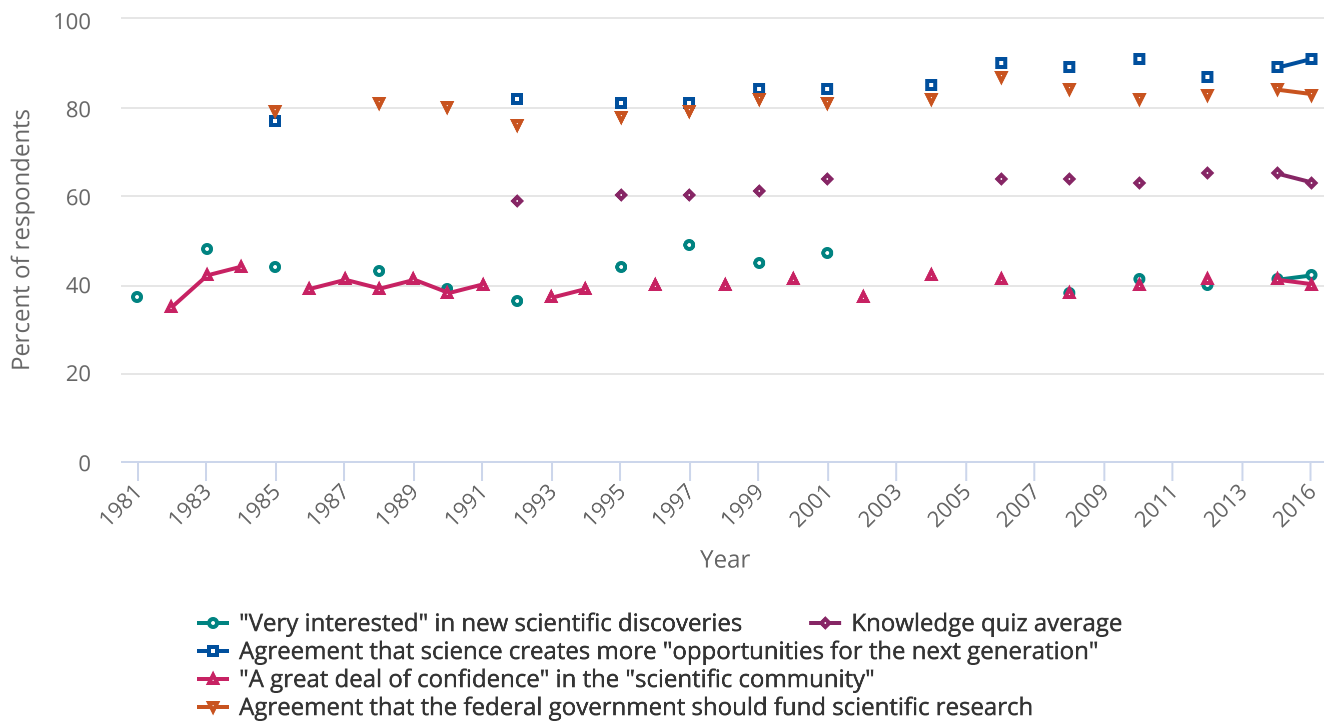
Given the centrality of S&T to the United States, this chapter presents indicators about interest in S&T news, where people encounter S&T in the media, trend data regarding knowledge of S&T, and indicators of people's attitudes about S&T-related issues. To put U.S. data in context, the chapter examines trend indicators for past years and comparative indicators for other countries, where reliable data are available.

A review of five key indicators in this chapter—interest in new scientific discoveries, basic scientific knowledge, belief that science creates opportunity, confidence in the scientific community, and support for science funding—indicates that Americans' overall attitudes about science are generally stable or becoming more positive, with some small fluctuations. The key indicators were chosen because data are available for a relatively long period for each indicator and because the indicators reflect the main themes raised in the chapter. Looking at these indicators together provides a sense of how Americans' overall attitudes and knowledge about S&T have changed over more than 30 years.

Specifically, the percentage of Americans saying that they are "very interested" in new scientific discoveries has been relatively stable in recent years, although the percentage is lower than in previous decades. Similarly, Americans' basic knowledge of science has also grown slightly over time. The percentages agreeing that S&T creates new opportunities and that it is important to fund scientific research have also been at relatively high levels in recent years compared with those from previous highs (Figure 7-1). Each of these five indicators is associated with education level, whether measured in terms of highest degree earned (Figure 7-2) or science- and math-specific courses taken in high school and college. In contrast, respondents' age and sex are generally unrelated or weakly related to these types of key indicators (Figure 7-2).

FIGURE 7-1

Key science and engineering knowledge and attitude indicators: 1981–2016



Note(s)

Data are not available for all knowledge and attitude indicators for all years. Includes the responses "strongly agree" and "agree" to the following statements: *Agreement that science creates more "opportunities for the next generation"* and *Agreement that the federal government should fund scientific research.* Data present the percentage of respondents who expressed a particular view, except in the case of the knowledge quiz average, which shows the estimated average percent of correct answers in each year.

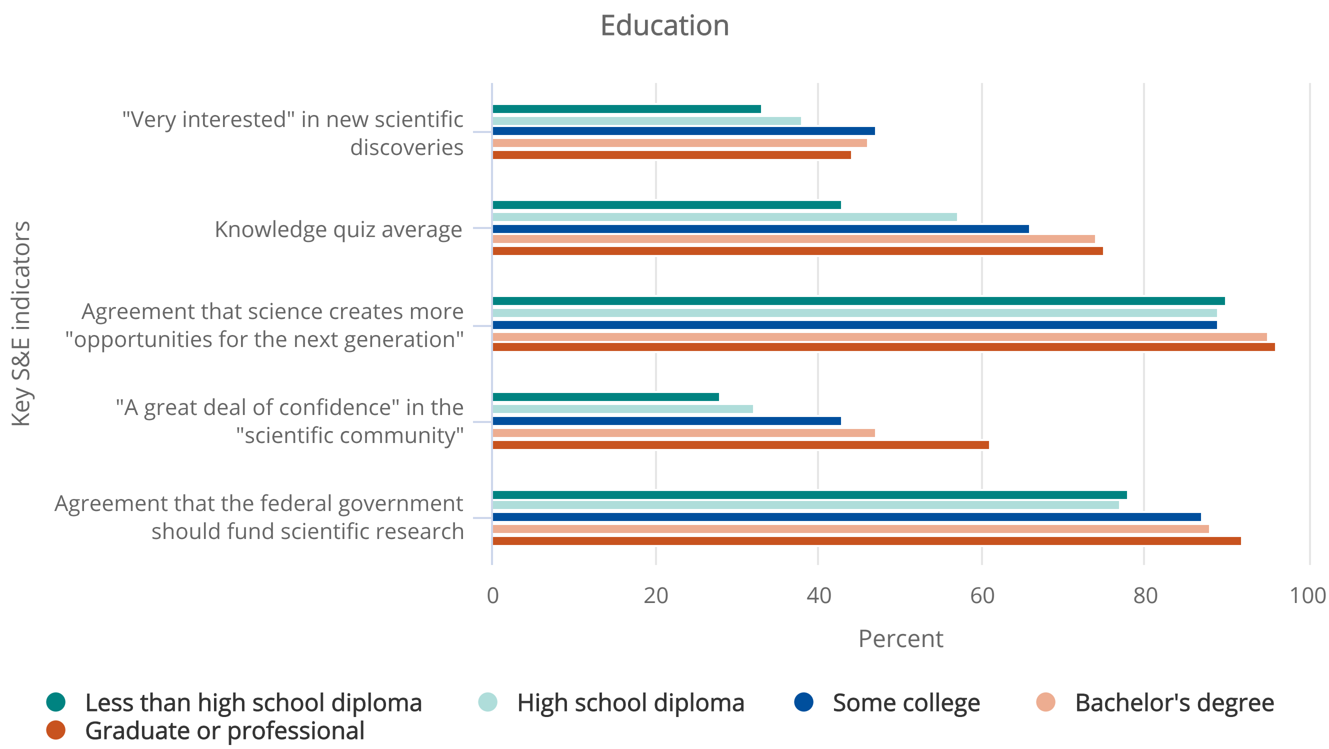
Source(s)

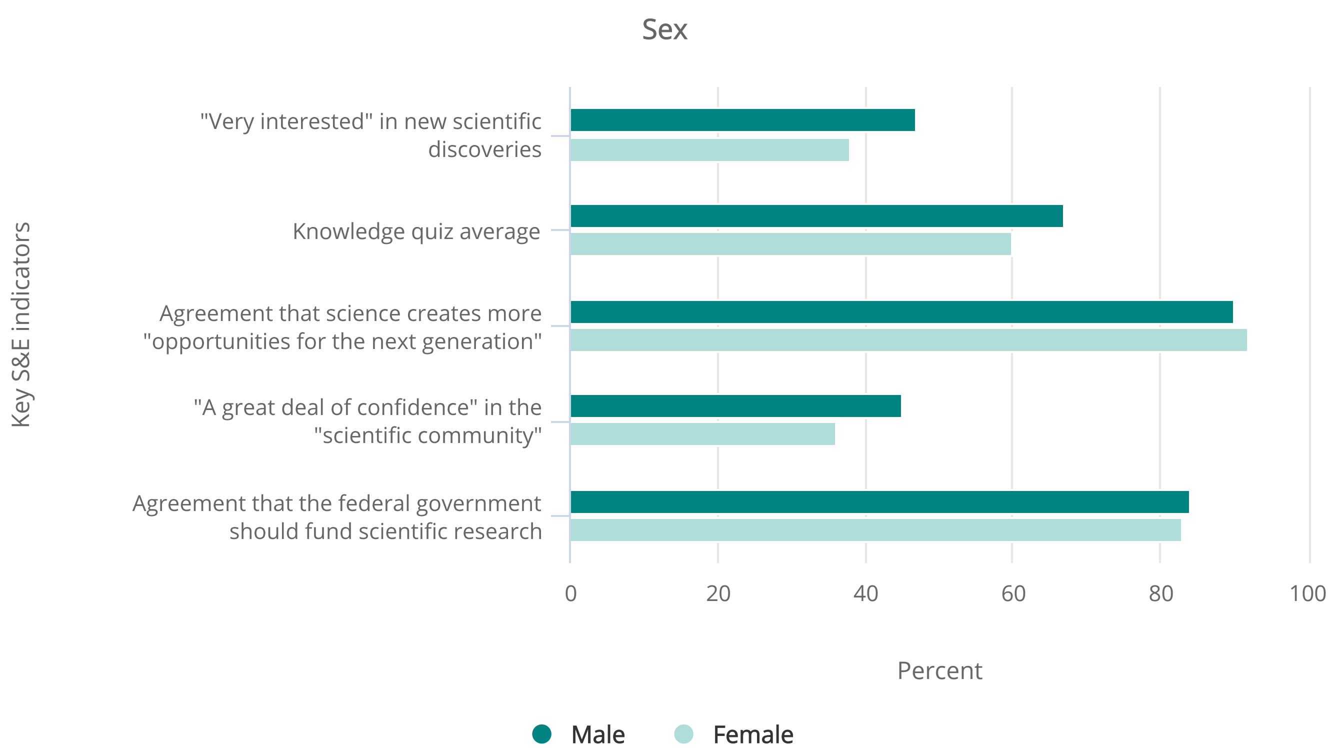
National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1981–2001); University of Michigan, Survey of Consumer Attitudes (2004); NORC at the University of Chicago, General Social Survey (2006–16). See Appendix Tables 7-1, 7-8, 7-18, 7-22, and 7-28.

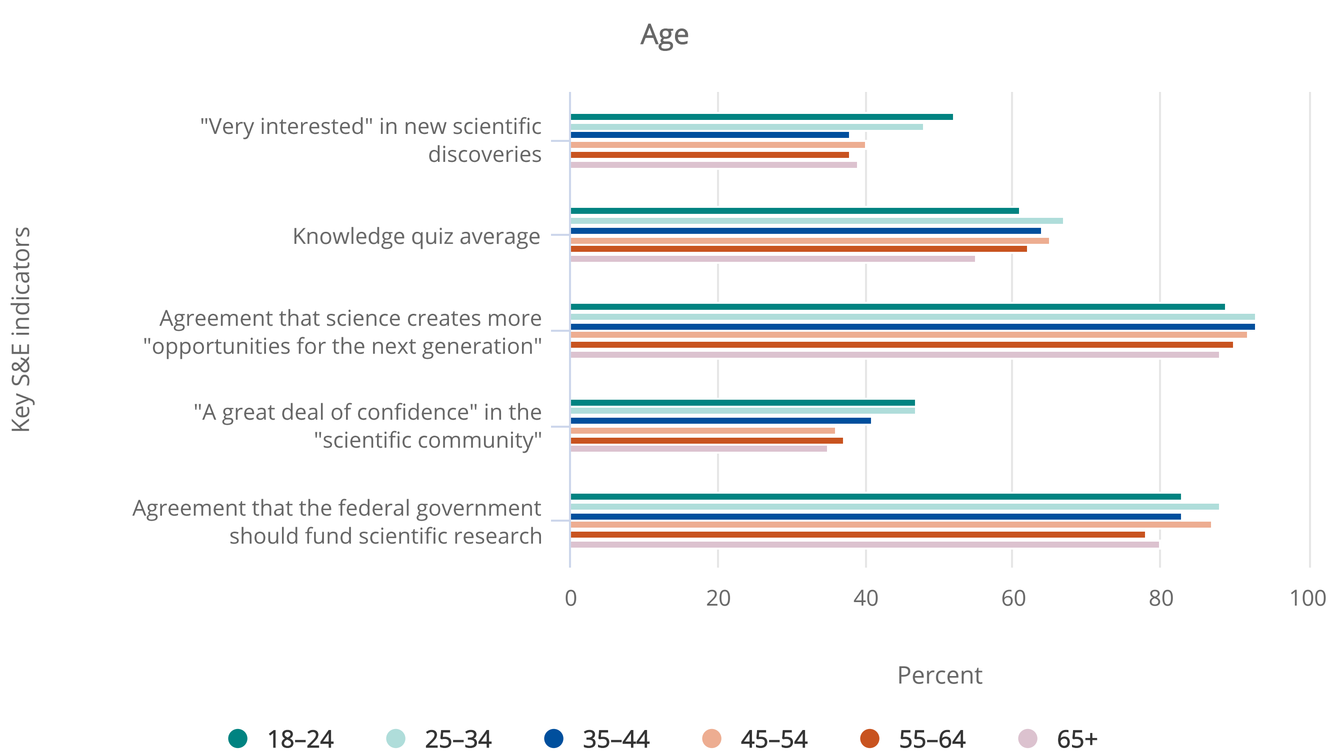
Science and Engineering Indicators 2018

FIGURE 7-2

Key science and engineering indicators, by selected respondent education, sex, and age: 2016




Sex
"Very interested" in new scientific discoveries
Knowledge quiz average
Agreement that science creates more "opportunities for the next generation"
"A great deal of confidence" in the "scientific community"
Agreement that the federal government should fund scientific research
Key S&E indicators
0
20
40
60
80
100
Percent
Male
Female


Age
"Very interested" in new scientific discoveries
Knowledge quiz average
Agreement that science creates more "opportunities for the next generation"
"A great deal of confidence" in the "scientific community"
Agreement that the federal government should fund scientific research
Key S&E indicators
0
20
40
60
80
100
Percent
18–24
25–34
35–44
45–54
55–64
65+

Note(s)

Includes the responses "strongly agree" and "agree" to the following statements: *Agreement that science creates more "opportunities for the next generation"* and *Agreement that the federal government should fund scientific research.*

Source(s)

NORC at the University of Chicago, General Social Survey (2016). See Appendix Tables 7-1, 7-10, 7-18, 7-21, and 7-29.

Science and Engineering Indicators 2018

Chapter Organization

The chapter is divided into four main sections. The first includes indicators of the public's ongoing engagement with S&T, including interest in S&T news, sources of information on S&T, and involvement in informal S&T activities. The second section reports on indicators of public knowledge, including trend measures of factual knowledge of S&T and people's understanding of the scientific process. The second section also includes results of survey experiments designed to better understand how question wording affects responses to knowledge questions on controversial issues. The third section presents data on attitudes indicating public support for S&T in general, including support for government funding of basic research and confidence in the leadership of the scientific community. The fourth section addresses attitudes on public issues in which S&T plays an important role, such as the environment, climate change, energy, nuclear power, and the use of animals in scientific research. It also includes indicators of public opinion about several active lines of research and new technologies, including genetically engineered food, stem cell research, and cloning.

A Note about Data and Terminology

The chapter emphasizes trends, patterns of variation within the U.S. population, and comparisons between public opinion in the United States and in other countries or regions. It reviews survey data from national samples with sound, representative sampling designs. The text focuses on the trends and demographic patterns in the data. Where possible, the focus is on new or updated data released since publication of *Science and Engineering Indicators 2016*.

The biennial General Social Survey (GSS), sponsored by the National Science Foundation (NSF), is a major source of data for this chapter. The GSS is a nationally representative, face-to-face survey on the attitudes and the behaviors of the U.S. population. The data are weighted to ensure representativeness. Questions about S&T information, knowledge, and attitudes were added to the GSS by NSF beginning in 2006. Comparable survey data were collected by telephone for NSF between 1982 and 2004. As with the GSS, data collected for NSF prior to 1982 come from face-to-face interviews. The changes in data collection methods over these years may affect comparisons over time. Such situations are highlighted in the text.

A range of other data sources is also used in the chapter, although only surveys involving probability-based samples are included. The primary sources of additional U.S. data include Gallup and the Pew Research Center. Like all survey data, the results reported in this chapter are subject to many sources of error—such as sampling error, response error, and measurement error due to question wording and random variation—that should be kept in mind when interpreting the findings. This report exercises caution in interpreting results from surveys that omit portions of the target population, have low response rates, or have topics that are particularly sensitive to subtle differences in question wording. Only differences that are statistically unlikely to have occurred by chance and that are substantive are emphasized in this chapter. The GSS typically uses face-to-face interviews, but most of the data from groups such as Gallup and the Pew Research Center use telephone samples (including both landlines and mobile phones) that inherently exclude those without telephones. The only Internet-based surveys used in the chapter are those collected by GfK and the Pew Research Center, both of which choose their panel members based on techniques similar to the telephone samples used by other organizations. For these, probability-based sampling typically is done using telephone and mail to invite people to be part of the panel, and then respondents are probabilistically selected for individual surveys. The additional step means that response rates are often lower than high-quality telephone surveys. Nevertheless, face-to-face surveys are believed to be the best way to obtain high response rates and to maximize participation by respondents with low income or education levels who may be less likely to respond to other types of surveys (see sidebar U.S. Survey Data Sources and sidebar International Survey Data Sources).

SIDEBAR

U.S. Survey Data Sources

Table 7-A below describes U.S. surveys used in this chapter.

TABLE 7-A

U.S. survey data sources

(Data sources, selected details)

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
Muhlenberg College and University of Michigan	National Surveys on Energy and Environment	2009–13, 2016–17	Climate change	Telephone interviews	*n* = 841 to 988; ±3% to 3.5%
National Science Foundation	Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan Survey of Consumer Attitudes (2004)	1979–2001, 2004	Information sources, interest, visits to informal science institutions, general attitudes, government spending attitudes, science and mathematics education attitudes, animal research attitudes	Telephone interviews	*n* = 1,574 to 2,041; ±2.47% to 3.03%
NORC at the University of Chicago	General Social Survey (GSS)	1973–2016	Government spending attitudes, confidence in institutional leaders	Face-to-face interviews, supplemented by telephone interviews	Government spending (2000–16): *n* = 1,390 to 2,256; ±2.5% to 3.9% Confidence in institutional leaders (1973–2016): *n* = 876 to 3,278; ±2.5% to 4.4%
NORC at the University of Chicago	GSS science and technology module	2006, 2008, 2010, 2012, 2014, 2016	Information sources, interest, visits to informal science institutions, general attitudes, government spending attitudes, science and mathematics education attitudes, animal research attitudes, nanotechnology awareness and attitudes, science knowledge	Face-to-face interviews, supplemented by telephone interviews	*n* = 1,864 to 2,256; ±2.5% to 3.3%

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
National Survey of American Public Opinion on Climate Change	American Belief in Climate Change	2012	Climate change	Telephone interviews	*n* = 726; ±4.0%
Gallup Organization	Various ongoing surveys	1982–2017	Federal priorities, environmental protection, climate change, global warming, nuclear power, alternative energy, animal research, stem cell research, quality of science and mathematics education in U.S. public schools attitudes	Telephone interviews	*n* = ~1,000; ±3.0% to 4.0%
Pew Research Center for the People and the Press	General Public Science Survey, separate survey of American Association for the Advancement of Science members	2014	Public's and scientists' beliefs about science- and technology-related issues, benefits of science to well-being of society, animal research attitudes	Telephone interviews (survey of general public)	Public: *n* = 2,002; ±3.1% Scientists: *n* = 3,478; ±1.7%
Pew Research Center for the People and the Press	Media and political surveys (various)	1985–2016	Information sources, Internet use, national policy attitudes (environment, global warming, energy, stem cell research), government spending for scientific research attitudes, views of the news media, media believability	Telephone interviews	*n* = ~1,000 to 5,122; ±1.6% to 4.0%

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
Yale Project on Climate Change Communication and the George Mason University Center for Climate Change Communication	Climate Change in the American Mind	2008–16	Climate change	Online (probability-based sample)	*n* = 1,010 to 2,164; ±3.0%

Note(s)

All surveys are national in scope and based on probability sampling methods. Statistics on the number of respondents and margin of error are as reported by the sponsoring organization. When a margin of error is not cited, none was given by the sponsor.

Science and Engineering Indications 2018

SIDEBAR

International Survey Data Sources

Table 7-B below describes international surveys used in this chapter.

TABLE 7-B

International survey data sources

(Data sources, selected details)

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
British Council, Russia	Survey of Public Attitudes Toward Science and Technology in Russia	2003	Various knowledge items	Paper questionnaires	*n* = 2,107
Council of Canadian Academies	Public Survey of Science Culture in Canada	2013	Various knowledge and attitude items, engagement, science skills	Landline and mobile phone (60%); Internet (40%)	*n* = 2,004; ±2.2%
Chinese Association for Science and Technology, China Research Institute for Science Popularization	Chinese National Survey of Public Scientific Literacy	2001, 2007, 2010, 2015	Various knowledge and attitude items, interest, occupational prestige, visits to informal science institutions	Face-to-face interviews	2001: *n* = 8,350 2007: *n* = 10,059 2010: *n* = 68,416 2015: *n* = 70,400
European Commission	Special Eurobarometer 224/ Wave 63.1: *Europeans, Science and Technology* (2005)	2005	Knowledge, trust in scientists, public support for basic research, other attitudes, visits to informal science institutions	Face-to-face interviews	*n* = 24,896 (EU total; member states: Austria: 1,034, Belgium: 1,024, Cyprus: 504, Czech Republic: 1,037, Denmark: 1,013, Estonia: 1,000, Finland: 1,007, France: 1,021, Germany: 1,507, Greece: 1,000, Hungary: 1,000, Ireland: 1,008, Italy: 1,006, Latvia: 1,034, Lithuania: 1,003, Luxembourg: 518, Malta: 500, Netherlands: 1,005, Poland: 999, Portugal: 1,009, Slovakia: 1,241, Slovenia: 1,060, Spain: 1,036, Sweden: 1,023, United Kingdom: 1,307)

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
	Special Eurobarometer 224b/ Wave 64.3: *Europeans and Biotechnology in 2005: Patterns and Trends* (2006)	2005	Biotechnology attitudes	Face-to-face interviews	*n* = ~25,000; (EU total; member states: Austria: ~1,000, Belgium: ~1,000, Cyprus: ~1,000, Czech Republic: ~1,000, Denmark: ~1,000, Estonia: ~1,000, Finland: ~1,000, France: ~1,000, Germany: ~1,000, Greece: ~1,000, Hungary: ~1,000, Ireland: ~1,000, Italy: ~1,000, Latvia: ~1,000, Lithuania: ~1,000, Luxembourg: ~1,000, Malta: ~1,000, Netherlands: ~1,000, Poland: ~1,000, Portugal: ~1,000, Slovakia: ~1,000, Slovenia: ~1,000, Spain: ~1,000, Sweden: ~1,000, United Kingdom: ~1,000)
	Special Eurobarometer 300/ Wave 69.2: *Europeans' Attitudes Towards Climate Change* (2008)	2008	Climate change attitudes	Face-to-face interviews	*n* = ~26,661 (EU total; member states: Austria: 1,000, Belgium: 1,003, Bulgaria: 1,000, Cyprus: 504, Czech Republic: 1,014, Denmark: 1,005, Estonia: 1,006, Finland: 1,004, France: 1,040, Germany: 1,534, Greece: 1,000, Hungary: 1,000, Ireland: 1,004, Italy: 1,022, Latvia: 1,008, Lithuania: 1,021, Luxembourg: 501, Malta: 500, Netherlands: 1,041, Poland: 1,000, Portugal: 1,001, Romania: 1,019, Slovakia: 1,085, Slovenia: 1,003, Spain: 1,033, Sweden: 1,007, United Kingdom: 1,306)

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
	Special Eurobarometer 340/ Wave 73.1: *Science and Technology Report* (2010)	2010	Science and technology attitudes and interest, support for basic research, animal research attitudes	Face-to-face interviews	*n* = ~26,671 (EU total; member states: Austria: 1,000, Belgium: 1,012, Bulgaria: 1,009, Cyprus: 502, Czech Republic: 1,043, Denmark: 1,006, Estonia: 1,004, Finland: 1,001, France: 1,018, Germany: 1,531, Greece: 1,000, Hungary: 1,017, Ireland: 1,007, Italy: 1,018, Latvia: 1,013, Lithuania: 1,026, Luxembourg: 503, Malta: 500, Netherlands: 1,018, Poland: 1,000, Portugal: 1,027, Romania: 1,060, Slovakia: 1,030, Slovenia: 1,004, Spain: 1,004, Sweden: 1,007, United Kingdom: 1,311)
	Special Eurobarometer 341/ Wave 73.1: *Europeans and Biotechnology in 2010: Winds of Change?* (2010)	2010	Nuclear energy, nanotechnology, emerging biotechnologies, synthetic biology, and genetically engineered foods attitudes	Face-to-face interviews	*n* = ~26,671 (EU total; member states: Austria: 1,000, Belgium: 1,012, Bulgaria: 1,009, Cyprus: 502, Czech Republic: 1,043, Denmark: 1,006, Estonia: 1,004, Finland: 1,001, France: 1,018, Germany: 1,531, Greece: 1,000, Hungary: 1,017, Ireland: 1,007, Italy: 1,018, Latvia: 1,013, Lithuania: 1,026, Luxembourg: 503, Malta: 500, Netherlands: 1,018, Poland: 1,000, Portugal: 1,027, Romania: 1,060, Slovakia: 1,030, Slovenia: 1,004, Spain: 1,004, Sweden: 1,007, United Kingdom: 1,311)

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
	Special Eurobarometer 401/ Wave 6: *Responsible Research and Innovation (RRI) Science and Technology* (2013)	2013	Research, innovation, science, and technology attitudes	Face-to-face interviews	*n* = ~27,563 (EU total; member states: Austria: 1,022, Belgium: 1,000, Bulgaria: 1,018, Croatia: 1,000, Cyprus: 505, Czech Republic: 1,000, Denmark: 1,004, Estonia: 1,003, Finland: 1,003, France: 1,027, Germany: 1,499, Greece: 1,000, Hungary: 1,033, Ireland: 1,002, Italy: 1,016, Latvia: 1,006, Lithuania: 1,027, Luxembourg: 505, Malta: 500, Netherlands: 1,019, Poland: 1,000, Portugal: 1,015, Romania: 1,027, Slovakia: 1,000, Slovenia: 1,017, Spain: 1,003, Sweden: 1,006, United Kingdom: 1,306)
	Special Eurobarometer 419/ Wave 6: *Public Perceptions of Science, Research, and Innovation* (2014)	2014	Science, research, and innovation public attitudes	Face-to-face interviews	*n* = ~27,910 (EU total; member states: Austria: 1,005, Belgium: 1,025, Bulgaria: 1,033, Cyprus: 503, Croatia: 1,010, Czech Republic: 1,100, Denmark: 1,004, Estonia: 1,012, Finland: 1,017, France: 1,018, Germany: 1,511, Greece: 1,012, Hungary: 1,060, Ireland: 1,006, Italy: 1,014, Latvia: 1,016, Lithuania: 1,013, Luxembourg: 501, Malta: 501, Netherlands: 1,030, Poland: 1,082, Portugal: 1,009, Romania: 1,020, Slovakia: 1,007, Slovenia: 1,034, Spain: 1,009, Sweden: 1,050, United Kingdom: 1,308)
Gerbert Ruf Foundation, Mercator Foundation Switzerland, University of Zurich	Wissenschaftsbarometer	2016	Scientific knowledge, information sources	Telephone interviews	*n* = 1,000

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
India National Council of Applied Economic Research	National Science Survey	2004	Various knowledge and attitude items, visits to informal science institutions	Face-to-face interviews	*n* = 30,255
Israeli Ministry of Science, Technology and Space	Perceptions and attitudes of the Israeli public about science, technology and space	2016	Various knowledge and attitude items	Online (Hebrew speakers); telephone interviews (Arabic speakers)	*n* = 501; ±4.4%
Japan Science and Technology Agency, Research Institute of Science and Technology for Society	Survey of Scientific Literacy	2011	Various knowledge items	Internet survey and interviews	*n* = 812 to 984
Korea Foundation for the Advancement of Science and Creativity (formerly Korea Science Foundation)	Survey of Public Attitudes Toward and Understanding of Science and Technology	2004, 2006, 2008, 2012	Interest, various knowledge and attitude items, visits to informal science institutions	Face-to-face interviews	*n* = 1,000; ±3.1%
Malaysian Science and Technology Information Center, Ministry of Science, Technology and Innovation	Survey of the Public's Awareness of Science and Technology: Malaysia	2014	Interest, awareness, various knowledge and attitude items, visits to informal science institutions	Face-to-face interviews	*n* = 2,653; ±2.71%

Sponsoring organization	Title	Years used	Questions used	Data collection method	Number of respondents; margin of error of general population estimates
Pew Global Attitudes Project, Pew Research Center	Global Attitudes Survey	2013	Climate change concerns	Depending on country, face-to-face interviews, telephone interviews	*n* = 1,002 (United States); ±3.5% *n* = 700 to 3,226 (38 other countries); ±3.1% to 7.7%
Wellcome Trust	Wellcome Trust Monitor	2015	UK public's interest in and attitudes towards biomedical science	Face-to-face interviews	*n* = 1,524

EU = European Union; UK = United Kingdom.

Note(s)

All surveys are national in scope and based on probability sampling methods. Statistics on the number of respondents and margin of error are as reported by the sponsoring organization. When a margin of error is not cited, none was given by the sponsor.

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Another important limitation is that up-to-date, high-quality data are not always available. In some cases, there are only single surveys covering a particular period, large gaps between data collection years, or only a small number of questions on any given topic. This challenge is particularly acute when it comes to international data. There have been many surveys on S&T in Europe, but these are not conducted as regularly as the GSS, and data from Africa and South America are especially rare. As noted, the current chapter focuses on data that have become available after the preparation of the 2016 *Indicators* report. Earlier data can be found in past editions of *Indicators* (e.g., [NSB 2016]). A summary is also available in Bauer, Shukla, and Allum (2012) of relevant data (up to 2006) from numerous countries and regions. Moreover, even in cases in which international comparisons attempt to compare identical questions, the responses may not be wholly comparable because of cultural differences in the meaning of the questions.

Throughout this chapter, the terminology used in the text reflects the wording in the corresponding survey questions. In general, survey questions asking respondents about their primary sources of information, interest in issues in the news, and general attitudes use the phrase *science and technology*. Thus, *S&T* is used when discussing these data. Survey questions asking respondents about their confidence in institutional leaders, the prestige of occupations, and their views on different disciplines use terms such as *scientific community*, *scientists*, *researchers*, and *engineers*, so *science and engineering* (*S&E*) is used when appropriate for examining issues related to occupations, careers, and fields of research. Although science and engineering are distinct fields, national survey data that make this distinction are scarce (see, however, [NSB 2014:7-35]). The term *Americans* is used throughout to refer to U.S. residents included in a national survey; equivalent terms (e.g., *Canadians*) are used for residents of other countries. However, not all respondents were necessarily citizens of the countries in which they were surveyed. When discussing data collected on behalf of NSF, the term *recent* is used to refer to surveys conducted since 2006, when data collection shifted to the GSS.

Interest, Information Sources, and Involvement

Trends in Americans' understanding of and attitudes about topics such as S&T depend, in part, on how much exposure they get to such content throughout their lives, as well as how much attention they pay to such content (Slater, Hayes, and Ford 2007). Exposure and attention to S&T can make residents more informed, shape their attitudes, and help them make decisions that are better for themselves, their families, and their communities. Media use may also foster a desire to seek and consider new information (Rimal, Flora, and Schooler 1999). All of these issues are interconnected and are meant to provide indicators of where S&T fits in peoples' lives.

This section reviews overall expressed interest in media reports about S&T and where the public turns to within the news media when looking for S&T information. It concludes with indicators of personal involvement in S&T-related activities through visits to museums and other cultural institutions.

Public Interest in S&T

U.S. Patterns and Trends

Most Americans continue to say they are interested in S&T. In 2016, 42% said they were "very interested" in new scientific discoveries, and another 42% said they were "moderately interested" (Figure 7-3). Similarly, 42% said they were "very interested" in use of new inventions and technologies, with 46% "moderately interested." Medical discoveries drew the highest interest: 60% said they were "very interested," and another 35% said they were "moderately interested."

Americans expressed relatively low interest in two other science topics. About a quarter (24%) said they were "very interested" in space exploration (44% "moderately interested"). This puts space exploration near the bottom of the list of subjects asked about in the survey, similar to agricultural and issues (21% "very interested" in 2016). Beyond science, Americans were "very interested" in local school issues (44%), economic issues and business conditions (39%), and military and defense policy (34%).

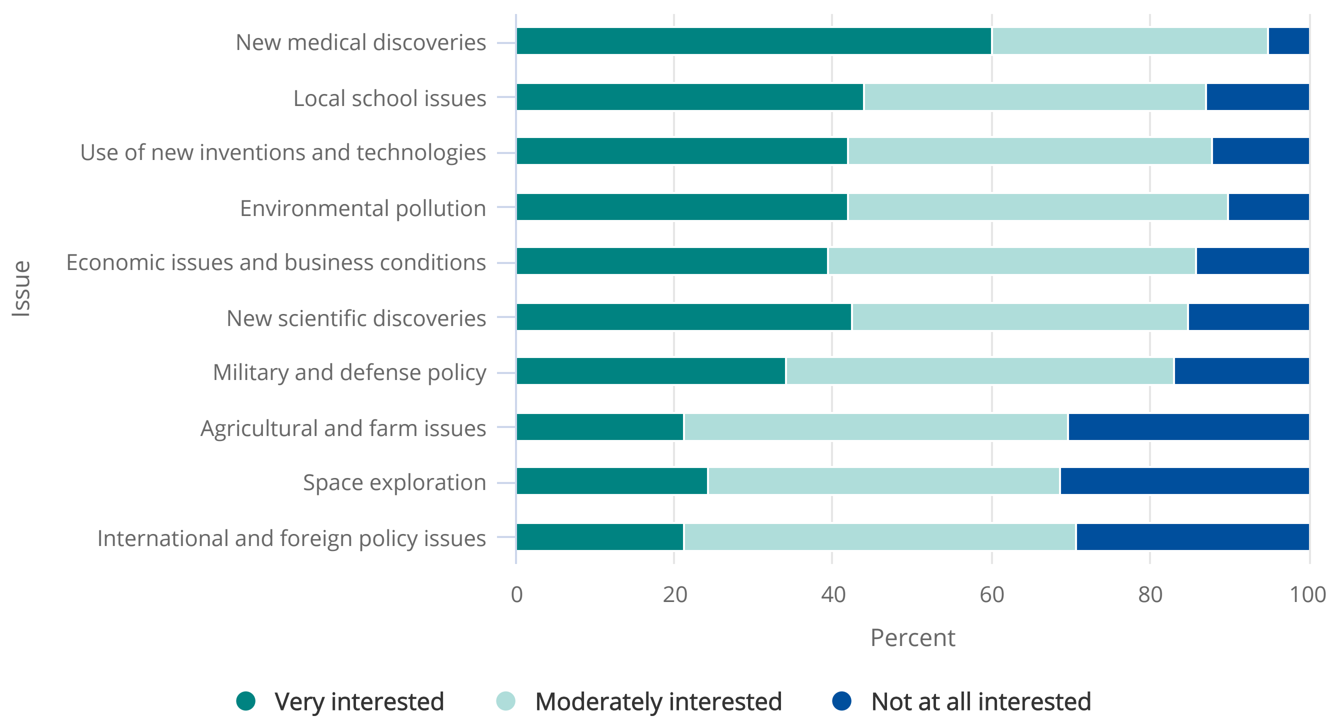
Although generally down from previous highs, science-related interest has been fairly stable in recent years, with the exception of interest in environmental pollution, which has continued a slow decline over several decades (Figure 7-4). In 1990, 64% of respondents said they were "very interested" in the topic of environmental pollution, but this fell to 42% in 2016. Interest in medical discoveries is also lower than it was in previous decades, although it has been relatively stable in recent years (Figure 7-4; Appendix Table 7-1 provides data by selected issues, and Appendix Table 7-2 provides data by demographic groups). It is not clear from the data as to why respondents have been less likely to express interest in environmental pollution over time. In contrast, the discussion of specific environmental issues later in this chapter indicates that concern about the environment is relatively high in historical terms. The term *pollution* may have become less salient as public discussion has turned to issues such as climate change, or the change may have something to do with the fact that environmental pollution may be perceived as a negative topic, whereas the other subjects may be seen as relatively neutral or positive. Also, while interest in environmental pollution has steadily declined, concern about specific environmental issues has gone up and down several times in recent decades. (Note that "level of interest" and "level of concern" are not necessarily equivalent.) Individuals can be concerned about a particular issue but not be highly interested in that topic (or the broader underlying issue), especially in cases in which the topic has been on the public agenda for many years.

Interest in science topics—as with most other topics—is associated with education levels, as well as with mathematics and science course taking. Women tend to be more interested in medical discoveries (63% for women, compared to 55% for men), whereas men are more interested in other S&T topics. For example, 47% of men said they were very interested in new scientific discoveries, compared to 38% of women (Appendix Table 7-2).

Questions about interest may greatly depend on the specific wording used to describe the subject and on the type of response that survey participants are allowed to select. Although new scientific discovery ranks in the middle of a group of issues in the GSS data (42% were "very interested"), a Pew Research Center study (Mitchell et al. 2016) found that only 16% of Americans said they followed news about S&T in the newspaper, on television, radio, or the Internet "very closely." This response was similar to the percentage of Americans who say they followed sports "very closely" but was about half of the number who said they followed government and politics (30%) or crime (27%) "very closely."

FIGURE 7-3

Public interest in selected issues: 2016



Note(s)

Responses to the following: *There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read you a short list of issues, and for each one I would like you to tell me if you are very interested, moderately interested, or not at all interested.* Responses of "don't know" are not shown. Percentages may not add to 100% because of rounding.

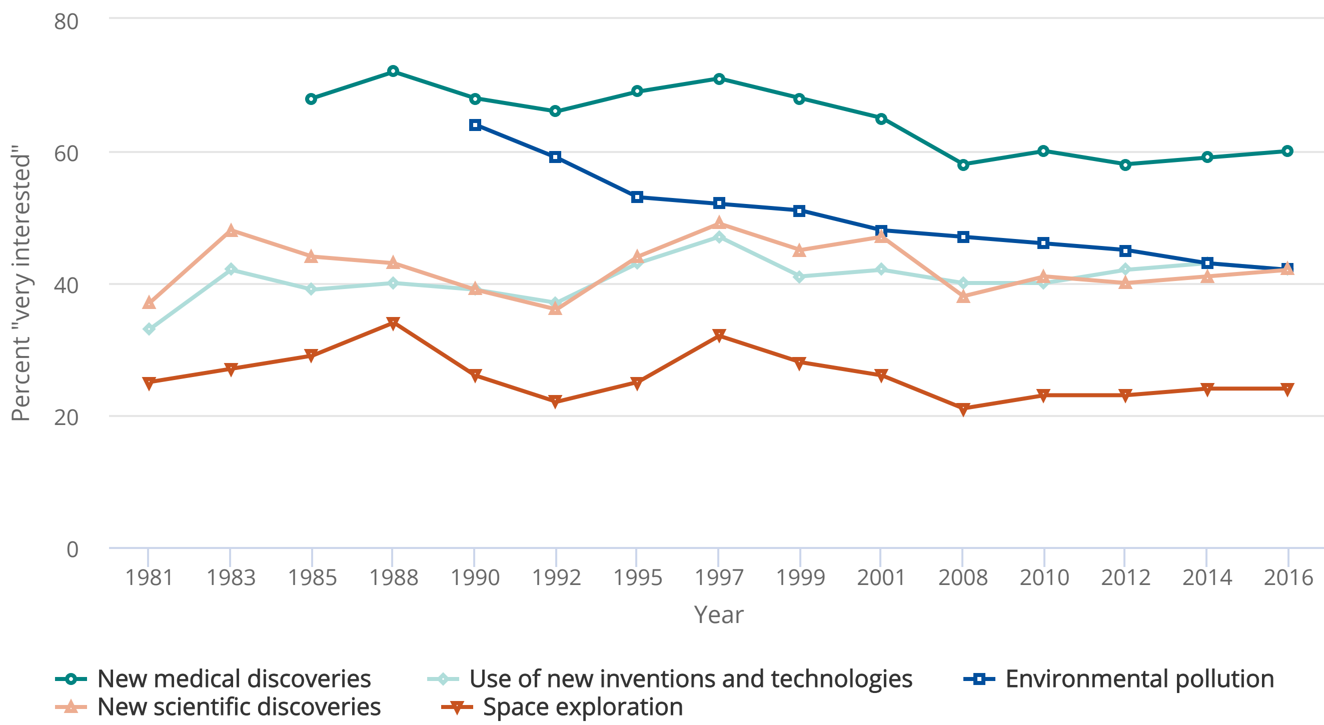
Source(s)

NORC at the University of Chicago, General Social Survey (2016). See Appendix Table 7-1.

Science and Engineering Indicators 2018

FIGURE 7-4

Public interest in selected science-related issues: 1981–2016



Note(s)

Data are not available for all years. Responses to the following: *There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read you a short list of issues, and for each one I would like you to tell me if you are very interested, moderately interested, or not at all interested.* Figure shows only "very interested" responses.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1981–2001); NORC at the University of Chicago, General Social Survey (2008–16). See Appendix Table 7-1.

Science and Engineering Indicators 2018

International Comparisons

Outside of the United States, a majority of residents of other countries for which there are 2015 or 2016 data also typically report high levels of interest in various science topics—particularly, health. Direct comparison is problematic, but the available evidence suggests that the United States often has similar or higher levels of interest in science topics than other countries. In Asia, for example, a large-scale 2015 survey of Chinese respondents found that 93% said they were interested in health topics, which is similar to the 95% of Americans who expressed high or moderate interest. Similarly, 78% of Chinese respondents said they were interested in new scientific discoveries, compared to 84% of Americans who expressed interest. For new inventions and technologies, 75% of Chinese said they were interested in new inventions and technologies, compared to 88% of

Americans who expressed some interest (CRISP 2016). In Europe, expressed interest appears to be lower than in the United States or China. For the United Kingdom (UK), the Wellcome Trust (2016) found that 77% of UK residents said they were interested in medical research, similar to previous years, and 63% of UK residents said they were interested in hearing directly from scientists about the scientists' research. In Germany in 2016, 41% said they had a considerable interest in scientific topics, and an additional 43% of Germans said they had some interest (Wissenschaft im dialog 2016). In Switzerland, about half chose either 5 (20%) or 4 (31%) on a 5-point measure that asked them to describe their interest in science and research as somewhere between "no interest at all" and an "enormous amount of interest" (Schafer and Metag 2016). In northern Europe, about 75% of Finns said they were interested in following news about medicine, 73% said they were interested in general science news, and 68% said they were interested in environmental news (FSSI 2016). Science interest in South America appears to be somewhat lower, with 58% of respondents in Chile saying in 2016 that they were interested in science (CONICYT 2016) and 52% of Argentinians saying that they were interested in S&T. About 70% of Argentinians, however, said they were interested in medicine and health (MCTIP 2015).

Further back, a 2013 pan-European study found that 53% of Europeans were "very interested" or "fairly interested" in S&T versus 87% of Americans, who were "very interested" or "moderately interested." The 27 European countries surveyed display a broad range of interest levels, with a high of 77% in Sweden and lows of 34% and 35% in the Czech Republic and Bulgaria, respectively (European Commission 2013).

S&T Information Sources

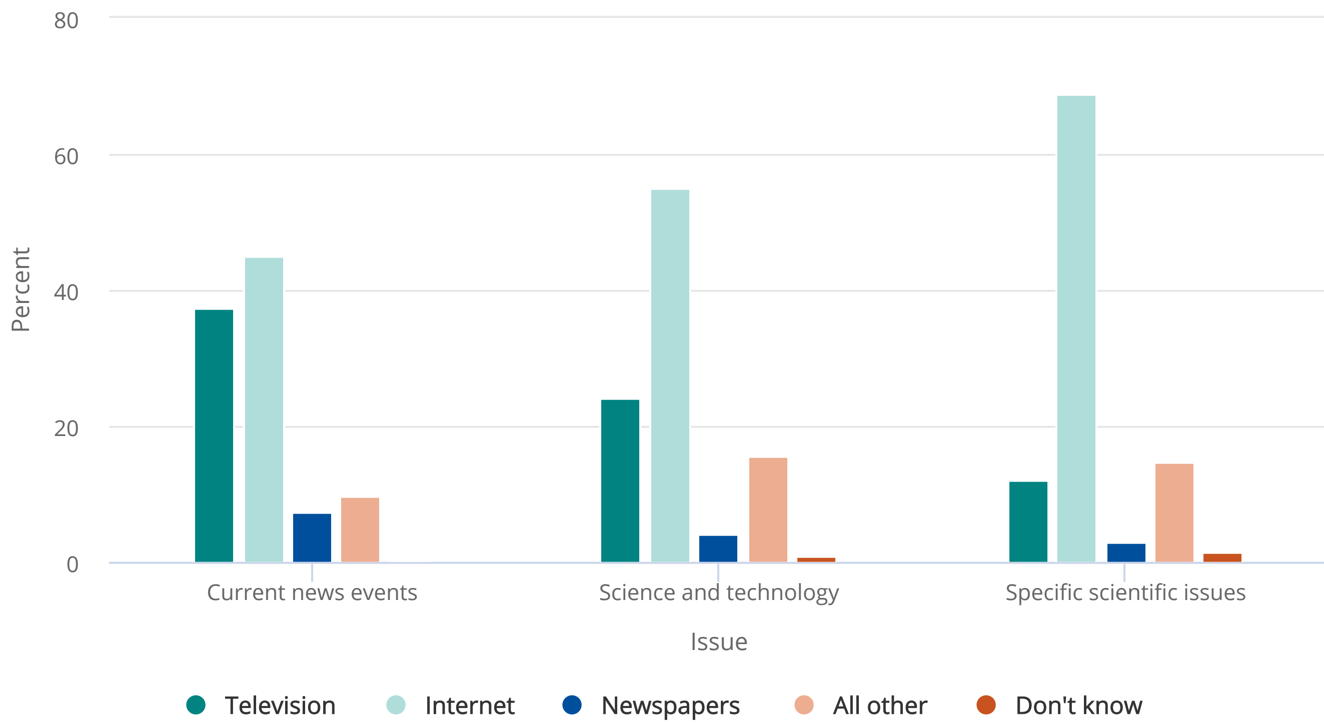
U.S. Patterns and Trends

The news media environment continues to change as new organizations emerge, existing organizations disappear or merge, and journalistic routines change in response to economic, social, and technological forces. The available data show clear trends in the sources Americans say they use to get news about current events and S&T.

As background, according to the GSS data, daily newspaper readership declined from 67% in 1972 to 25% in 2014 and 20% in 2016. The percentage who say they never read a newspaper climbed from about 4% in 1972 to 29% in 2014 and 38% in 2016. The available question does not specifically ask respondents about whether they consider reading a newspaper online when responding to this question; therefore, it is difficult to know if the drop in news readership represents a drop or a shift toward online newspaper reading. Pew Research Center (Mitchell et al. 2016) findings suggest that about three quarters (77%) of Americans follow the national news "very closely" (33%) or "somewhat closely" (44%). This suggests that many Americans continue to get news, though not from traditional print newspapers (Figure 7-5). Also, whereas the GSS reports that newspaper reading has declined, the data suggest that television viewing time has stayed stable in the face of technological change. According to the GSS, Americans said they watched about 2.9 hours of television per day in 2016, and this number has stayed between a low of about 2.8 hours (multiple years) and a high of about 3.2 hours (multiple years) per day since 1975.

FIGURE 7-5

Primary source respondents used to learn about current news events, science and technology, and specific scientific issues: 2016



Note(s)

"All other" includes radio, magazines, books, government agencies, family, and friends or colleagues.

Source(s)

NORC at the University of Chicago, General Social Survey (2016). See Appendix Table 7-3 through Appendix Table 7-5.

Science and Engineering Indicators 2018

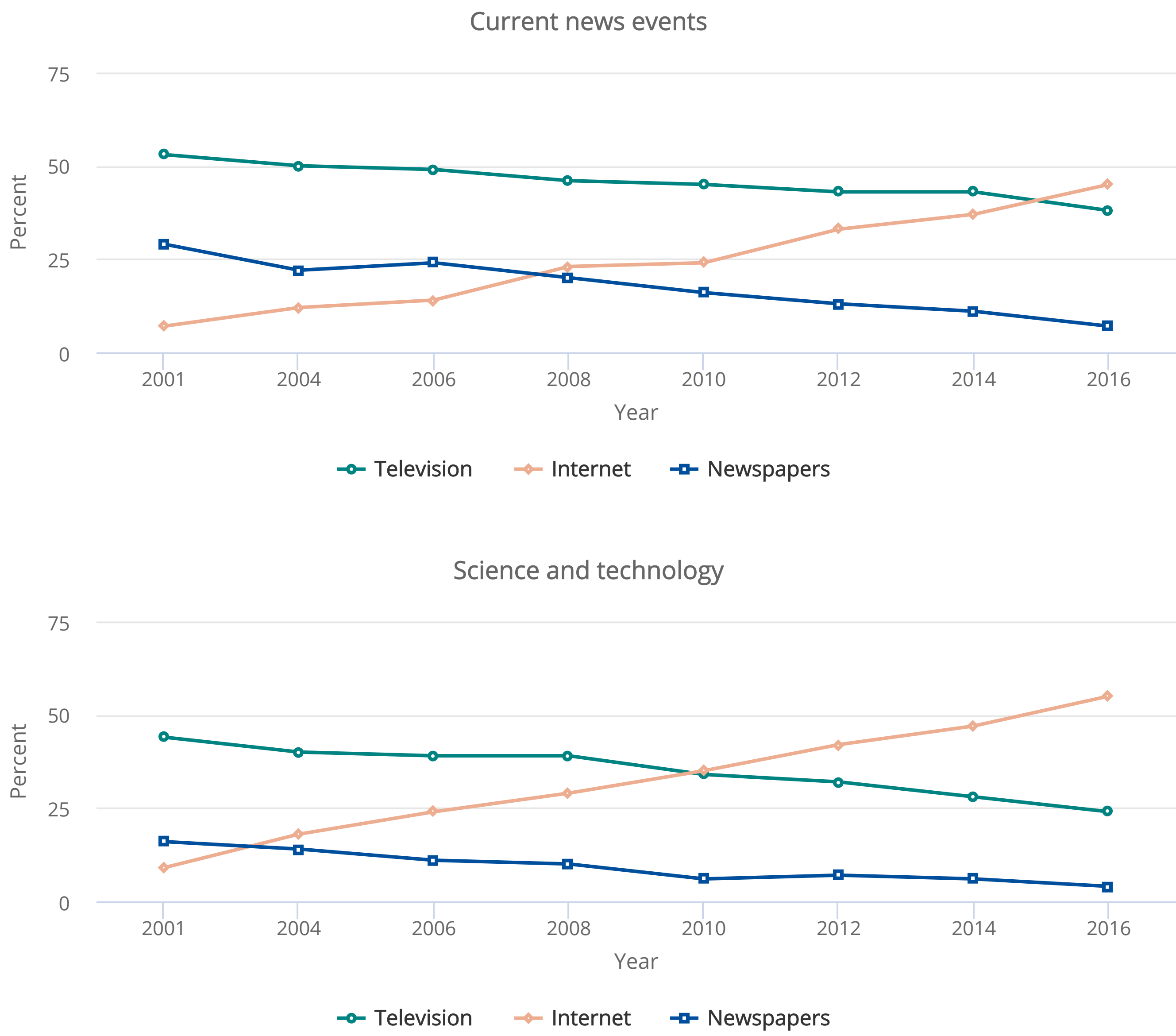
With regard to source, for news about general current events, 45% of Americans said that the Internet was their primary source of information about current events in 2016, up from 37% in 2014 (Figure 7-6). This means the Internet has now surpassed television as Americans' main source of news. About 37% of Americans said television was their primary source of information in 2016, down from 43% in 2014. Newspapers also dropped to 7% in 2016 from 11% in 2014 (Figure 7-6; Appendix Table 7-3). The percentage of Americans who report getting information about current events from the Internet has increased steadily since about 2001, and the percentages using newspapers and television for current events have declined.

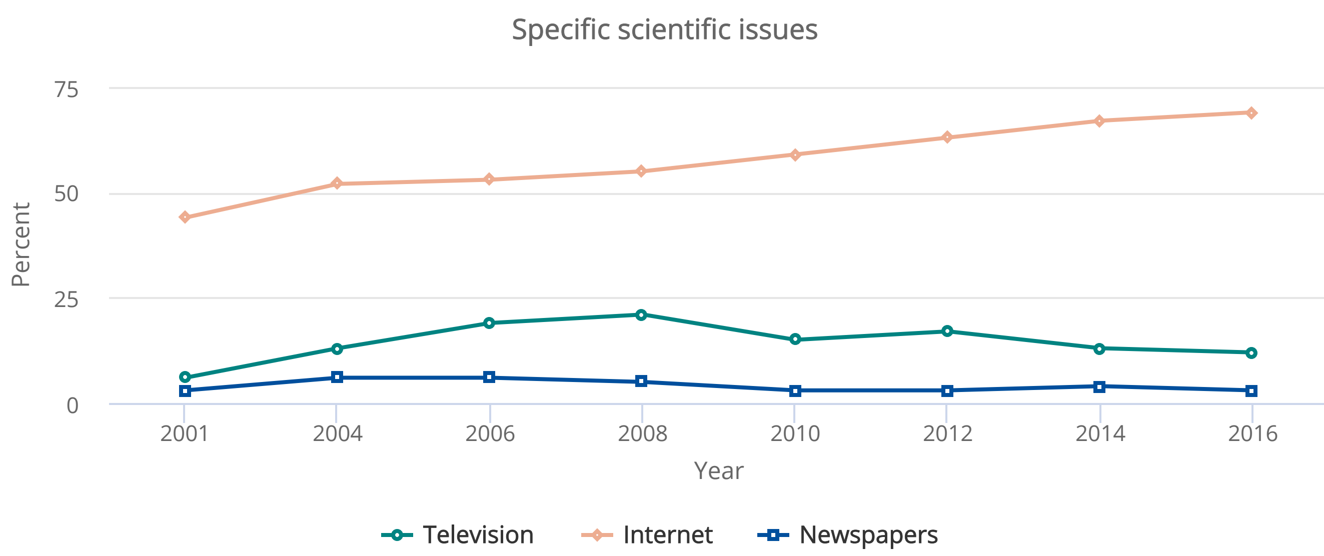
For news specifically about S&T, Americans are also more likely to rely on the Internet than on television. In 2016, 55% of Americans cited the Internet as their primary source of S&T information, up from 47% in 2014. This percentage has grown steadily since 2001, when the Internet was added to the survey and 9% named it as their primary source of S&T news. Reliance on television has continued to drop. About 24% of Americans reported that television was their primary source of S&T news in 2016, down from 28% in 2014. In 2016, 4% of Americans said that they get their S&T information from newspapers, compared with 6% in 2014 (Figure 7-6; Appendix Table 7-4). Of the 55% who said they go online for S&T information, 36% (i.e., 20% overall) said that they use a search engine such as Google to seek information, while 45% (or 25% overall) said they use online newspapers (25%), online magazines (14%), or other online news sites (6%). Of course, Google searches might lead people to one of these other sources of information.

The Internet has also been the most common resource that Americans say they would use to seek information about specific scientific issues, and this has continued to grow since at least 2001 (Figure 7-6). In 2016, 69% said they would go online to find information about a specific S&T issue. Another 12% said they would turn to television, and just 3% said they would use newspapers. In 2014, 67% said they would use the Internet, up from 63% in 2012 (Figure 7-6).

FIGURE 7-6

Primary source respondents used to learn about current news events, science and technology, and specific scientific issues: 2001–16





Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (2001); University of Michigan, Survey of Consumer Attitudes (2004); NORC at the University of Chicago, General Social Survey (2006–16). See Appendix Table 7-3 through Appendix Table 7-5.

Science and Engineering Indicators 2018

Different subgroups of Americans tend to rely on different sources of information. Generally, higher levels of education and income are associated with relatively higher levels of Internet and newspaper use, whereas respondents with lower levels of education and income are more likely to say they rely on television. For example, 39% of those whose highest education level is high school say they use the Internet for current event news, while 56% of those with bachelor's degrees give this response. In contrast, 42% of those whose highest level of education is high school say television is their primary source of current event news, compared to 26% of those with bachelor's degrees. Newspaper reliance is more common for relatively older respondents, and Internet reliance is more common for relatively younger and higher-earning respondents. In 2016, almost no respondents under the age of 24 said that newspapers were their primary source of S&T news, although this does not mean they may not have received science news written for newspapers and published online. Television use is also somewhat less common for younger respondents (Appendix Table 7-3, Appendix Table 7-4, and Appendix Table 7-5).

International Comparisons

International patterns of media sources for news appear to differ from those in the United States, especially in the continuing importance of television. However, different question wording and the fact that many international surveys allow specifying more than one news source prevent direct comparison. For example, in China, 93% of respondents said that television was a main source for S&T information, while 53% said the Internet and 39% said newspapers were among their main sources (CRISP 2016). In the UK, individuals were more likely to report that they had heard about or seen medical research on television (43%) than through a website or newspaper (21% and 19%). However, 90% said they had looked for information about medical research online. In Germany, 67% said they often (33%) or sometimes (34%) get information about science and research from television, compared to 54% for newspapers and magazines and 44% for the Internet (Wissenschaft im dialog 2016). In Finland, 81% said television was "very important" or "fairly important" as a source of science and research information, compared to 71% who said that newspapers were personally important and 70% who indicated the Internet was important (FSSI 2016). In South America, 39% of Chileans said they always or almost always watch S&T or nature programs on television, 23% said they always or almost always use the Internet to search for science information, and 19% said the same about reading such information in newspapers (CONICYT 2016).

Involvement

U.S. Patterns and Trends

Many U.S. residents may encounter S&T through America's rich and diverse informal science and cultural institutions (Bell et al. 2009).[1] In 2016, zoos and aquariums were the most popular type of informal science institutions, with 48% of Americans saying they had visited such a facility in the previous year. This proportion has gradually declined from about 58% in 2001 and 52% in 2008. Attendance levels are now back to where they were through much of the 1980s and 1990s (Appendix Table 7-6). Beyond zoos and aquariums, 30% of Americans said they had visited a natural history museum in the previous year, and 26% said they had visited an S&T museum. These percentages are similar to those for 2012.

Americans with more years of formal education were more likely than others to visit informal science sites, as were those in higher income brackets (Appendix Table 7-7). In general, visits to informal science institutions peak during the years in which people are raising their children. About 73% of those in the 35–44 age group reported visiting at least one informal science institution in the previous year, compared to 68% in the 18–24 age group and 35% of those in the 65 and over age group. One limitation of the data is that they do not speak to the quality of the institution visited and the full range of informal S&T activities that individuals may participate in during a given year (e.g., science festivals, maker days, stand-alone talks, citizen science activities).

Examples of natural history museums include the Smithsonian's National Museum of Natural History in Washington, District of Columbia, the Field Museum in Chicago, Illinois, the Denver Museum of Nature and Science in Colorado, and the Fernbank Museum of Natural History in Atlanta, Georgia. An S&T museum can include museums or centers such as the Smithsonian's National Air and Space Museum in Washington, District of Columbia, the Center of Science and Industry in Columbus, Ohio, the Sci-Port Discovery Center in Shreveport, Louisiana, or the Exploratorium in San Francisco, California (ASTC 2017).

International Comparisons

Other countries tend to have a similar or lower likelihood of having participated in the informal science activities for which there are U.S. data. In 2015, 54% of Chinese respondents said they had visited a zoo or aquarium in the last year, 22% said they had visited a natural history museum, and 23% said they had visited an S&T museum (CRISP 2016). About 46% of Germans said they had visited a zoo or aquarium, and 40% said they had been to a science or technology museum in the last year, although the German survey did not differentiate between natural history museums and more S&T-focused museums (Wissenschaft im dialog 2016). In the UK, 36% said they had visited a zoo or aquarium, and 20% said they had been to a science museum or an S&T museum or center (Wellcome Trust 2016). About 31% of Chileans said they had been to a zoo or aquarium in the last year, and 15% said they had been to an S&T museum (CONICYT 2016).

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[1] People become involved with S&T through many kinds of nonclassroom activities beyond attending informal science institutions. Examples of such activities include participating in government policy processes, going to movies that feature S&T, attending talks or lectures, bird watching, and building computers. *Citizen science* is a term used for activities by citizens with no specific science training who participate in the research process through activities such as observation, measurement, or computation. Nationally representative data on this sort of involvement with S&T are unavailable.

Public Knowledge about S&T

Science and Engineering Indicators has been reporting results of assessments of Americans' knowledge about S&T since 1979. Initial indicators focused on the proper design of a scientific study and whether respondents viewed pseudoscientific belief systems, such as astrology, as scientific. The questions also examined understanding of probability, and questions meant to assess understanding of basic scientific facts were added in the late 1980s and early 1990s (Miller 2004). These later factual questions—called here the *trend factual knowledge* questions—remain the core of one of the only available data sets on trends in adult Americans' knowledge of science (NASEM 2016c).

Although tracking indicators on science knowledge is an important part of this chapter, it is also important to recognize that research has shown that science literacy only has a small—though meaningful—impact on how people make decisions in their public and private lives (see, e.g., [Allum et al. 2008]; [Bauer, Allum, and Miller 2007]; [NASEM 2016c]; [NSB 2012:7–27]). It is also, however, clear that such knowledge need not result in accepting the existence of a scientific consensus or a policy position that such a consensus might suggest (Kahan et al. 2012). One challenge of measuring the effect of science literacy is that processes—such as formal and informal education—through which knowledge is gained also contribute to interest in S&T and confidence in the S&T community. These same processes might also affect general and specific attitudes about science. The National Academies of Sciences, Engineering, and Medicine also recently highlighted that science literacy is largely a function of general (or "foundational") literacy and that more focus should be put on the ability of groups to use science to make high-quality decisions (NASEM 2016c). In this regard, it should be recognized that the science literacy of individuals is unequally distributed across societies, so that some groups or communities are able to make use of science when needed while others are not because they may not have access to resources such as local expertise (e.g., community members who are also scientists, engineers, doctors).

It is also noteworthy that the current survey uses a relatively small number of questions compared to all the scientific subjects about which someone could be asked and thus cannot be said to represent a deep measurement of scientific knowledge. Given such concerns, the 2010 version of *Indicators* included responses to an expanded list of knowledge questions and found that people who "answered the additional factual questions accurately also tended to provide correct answers to the trend factual knowledge questions included in the GSS" (NSB 2010:7-20). The trend questions used in this report thus likely represent a reasonable indicator of basic science knowledge. The goal when designing these questions was to assess whether an individual likely possessed the knowledge that might be needed to understand a quality newspaper's science section (Miller 2004).

There is, however, evidence that the current trend measures may be better at differentiating low and medium levels of knowledge than they are at differentiating those with higher levels of knowledge (Kahan 2016). More generally, considering the limitations of using a small number of questions largely keyed to knowledge taught in school, generalizations about Americans' knowledge of science should be made cautiously.

Another issue is that, although the focus in *Indicators* is on assessing knowledge about scientific facts and processes, it could also be important to assess knowledge about the institutions of science and how they work—such as peer review and the role of science in policy discussions (Toumey et al. 2010). Others have similarly argued that the knowledge needed for citizenship might be different from what might be needed to be an informed consumer or to understand the role of science in our culture (Shen 1975). Science literacy can also be understood as the capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (OECD 2003:132–33).

The degree to which respondents demonstrate an understanding of basic scientific terms, concepts, and facts; an ability to comprehend how S&T generates and assesses evidence; and a capacity to distinguish science from pseudoscience have become widely used indicators of basic science literacy. The 2016 GSS continues to show that many Americans provide multiple incorrect answers to basic questions about scientific facts and do not apply appropriate reasoning strategies to questions about selected scientific issues. Residents of other countries, including highly developed ones, rarely appear to perform better when asked similar questions.

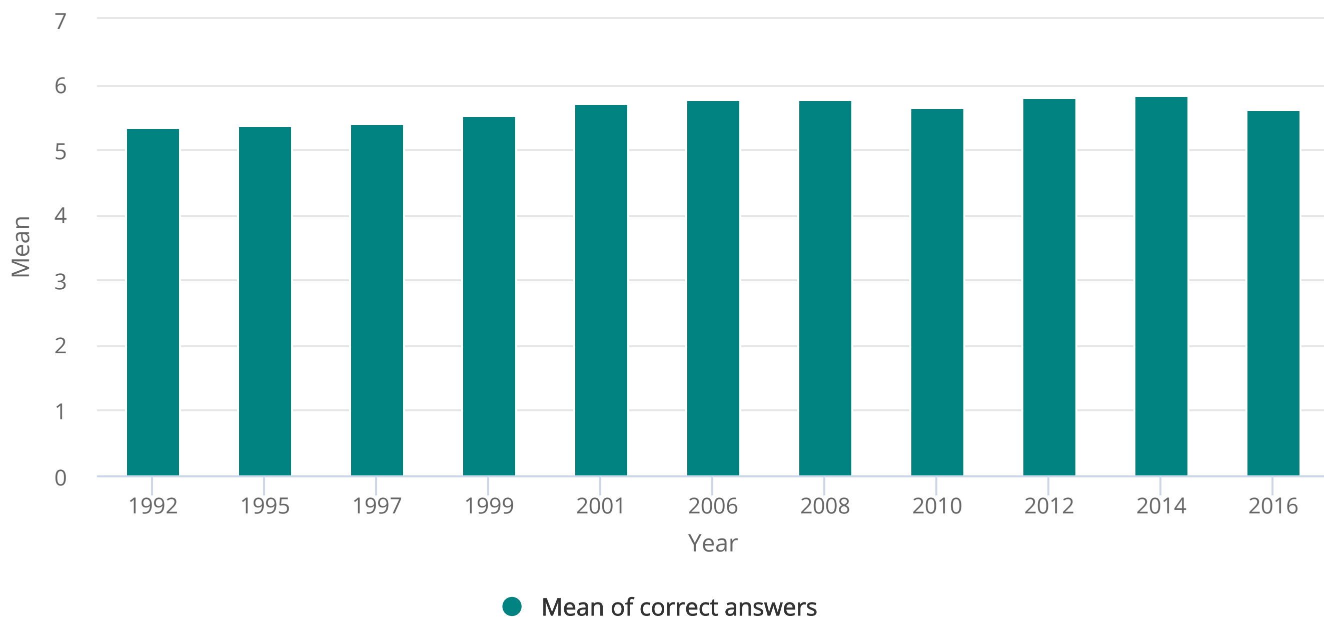
Understanding Scientific Terms and Concepts

U.S. Patterns and Trends

In 2016, Americans correctly answered an average of 5.6 of the 9 true-or-false or multiple-choice items (63%) from NSF's factual knowledge questions. This score is not substantially lower than the 2012 and 2014 scores of 5.8 and is thus generally consistent with recent years (Figure 7-7; Appendix Table 7-8). Two additional true-or-false questions about the theory of evolution and the Big Bang, which are not included in the 9-item measure, are also discussed subsequently.

FIGURE 7-7

Mean number of correct answers to trend factual knowledge of science scale: 1992–2016



Note(s)

Mean number of correct answers to nine questions included in trend factual knowledge of science scale; see Appendix Table 7-2 for explanation and list of questions. See Appendix Table 7-8 for percentage of questions answered correctly. See Appendix Tables 7-9 and 7-10 for responses to individual questions.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1992–2001); NORC at the University of Chicago, General Social Survey (2006–16).

Science and Engineering Indicators 2018

The public's measured level of factual knowledge about science has not changed much over the past two decades. Since 2001, the average number of correct answers to a series of 9 questions for which fully comparable data have been collected has ranged from 5.6 to 5.8 correct responses—a difference that is small enough that it could have occurred by chance, given the sample size—although scores for individual questions have varied somewhat more over time (Figure 7-8; Appendix Table 7-8, Appendix Table 7-9, and Appendix Table 7-10).[1] The Pew Research Center (2013) used several of the same questions in a 2013 survey and received similar results.

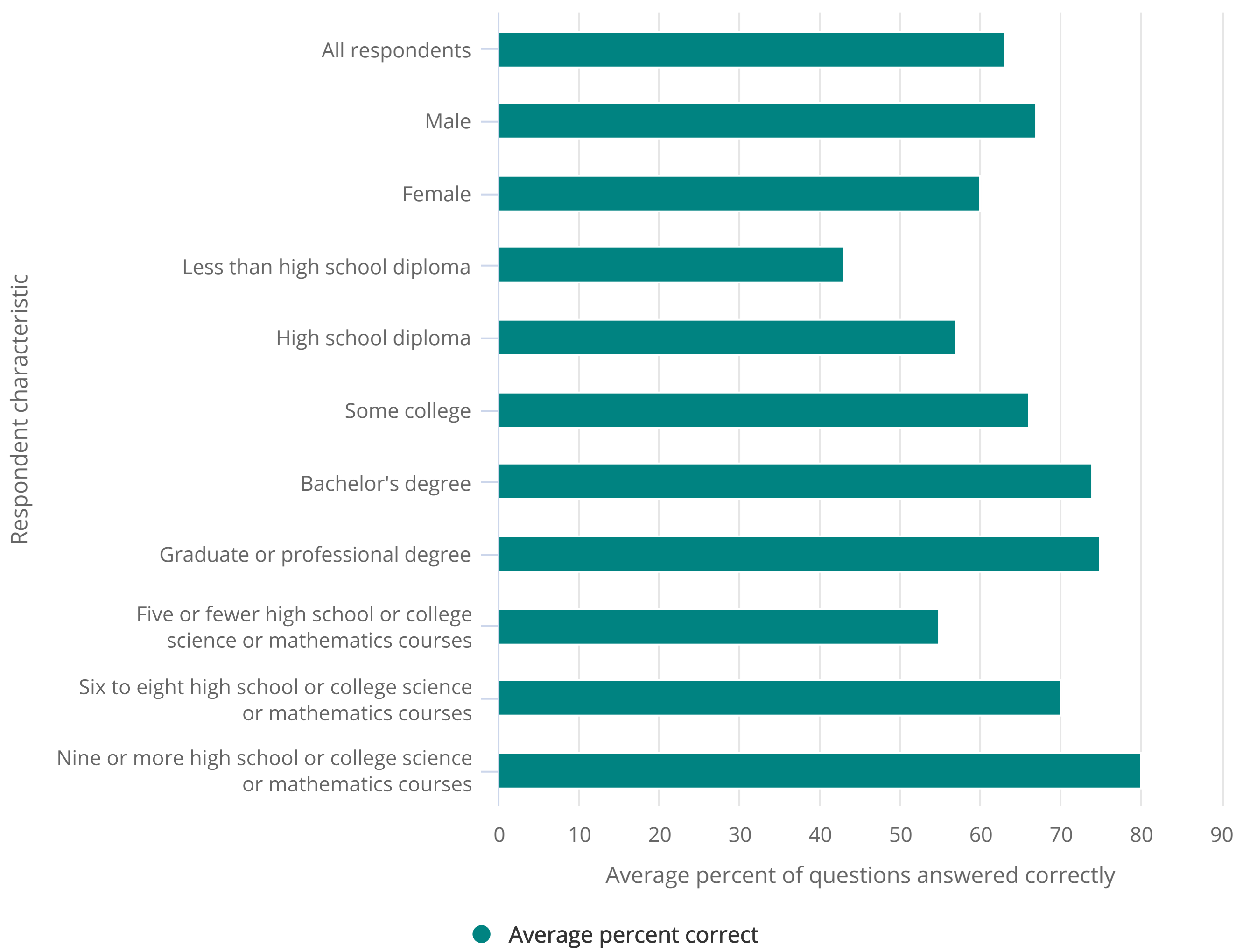
Within the GSS data, trend factual knowledge of science is strongly related to individuals' level of formal schooling and the number of science and mathematics courses completed (Figure 7-8; Appendix Table 7-8 and Appendix Table 7-10). Those who had not completed high school answered 43% of the 9 questions correctly, whereas those for whom a bachelor's degree was their highest academic credential answered 74% of the questions correctly. Similarly, Americans who took five or fewer high school or college science or mathematics courses answered 55% of the questions correctly, whereas those who had taken nine or more courses answered 80% correctly (Appendix Table 7-8).

Although NSF survey data showed a large gap in scientific knowledge between the top-performing age groups (typically those in the middle range of age categories) and those in the older age groups, the current data suggest that this gap has narrowed (Appendix Table 7-8). For example, in 1992, 35- to 44-year-olds answered 65% of the trend questions correctly, whereas those 65 years or older answered 47% of the questions correctly. By 2016, the top-performing age group (25- to 34-year-olds) answered 67% of the questions correctly, while respondents age 65 years or older answered 55% correctly. The gap thus shrank from 18 percentage points to 12 percentage points between 1992 and 2016. Analyses of surveys conducted between 1979 and 2006 concluded that public understanding of science has increased over time and by generation, even after controlling for formal education levels (Losh 2010, 2012).

Factual knowledge about science, as measured in the current GSS, is also associated with respondents' sex. Men (67%) tend to answer somewhat more factual science knowledge questions in the GSS correctly than women (60%) (Figure 7-8). The Pew Research Center found a similar result using a set of 12 questions that were different from those used by the NSF survey (Funk and Goo 2015). In the Pew survey, men's scores averaged 8.6, whereas women's scores averaged 7.3. For the NSF S&T survey (i.e., the current GSS data), men have typically done slightly better on physical science questions, whereas women have performed more similarly to men on biology questions (Appendix Table 7-10). However, men did better than women on an expanded set of biology questions in the 2008 GSS, which suggests that sex differences in correct answers may depend on the specific questions asked. The 2015 Pew Research Center data focus primarily on physical science questions, and the organization has not consistently seen these types of gender differences for questions focused on health and biomedical knowledge (Funk and Goo 2015). Some evidence also suggests that men might be more likely to guess rather than say they do not know the correct answer. This could partly account for men's slightly higher science knowledge score (Mondak 2004). Pew did not differentiate biology from physics questions.

FIGURE 7-8

Correct answers to trend factual knowledge of science scale, by respondent characteristic: 2016



Note(s)

Data reflect average percentage of nine questions answered correctly. "Don't know" responses and refusals to respond counted as incorrect. See Appendix Table 7-2 for explanation, list of questions, and additional respondent characteristics. See Appendix Tables 7-9 and 7-10 for responses to individual questions.

Source(s)

NORC at the University of Chicago, General Social Survey (2016).

Science and Engineering Indicators 2018

Evolution and the Big Bang

The GSS includes two additional true-or-false science questions that are not included in the index calculation because Americans' responses appear to reflect factors beyond familiarity with scientific facts. One of these questions is about evolution, and the other is about the origins of the universe. In 2016, 52% of Americans correctly indicated that "human beings, as we know them today, developed from earlier species of animals," and 39% correctly indicated that "the universe began with a big explosion" (Appendix Table 7-10). Both scores are relatively low compared with scores on the other knowledge questions in the survey. The percentage of Americans answering the evolution question has risen from a low of 42% in 2004, while the origins of the universe question is similar to where it has been since 2010 (38%) but is higher than it was during much of the last two decades—it was at lows of 32% in 1990 and 1997 (Appendix Table 7-9).

Those with more education and more factual knowledge typically do well on the two questions. Younger respondents are also more likely to answer both questions correctly. For example, 70% of those ages 18–24 years answered the evolution question correctly, whereas 45% of those 65 or older answered the evolution question correctly. This pattern is not as pronounced for the other knowledge questions described above (Appendix Table 7-10).

An additional question-wording experiment was included in the 2016 GSS to expand on similar experiments conducted in 2004 (NSB 2006) and 2012 (NSB 2014, 2016). These experiments involve randomly giving each survey respondent one of two or three different survey questions and then comparing the results. The earlier experiments showed that changing the wording to the evolution and origin of the universe questions substantially increased the percentage of respondents getting them correct. For example, in 2012, 48% of those asked whether it was true or false that "human beings, as we know them today, developed from earlier species of animals" gave the correct answer of true, but 72% answered the question correctly when presented with the same statement with the addition of the preface "According to the theory of evolution." Similarly, 39% of respondents correctly stated it was true that "the universe began with a big explosion," but 60% gave the correct answer when presented with the same statement prefaced by "According to astronomers" (Appendix Table 7-9).

Similar patterns were evident in the 2016 version of the experiments. For evolution, 74% gave the correct response to the evolution question when respondents were asked whether it was true or false that "elephants, as we know them today, descended from earlier species of animals" (for a discussion of this question, see [Maitland, Tourangeau, and Yan 2014] and [Maitland, Tourangeau, Yan, Bell, et al. 2014]). This is 22 percentage points higher than the 52% who gave the correct answer when asked the similar question about humans. For the Big Bang question, 69% gave the correct response when the preface "According to astronomers" was added to the original question, and 64% gave the correct response when asked whether it was true or false that "the universe has been expanding ever since it began." These represent differences of 30 percentage points and 25 percentage points, respectively, from the 39% of respondents who gave the correct response when asked the original question of whether the universe began with a huge explosion. As before, the results suggest that the evolution and origin of the universe items, as originally worded, may lead some people to provide incorrect responses based on factors other than their knowledge of what most scientists believe. While issues of personal identity are not the focus of *Indicators,* other research has pointed to the important role that religious beliefs play in shaping views about evolution and the origins of the universe (e.g., [Roos 2014]). While issues of personal identity are not the focus of *Indicators,* research has pointed to the role that religious beliefs play in shaping views about evolution and the origins of the universe (e.g., [Roos 2014]). For additional findings related to these questions, see sidebar Testing Alternative Wording of the Big Bang and Evolution Questions.

SIDEBAR

Testing Alternative Wording of the Big Bang and Evolution Questions

The General Social Survey (GSS) included an experiment to test which alternative question wording regarding the origin of the universe (the “Big Bang”) and evolution best captures overall knowledge of science. These questions were part of the NSF’s factual knowledge of science questions until, as noted above, it was found that small question wording changes substantially improve the number of correct answers.

Asking respondents about what scientists believe, rather than implicitly what the respondent believes, increases correct responding. Asking about the evolution of elephants or whether the universe is expanding also increases the number of correct responses. This suggests the possibility that Americans may be answering these questions incorrectly due to personal views rather than a lack of knowledge about what science considers the correct answers. If so, alternative questions might be selected that could better capture factual knowledge of science.

It is important, however, to ensure that any proposed alternative questions capture factual knowledge of science better than the existing questions. The fact that people give more correct answers to a reworded question need not indicate that the reworded question better captures general knowledge. The reworded questions may have cues, such as the mention of scientists, which yield more correct responses because of reasons other than knowledge.

Also, even if people know the correct answer to the human evolution question but select the wrong answer because of personal beliefs, those beliefs might indicate a broader lack of understanding of science. For example, a question about the evolution of elephants could more accurately capture knowledge of what science says about evolution but be a worse overall indicator of knowledge of other scientific facts or understanding of the scientific process.

A key test, then, of the value of alternative wordings is whether they are more strongly associated with the current 9-item factual knowledge of science questions than the original questions. If they are, this suggests that the questions likely capture broad factual knowledge of science better. Another, less critical indicator includes the questions’ association with understanding the scientific process.

An examination of all GSS data to date containing the various question wordings finds that those questions prefaced with “According to astronomers…” or “According to the theory of evolution…” do better than the alternative questions with respect to factual knowledge of science. That is, the “According to” questions have a stronger association with factual knowledge than do the alternatives. In particular, people correctly answering either of the “According to” questions have a factual knowledge score on average about 1.7 points higher on the 9-point scale than those who answer these questions incorrectly. This contrasts with a 1.3-point difference for those correctly versus those incorrectly answering the original Big Bang question and a 1-point difference for the “universe is expanding” question. The 1.7-point difference on the “According to” evolution question also contrasts with a 1.1-point difference for the original evolution question and a 1-point difference for the elephant evolution question.

The “According to" Big Bang question also has a stronger association with understanding of the scientific process than the original Big Bang question. The “According to” Big Bang question does not have a demonstrably stronger relationship with understanding of the scientific process than *the universe is expanding* alternative. Similarly, it is not clear which of the three versions of the evolution question has a stronger relationship with understanding of the scientific process. The findings for understanding the scientific process are less definitive in part because such understanding has a generally weaker relationship with the question alternatives than does the factual knowledge score and because relatively little data are available for the alternatives.

The stronger relationship of the “According to” questions with factual knowledge of science than the original or other alternative questions suggests that these “According to” questions are better indicators of such knowledge. Also, the stronger relationship of the “According to” Big Bang question with knowledge of the scientific process provides additional evidence for this question over the original version of the question. Whether the “According to” questions should replace the original questions will depend in part on weighing their strengths against losing the long-time series available for the original questions.

SIDEBAR

Race, Ethnicity, and Factual Science Knowledge

A recent National Academies (NASEM 2016c) report on science literacy highlighted racial disparities in science knowledge as a topic in which scholars have done too little research. The report noted that studies done by the Pew Research Center highlighted consistent differences in knowledge scores using Pew's set of 12 questions (Funk and Goo 2015) but concluded that more research is needed to understand the factors that may be contributing to racial disparities in science knowledge.

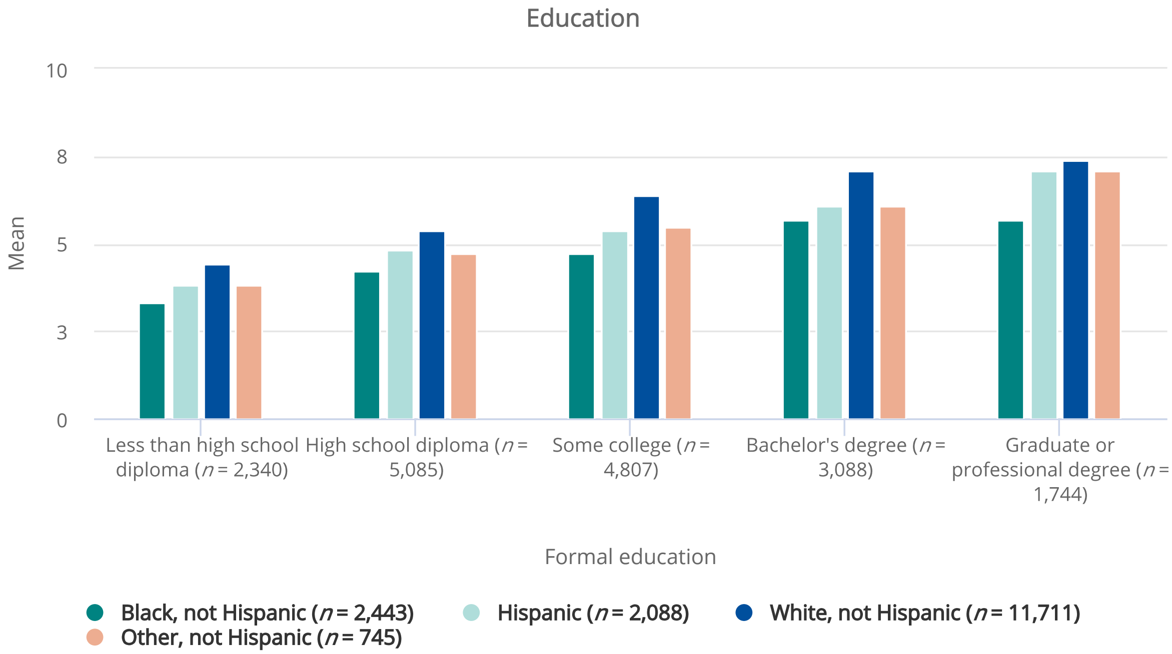
The biennial NSF S&T survey, which is a major data source for this chapter, typically has insufficient sample size to analyze knowledge scores by race and ethnicity. However, when data from the 2006–16 S&T surveys are combined, patterns similar to those reported by Pew emerge. White respondents not of Hispanic origin for whom a high school education was their highest degree, on average, answered 5.4 of the 9 factual knowledge questions correctly; their black counterparts answered an average of 4.2 of the questions correctly. This is a 1.2-point gap. White respondents whose highest education was a bachelor's degree answered an average of 7.1 questions correctly, whereas black respondents with the same overall education level answered 5.7 questions correctly. This remains a similar 1.4-point gap. The same pattern was evident when comparing white and Hispanic respondents (Figure 7-A).

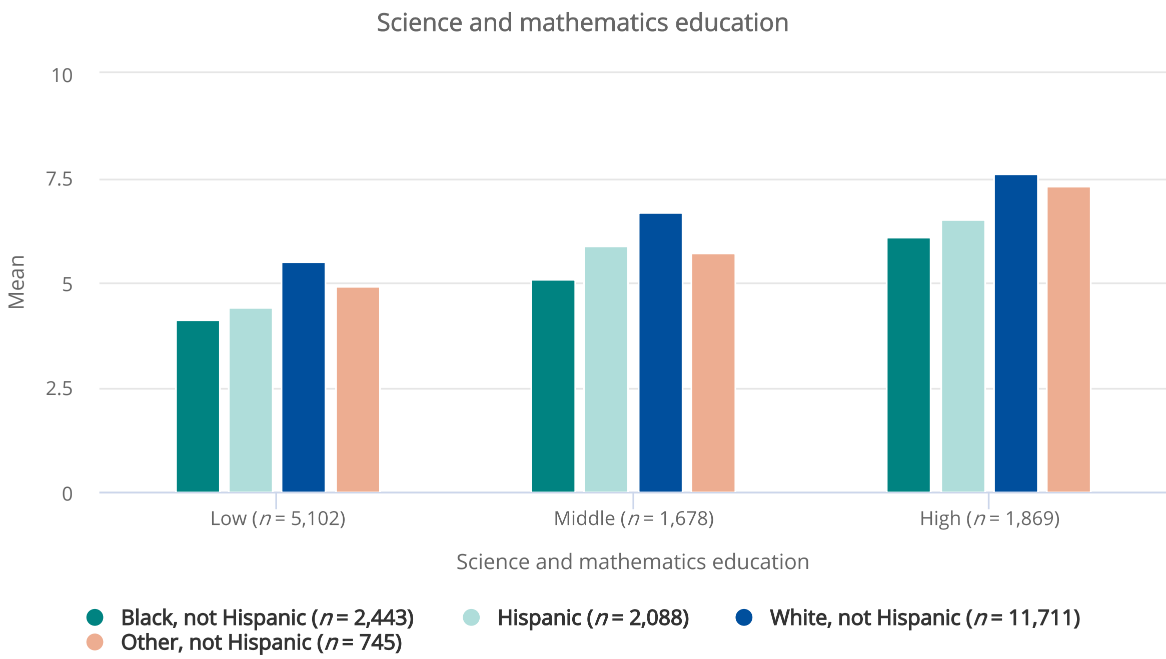
Looking at the number of science and mathematics courses taken in high school and college reveals a similar pattern. Among those who took relatively few science and mathematics courses (those who were in the bottom third of all respondents for the number of such course taken), white respondents answered an average of 5.5 science knowledge questions correctly, and black respondents answered 4.1 questions correctly. This represents a 1.4-point gap. The corresponding gap between white and black respondents was 1.5 points among those who took relatively more science and mathematics courses (those who were in the top third of all respondents). The patterns are again similar when comparing white and Hispanic respondents (Figure 7-A).

As suggested by the National Academies report (NASEM 2016c), fully understanding why differences in science knowledge scores vary will require additional research. There may be systematic differences, for example, in the quality of the education that different groups are receiving. Also, alternative types of science knowledge questions might result in a different pattern. Another line of research could examine how these differences might affect how different groups think about science both in terms of their willingness to choose scientific careers or their support and appreciation for science.

FIGURE 7-A

Correct answers to factual knowledge questions, by respondent characteristic: 2006–16 (combined)





Note(s)

See notes to Appendix Table 7-2 for an explanation of the trend factual knowledge of science scale. Categories do not add to total *n* because "don't know" responses and refusals to respond are not shown. For science and mathematics education, "low" equates to five or fewer high school and college science or mathematics courses, "middle" is six through eight courses, and "high" means nine or more courses. "Don't know" responses and refusals to respond count as incorrect. Hispanic includes respondents of any race who identify as Hispanic. Other includes American Indian or Alaska Native, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian, Native Hawaiian, Guamanian or Chamorro, Samoan, Other Pacific Islander, and some other race.

Source(s)

NORC at the University of Chicago, General Social Survey (2006–16).

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International Comparisons

There are very few current international efforts to measure science knowledge in the way that this is done in the United States because scholarly attention has shifted to understanding attitudes about science and scientists. This has likely occurred because of the aforementioned evidence that science knowledge is only weakly related to science attitudes (Bauer, Allum, and Miller 2007), including support of science (NASEM 2016c). Most data now available are thus somewhat dated.

Knowledge scores for individual items vary from country to country, and it is rare for one country to consistently outperform others across all items in a given year (Table 7-1). One exception is a 2013 Canadian survey that has Canadians scoring as well as or better than Americans and residents of most other countries on the core science questions (CCA 2014). For the physical and biological science questions, knowledge scores are relatively low in China, Russia, and Malaysia (CRISP 2016; Gokhberg and Shuvalova 2004; MASTIC 2010). Compared with overall scores in the United States and the European Union (EU) (European Commission 2005), scores in Japan (NISTEP 2012) are also relatively low for several questions.

Scores on a smaller set of four questions administered in 12 European countries in 1992 and 2005 show each country performing better in 2005 (European Commission 2005), in contrast to a flat trend in corresponding U.S. data. In Europe, as in the United States, men, younger adults, and more educated people tended to score higher on these questions.

TABLE 7-1

Percentage of correct answers to factual knowledge questions in physical and biological sciences, by region or country: Most recent year

(Percent)

Question	United States[a] (2016)	Canada (2013)	China (2015)	EU (2005)	India (2004)	Israel (2016)	Japan[b] (2011)	Malaysia (2014)	Russia (2003)	South Korea (2004)	Switzerland (2016)
Physical science											
The center of the Earth is very hot. (True)	85	93	47	86	57	86	84	75	NA	87	NA
The continents have been moving their location for millions of years and will continue to move. (True)	81	91	51	87	32	86	89	62	40	87	80
Does the Earth go around the Sun, or does the Sun go around the Earth? (Earth around Sun)	73	87	NA	66	70	86	NA	85	NA	86	NA
All radioactivity is man-made. (False)	70	72	41	59	NA	76	64	20	35	48	NA
Electrons are smaller than atoms. (True)	48	58	22	46	30	60	28	35	44	46	39
Lasers work by focusing sound waves. (False)	45	53	19	47	NA	67	26	30	24	31	NA
The universe began with a huge explosion.[c] (True)	39	68	NA	NA	34	64	NA	NA	35	67	NA
Biological science											

Question	United States[a] (2016)	Canada (2013)	China (2015)	EU (2005)	India (2004)	Israel (2016)	Japan[b] (2011)	Malaysia (2014)	Russia (2003)	South Korea (2004)	Switzerland (2016)
It is the father's gene that decides whether the baby is a boy or a girl.[d] (True)	59	NA	49	64	38	72	26	45	22	59	60
Antibiotics kill viruses as well as bacteria.[e] (False)	51	53	24	46	39	53	28	16	18	30	56
Human beings, as we know them today, developed from earlier species of animals.[f] (True)	52	74	68	70	56	63	78	NA	44	64	NA

NA = not available; question not asked.

EU = European Union.

[a] See Appendix Table 7-9 for U.S. trends.

[b] Numbers for Japan are the average from two studies conducted in 2011.

[c] An experiment in the 2012 General Social Survey showed that adding the preface "according to astronomers" increased the percentage correct from 39% to 60%.

[d] China, EU, and Switzerland surveys asked about "mother's gene" instead of "father's gene." Israel surveys asked about "hereditary material from the father."

[e] Japan survey asked about "antibodies" instead of "antibiotics."

[f] An experiment in the 2012 General Social Survey showed that adding the preface "according to the theory of evolution" increased the percentage answering correctly from 48% to 72%.

Note(s)

See notes to Table 7-2 for the full list of questions in the trend factual knowledge of science scale. EU data include Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom but do not include Bulgaria and Romania.

Source(s)

United States—University of Chicago, National Opinion Research Center, General Social Survey (2016), National Science Board (NSB), *Science and Engineering Indicators 2014* (2014), http://www.nsf.gov/statistics/seind14; Canada—Council of Canadian Academies, Expert Panel on the State of Canada's Science Culture, *Science Culture: Where Canada Stands* (2014); China—Chinese Association for Science and Technology/China Research Institute for Science Popularization, Chinese National Survey of Public Scientific Literacy (2015); EU—European Commission, Eurobarometer 224/Wave 63.1: *Europeans, Science and Technology* (2005); India—National Council of Applied Economic Research, National Science Survey (2004); Israel—Israeli Ministry of Science, Technology and Space, Geocartography Knowledge Group, Perceptions and Attitudes of the Israeli Public about Science, Technology and Space (2016); Japan—National Institute of Science and Technology Policy/Ministry of Education, Culture, Sports, Science and Technology, Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan (2011); Malaysia—Malaysian Science and Technology Information Centre/Ministry of Science, Technology and Innovation, Survey of the Public's Awareness of Science and Technology: Malaysia (2014); Russia—Gokhberg L, Shuvalova O, *Russian Public Opinion of the Knowledge Economy: Science, Innovation, Information Technology and Education as Drivers of Economic Growth and Quality of Life*, British Council, Russia (2004), Figure 7; South Korea—Korea Science Foundation (now Korea Foundation for the Advancement of Science and Creativity), Survey of Public Attitudes Toward and Understanding of Science and Technology (2004); Switzerland—University of Zurich, Institute of Mass Communication and Media Research, Department of Science, Crisis and Risk Communication, Science Barometer Switzerland (2016).

Science and Engineering Indicators 2018

Reasoning and Understanding the Scientific Process

U.S. Patterns and Trends

Another indicator of the public understanding of science focuses on the public's understanding of how science generates and assesses evidence rather than knowledge of particular science facts. Such measures reflect recognition that knowledge of specific S&T facts is conceptually different from knowledge about the overall scientific processes (Miller 1998), as well as the increased emphasis placed on process in science education (NRC 2012).

Data on three scientific process elements—probability, experimental design, and the scientific method—show trends in Americans' understanding of the process of scientific inquiry. One set of questions tests how well respondents apply the principles of probabilistic reasoning to a set of questions about a couple whose children have a 1-in-4 chance of suffering from an inherited disease. A second set of questions deals with the logic of experimental design, asking respondents about the best way to design a test of a new drug for high blood pressure. A third open-ended question probes what respondents think it means to study something scientifically. Because probability, experimental design, and the scientific method are all central to scientific research, these questions are relevant to how respondents evaluate scientific evidence. These measures are reviewed separately and then as a combined indicator of public understanding about scientific inquiry.

With regard to probability, 82% of Americans in 2016 correctly indicated that the fact that a couple's first child has the illness has no relationship to whether three future children will have the illness. In addition, about 72% of Americans correctly responded that the odds of a genetic illness are equal for all of a couple's children. Overall, 64% got both probability questions correct (Table 7-2; Appendix Table 7-11). The public's understanding of probability has been fairly stable over time, with the percentage giving both correct responses ranging from 64% to 69% since 1999 and has been no lower than 62% dating back to 1992 (Table 7-2).[2]

With regard to understanding experiments, about half (51%) of Americans were able to answer a question about how to test a drug and then provide a correct response to an open-ended question that required them to explain the rationale for an experimental design (i.e., giving 500 people a drug while not giving the drug to 500 additional people, who then serve as a control group) (Table 7-2). The 2016 results, similar to the 2014 results and results from most recent survey years, are a substantial improvement over the unusually low 2012 results that had only 34% answering this set of questions correctly. Although there has been an average increase in the percentage of correct responses over the previous two decades, there has also been substantial year-to-year variation that may in part reflect reliance on human coders to categorize responses.[3]

When all the scientific reasoning questions are combined into an overall measure of understanding of scientific inquiry (Figure 7-9), about 43% of Americans could both correctly respond to the two questions about probability and provide a correct response to at least one of the open-ended questions about experimental design or what it means to study something scientifically (Table 7-2). The 2016 proportion was not meaningfully different from the 46% found in 2014. Further, 2014 had the highest proportion of correct responses on surveys for which NSF has data, dating back to 1995. In general, men, respondents with more education, and respondents with higher incomes did better on the scientific inquiry questions. Both younger and older age groups did relatively less well compared with those in the middle of the age range (Appendix Table 7-11).

TABLE 7-2

Correct answers to scientific process questions: Selected years, 1999–2016

(Percent)

Question	1999	2001	2004	2006	2008	2010	2012	2014	2016
Understanding of scientific inquiry scale[a]	32	40	39	41	36	42	33	46	43
Components of understanding scientific inquiry scale									
Understanding of probability[b]	64	67	64	69	64	66	65	66	64
Understanding of experiment[c]	34	40	46	42	38	51	34	53	51
Understanding of scientific study[d]	21	26	23	25	23	18	20	26	23

[a] To be classified as understanding scientific inquiry, the survey respondent had to (1) answer correctly the two probability questions stated in footnote b, and (2) either provide a theory-testing response to the open-ended question about what it means to study something scientifically (see footnote d) or a correct response to the open-ended question about experiment (i.e., explain why it is better to test a drug using a control group [see footnote c]).

[b] To be classified as understanding probability, the survey respondent had to answer correctly *A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness.* (1) *Does this mean that if their first child has the illness, the next three will not have the illness?* (No); and (2) *Does this mean that each of the couple's children will have the same risk of suffering from the illness?* (Yes).

[c] To be classified as understanding experiment, the survey respondent had to answer correctly (1) *Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug?* and (2) *Why is it better to test the drug this way?* (The second way because a control group is used for comparison.)

[d] To be classified as understanding scientific study, the survey respondent had to answer correctly (1) *When you read news stories, you see certain sets of words and terms. We are interested in how many people recognize certain kinds of terms. First, some articles refer to the results of a scientific study. When you read or hear the term scientific study, do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?* and (2) (If "clear understanding" or "general sense" response) *In your own words, could you tell me what it means to study something scientifically?* (Formulation of theories/test hypothesis, experiments/control group, or rigorous/systematic comparison.)

Note(s)

Data reflect the percentage of survey respondents who gave a correct response to each concept. "Don't know" responses and refusals to respond are counted as incorrect and are not shown. See Appendix Table 7-11 for more detail on the probability questions.

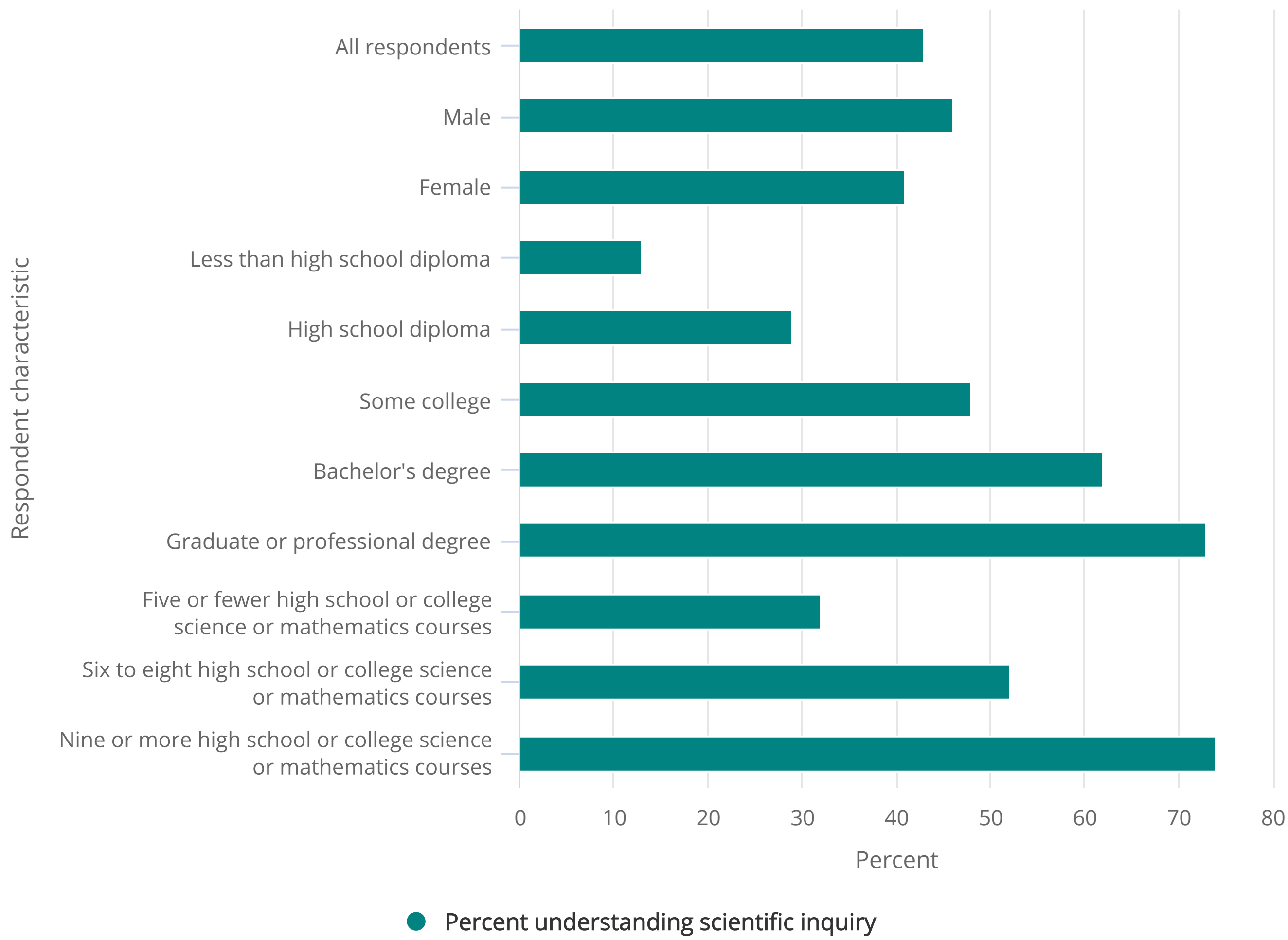
Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1999, 2001); University of Michigan, Survey of Consumer Attitudes (2004); NORC at the University of Chicago, General Social Survey (2006–16).

Science and Engineering Indicators 2018

FIGURE 7-9

Understanding scientific inquiry, by respondent characteristic: 2016



Note(s)

See Appendix Table 7-11 for explanation of understanding scientific inquiry and questions included in the index and additional respondent characteristics.

Source(s)

NORC at the University of Chicago, General Social Survey (2016).

Science and Engineering Indicators 2018

International Comparisons

Reasoning and understanding have not been the focus of surveys in most other countries in recent years. A 2010 Chinese survey reported that 49% understood the idea of probability, 20% understood the need for comparisons in research, and 31% understood the idea of scientific research (CRISP 2010). In a July 2011 Japanese survey, 62% correctly answered a multiple-choice question on experiments related to the use of a control group, whereas 57% answered correctly in a follow-up December 2011 survey (NISTEP 2012). As noted previously, 66% of Americans provided a correct response to a similar question in 2014.

Pseudoscience

Another indicator of public understanding about S&T comes from a measure focused on the public's capacity to distinguish science from pseudoscience. One such measure, Americans' views on whether astrology is scientific, has been included in *Indicators* because of the availability of data going back to the late 1970s. Other examples of pseudoscience include the belief in lucky numbers, extrasensory perception, or magnetic therapy.[4]

More Americans see astrology as unscientific today than in the past, although there has been some variation in recent years. In 2016, about 60% of Americans said astrology is "not at all scientific," a value near the middle of the historical range and down somewhat from 65% in 2014. Twenty-nine percent said they thought astrology was "sort of scientific," and the remainder said they thought astrology was "very scientific" (8%) or that they "didn't know how scientific" astrology is (3%). The percentage of Americans who report seeing astrology as unscientific has ranged between 50% (1979) and 66% (2004).

Respondents with more years of formal education and higher income were less likely to see astrology as scientific. For example, in 2016, 76% of those with bachelor's degrees indicated that astrology is "not at all scientific," compared with 57% of those whose highest level of education was high school. Age was also related to perceptions of astrology. Younger respondents were the least likely to reject astrology, with only 54% of the youngest age group (18–24 years old) and 53% of the next group (25–34 years old) saying that astrology is "not at all scientific." At least 60% of all other groups rejected astrology (Appendix Table 7-12).

Perceived Understanding of Scientific Research

U.S. Patterns and Trends

While factual knowledge is important, people may also develop attitudes and engage in behaviors because of their perception of how much they know (Ladwig et al. 2012). The NSF survey has included data on the degree to which respondents believe they "have a clear understanding of what it means" when they "read or hear the term scientific study." In 2016, 31% of Americans said they thought they had a clear understanding of the meaning, while 48% said they felt they had a "general understanding" of the topic. Another 21% said they had "little understanding" (19%) or said they did not know (2%) (Appendix Table 7-13 and Appendix Table 7-14).

The proportion of respondents saying they have a clear understanding of what the term *scientific study* means was 22% in 1979 and climbed to a high of 37% in 1997 before dropping back down to 24% in 2012 (Appendix Table 7-14). The current level, 31%, is at the overall average (31%); men, those with more education, and those with more income are most likely to say they have a clear understanding. A perceived sense of "clear understanding" also appears to peak in the 25- to 34-year-old age group. Factual knowledge also matters. About 51% of those in the highest quartile of factual knowledge as measured by the NSF said they had a clear understanding of the term *scientific study*. About 15% of those in the lowest quartile of factual knowledge said they felt they had a clear understanding of the term. About 4% of those in the highest knowledge quartile and 44% of those in the lowest knowledge quartile said they had "little understanding" of the term (Appendix Table 7-13).

International Comparisons

Only a small number of countries ask about their residents' perceived understanding of science. In Switzerland, about 28% agreed with a statement about being well-informed about science and research by choosing 4 or 5 on a 5-point scale, where 1 indicated complete disapproval of the statement and 5 indicated complete approval (Schafer and Metag 2016). This is similar to the 31% who expressed "clear understanding" in the United States.

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[1] Survey items that test factual knowledge sometimes use easily comprehensible language at the cost of scientific precision. This may prompt some highly knowledgeable respondents to believe that the items blur or neglect important distinctions and, in a few cases, may lead respondents to answer questions incorrectly. In addition, the items do not reflect the ways that established scientific knowledge evolves as scientists accumulate new evidence. Although the text of the factual knowledge questions may suggest a fixed body of knowledge, it is more accurate to see scientists as making continual, and often subtle, modifications in how they understand existing data in light of new evidence.

[2] Earlier NSF surveys used for the *Indicators* report employed additional questions to measure understanding of probability. Bann and Schwerin (2004) identified a smaller number of questions that could be administered to develop a comparable indicator. Starting in 2004, the NSF surveys used these questions for the trend factual knowledge scale. This scale does not include the questions aimed at studying scientific reasoning and understanding (e.g., questions about probability or the design of an experiment).

[3] Declines such as those seen in 2012 need to be regarded with caution. In that case, the percentage of Americans who correctly answered the initial multiple-choice question about how to conduct a pharmaceutical trial stayed stable between 2010 and 2012. It was only the follow-up question that asked respondents to use their own words to justify the use of a control group that saw a decline. For this question, interviewers record the response, and then trained coders use a standard set of rules to judge whether the response is correct. Although the instructions and training have remained the same in different years, small changes in survey administration practices can sometimes substantially affect such estimates.

[4] Because astrology is based on systematic observation of planets and stars, respondents might believe that this makes it "sort of scientific." The fact that those with more formal education and higher factual science knowledge scores are consistently more likely to fully reject astrology suggests that this nuance has only a limited effect on results. Another problem is that some respondents may also confuse astrology with astronomy, and such confusion seems most likely to occur in some of the same groups (i.e., relatively lower education and factual knowledge) that might be predicted to get the question wrong. This could artificially inflate the number of wrong responses. However, the question comes immediately after a question that asks respondents whether they ever "read a horoscope or personal astrology report," which offers respondents a hint that astrology is not astronomy. Also noteworthy is the fact that a Pew Forum on Religion & Public Life study (2009) using a different question found that 25% of Americans believe in "astrology, or that the position of the stars and planets can affect people's lives." Gallup found the same result with the same question in 2005 (Lyons 2005). In contrast, similar to 2014, the 2010 GSS found that 6% saw astrology as "very scientific," and 28% said they saw astrology as "sort of scientific" (34% total). The Pew Research Center found that 73% could distinguish between astrology and astronomy and that there were few demographic differences, beyond education (Funk and Goo 2015).

Public Attitudes about S&T in General

Scientific interest and knowledge are only aspects of how people think about S&T. How people perceive science and scientists can also matter considerably. Such attitudes could influence the public's willingness to fund S&T through public investment (Besley forthcoming; Miller, Pardo, and Niwa 1997; Muñoz, Moreno, and Luján 2012), as well as young people's willingness to enter S&T training and choose jobs in S&T (Besley 2015; Losh 2010). Committing resources—whether money to fund science research or time to pursue S&T training—means trusting that such commitments will pay off over the long term for individuals, families, and society. General views about S&T may also help shape opinions about specific technologies and research programs that could enhance lives or pose new risks.

This section presents general indicators of public attitudes and orientations toward S&T in the United States and other countries. It covers information on the perceived promise of and reservations about S&T, overall support for government funding of research, and confidence in scientific community leaders. Overall, the data show that Americans support both S&T and the people involved in S&T.

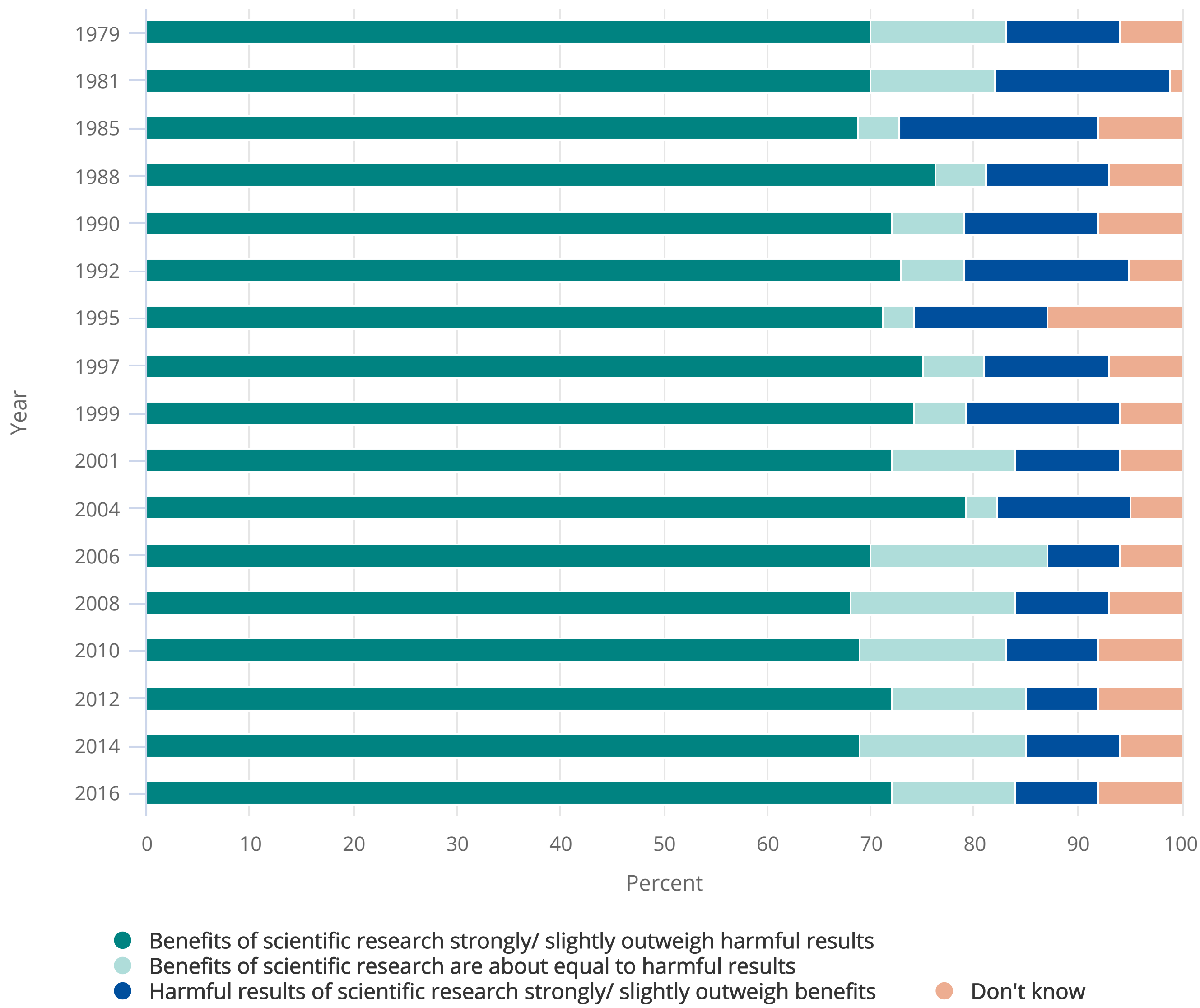
Perceived Promise of and Reservations about S&T

U.S. Patterns and Trends

Overall, Americans remain strong believers in the benefits of S&T even while seeing potential harms. Surveys since at least 1979 show that roughly 7 in 10 Americans have said they believe the effects of scientific research are more positive than negative for society (Figure 7-10; Appendix Table 7-15 and Appendix Table 7-16). In the 2016 GSS, 72% saw more benefits than harms from science, including 45% who said they believed the benefits "strongly outweigh" the negatives and 27% who said the benefits "slightly outweigh" the potential harms. About 8% said science creates more harms than benefits, including 6% who indicated that they thought science caused "slightly" more harm and 2% who thought the balance was "strongly" toward harm.

FIGURE 7-10

Public assessment of scientific research: 1979–2016



Note(s)

Responses to the following: *People have frequently noted that scientific research has produced benefits and harmful results. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?* In this figure, "Benefits...outweigh harmful results" and "Harmful results...outweigh benefits" each combine responses of "strongly outweigh" and "slightly outweigh." Figure includes all years for which data were collected. Percentages may not add to total because of rounding.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan, Survey of Consumer Attitudes (2004); NORC at the University of Chicago, General Social Survey (2006–16). See Appendix Tables 7-15 and 7-16.

Science and Engineering Indicators 2018

Older respondents and those with more education, income, and scientific knowledge are more likely to believe in the benefits of science than others (Appendix Table 7-15). For example, 52% of those who had not completed high school said they believe science does more good than harm, but 84% of those with bachelor's degrees and 94% of those with graduate degrees expressed this view (Appendix Table 7-15).[1]

Americans also overwhelmingly agree that S&T will foster "more opportunities for the next generation." In the 2016 GSS, 91% of Americans "strongly" agreed (39%) or agreed (52%) that S&T will create more opportunities (Appendix Table 7-17). This is up slightly from 2012 and 2014 but consistent with surveys from 2006 through 2010, during which 90%–91% agreed about the relative value of S&T. Overall, belief in opportunity from science has grown from 76% in 1985 (Appendix Table 7-17 and Appendix Table 7-18).

Although Americans are generally positive about science, concern about the speed at which science may be changing "our way of life" remains close to historically high levels. In 2016, about 51% of Americans "strongly" agreed (11%) or agreed (40%) that "science makes our way of life change too fast," percentages similar to those in 2014 (Appendix Table 7-19 and Appendix Table 7-20). Demographic patterns are also similar to those found for the question addressing benefits and harms. Those with less education and less income were more likely to express worry about the pace of change. For example, 59% of those with a high school degree agreed that science was changing life too fast, whereas 41% of those with a graduate degree agreed with this concern. Age, however, was not substantially associated with concerns about the pace of change.

The current high level of concern is similar to that found in 1979, when 53% indicated concern about the pace of change. It is, however, difficult to know if there is an underlying trend because the main increase in concern occurred at the same time (between 2004 and 2008) that the underlying survey switched from a telephone survey to a face-to-face survey. Concern about the pace of change was, nevertheless, lower during much of the 1980s and 1990s.

International Comparisons

Most survey respondents in other countries also generally report strong belief in the value of science, although these beliefs appear to be somewhat higher in the United States. In China, 84% of respondents said in 2015 that they thought S&T would lead to more opportunities for future generations (compared to 91% in the United States for a similar question) (Appendix Table 7-17). About 69% of respondents also said that they thought that "scientific and technological development will create more jobs than [it] will eliminate" (CRISP 2016). In Germany, 10% of respondents agreed that science does more harm than good, and 20% said that science would make life better for future generations. In contrast, 68% said it will lead to both benefits and harms (Wissenschaft im dialog 2016). The responses cannot be directly compared to the United States—where 12% said they believed benefits and harms were about equal (Appendix Table 7-15)—because the equivalent U.S. question does not explicitly give respondents the middle option. Respondents have to volunteer, without prompting, that they see both benefits and harms as equally likely. In Switzerland, 61% of respondents indicated that they generally thought science made life better by selecting 4 or 5 on a 5-point scale, where 1 indicated complete disapproval with a relevant statement and 5 indicated complete approval (Schafer and Metag 2016). Only about a third (34%) also agreed that science makes life move too fast (compared to 51% in the United States). About a third (34%) of Swiss residents also, however, approved of a statement that said the advantages of science and research made it worth the potential damages. In Chile, 39%

of respondents said they thought S&T would bring "many" risks to the world, and another 31% said they thought S&T would bring "some" risks, whereas only 25% said S&T would bring "few risks" or "no risks" (CONICYT 2016).

While not as recent, a 2013 special Eurobarometer on S&T found that, across Europe, large majorities saw substantial benefits from S&T. More than three-quarters (77%) of respondents said they felt that S&T had a "very" (60%) or "fairly" (17%) positive influence on society in their home country (European Commission 2013). Europeans were asked whether they believe S&T would "provide more opportunities for future generations." Three-quarters of Europeans (75%) agreed. A separate 2013 survey indicated that 74% of Canadians agreed that S&T would create more opportunities (CCA 2014). A third GSS question that was included in the 2013 special Eurobarometer focused on whether respondents agreed or disagreed that "science makes our way of life change too fast," for which about 62% of Europeans agreed (European Commission 2013). The 2013 Canadian survey suggested that just 35% of Canadians thought science makes life "change too fast" (CCA 2014).

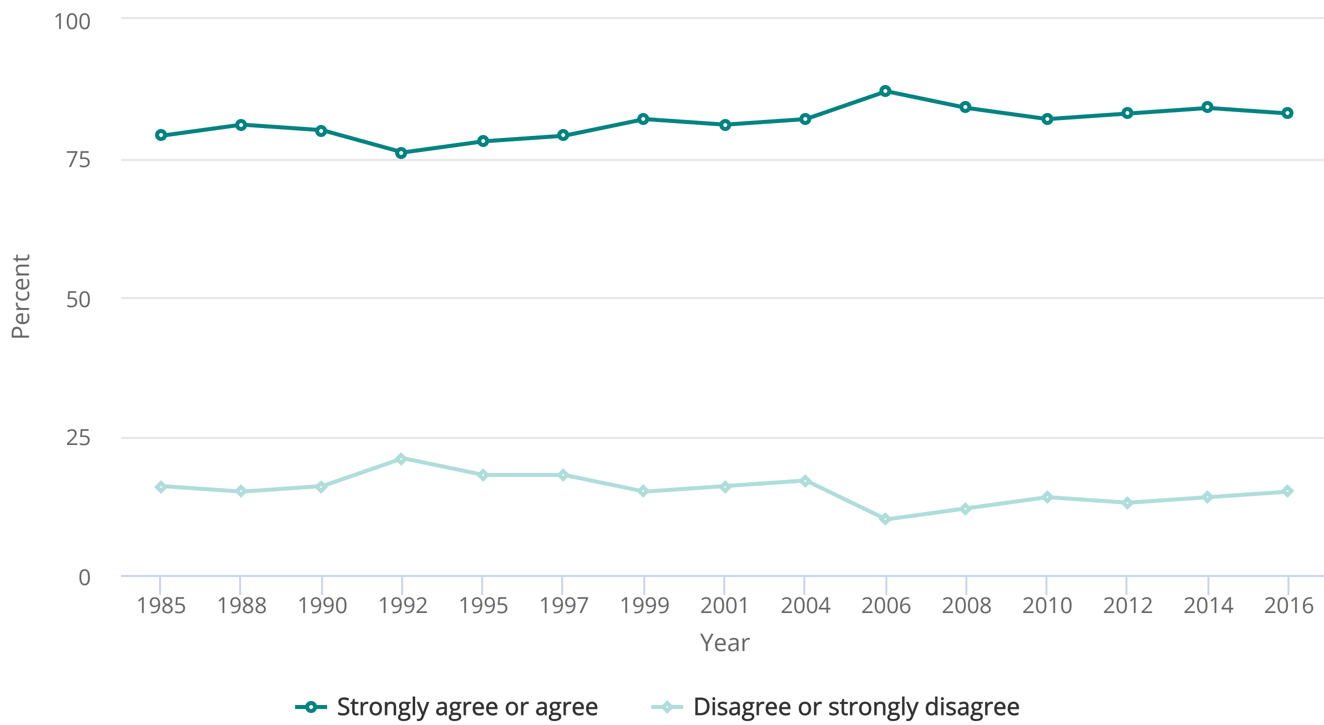
Federal Funding of Scientific Research

U.S. Patterns and Trends

U.S. public opinion has consistently and strongly supported federal spending on scientific research. In the 2016 GSS, 84% of Americans either "strongly agree[d]" (30%) or "agree[d]" (54%) that "even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government" (Figure 7-11; Appendix Table 7-21). This is similar to the percentage in recent years, although it has risen from that found in the 1985–2001 NSF surveys, when the value ranged between 77% (1992) and 82% (1999) (Appendix Table 7-22).

FIGURE 7-11

Public opinion on whether government should fund basic scientific research: 1985–2016



Note(s)

Responses to the following: *Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government. Do you strongly agree, agree, disagree, or strongly disagree?* Responses of "don't know" are not shown.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1985–2001); University of Michigan, Survey of Consumer Attitudes (2004); NORC at the University of Chicago, General Social Survey (2006–16). See Appendix Tables 7-21 and 7-22.

Science and Engineering Indicators 2018

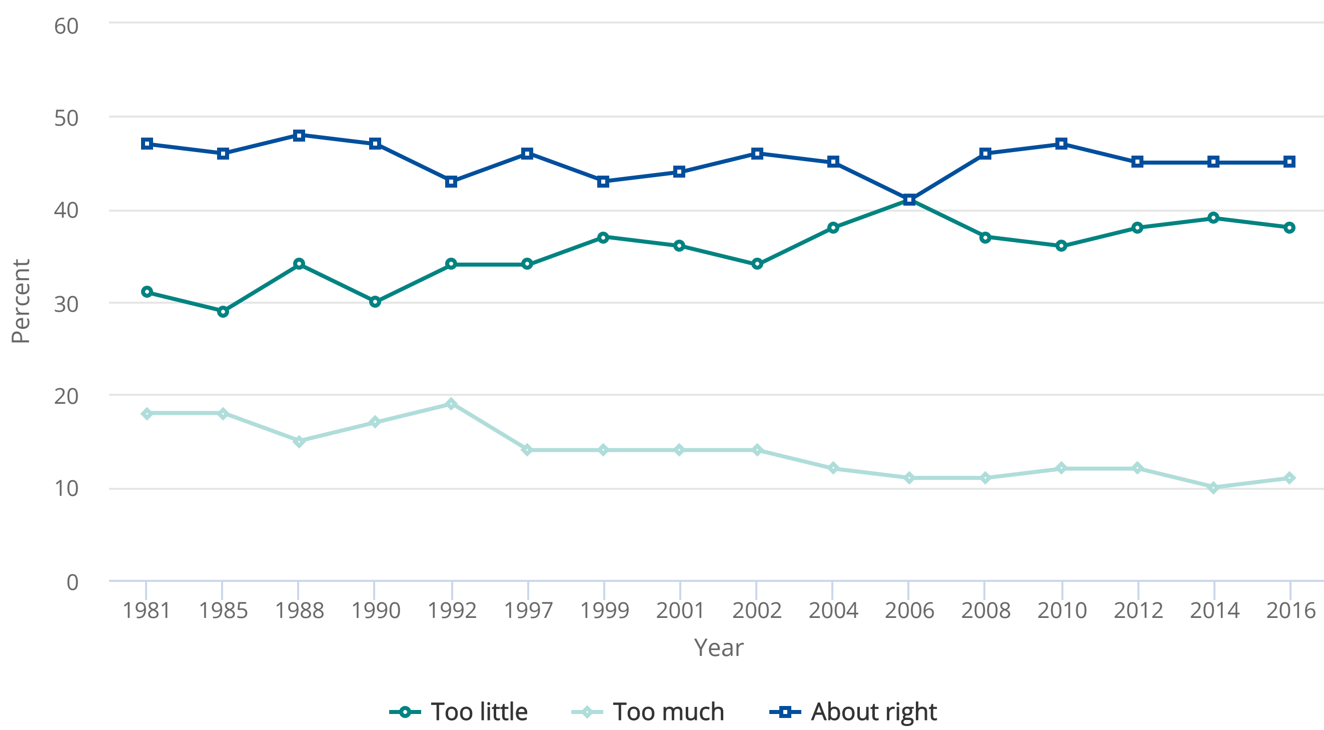
Americans with relatively higher levels of education, more income, and higher scores on the indicators of science knowledge are particularly likely to support funding scientific research. For example, 77% of those for whom high school was their highest level of completed education agreed that funding was needed, but 88% of those with a bachelor's as their highest degree expressed this view (Appendix Table 7-21).

The Pew Research Center (Funk, Rainie, and Page 2015) also found that, in 2014, most Americans said they think that "government investments" in both basic scientific research (71%) and engineering and technology (72%) "pay off in the long run." Overall, 61% of Americans told the Pew Research Center that they thought "government investment in research is essential for scientific progress."

Another indicator of views about S&T is the percentage of Americans who say they "think we're spending too little money" on supporting scientific research and related topics. The 2016 GSS found that 38% of respondents said we are spending "too little" on scientific research, while 45% said the amount was "about right." About 11% said it was "too much" (Figure 7-12; Appendix Table 7-23 and Appendix Table 7-24). In other words, 83% of Americans say they would like to see similar or increased funding for S&T in the years ahead (although the question does not specify who should be responsible for providing this spending). The percentage who said they thought we spend too little on science gradually increased from 1981 to 2006, fluctuating between 29% and 34% in the 1980s, between 30% and 37% in the 1990s, and then varying between 34% and 41% in the 2000s and 2010s. Also, as noted previously, older residents, those with more education, and those with more income were more likely to say that they believe too little is being spent on science.

FIGURE 7-12

Public assessment of amount of spending for scientific research: 1981–2016



Note(s)

Responses to the following: *We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one, I'd like you to tell me if you think we're spending too little money on it, about the right amount, or too much: [scientific research].* Responses of "right amount" and "don't know" are not shown.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1981–2001); University of Michigan, Survey of Consumer Attitudes (2004); NORC at the University of Chicago, General Social Survey (2006–16). See Appendix Table 7-23.

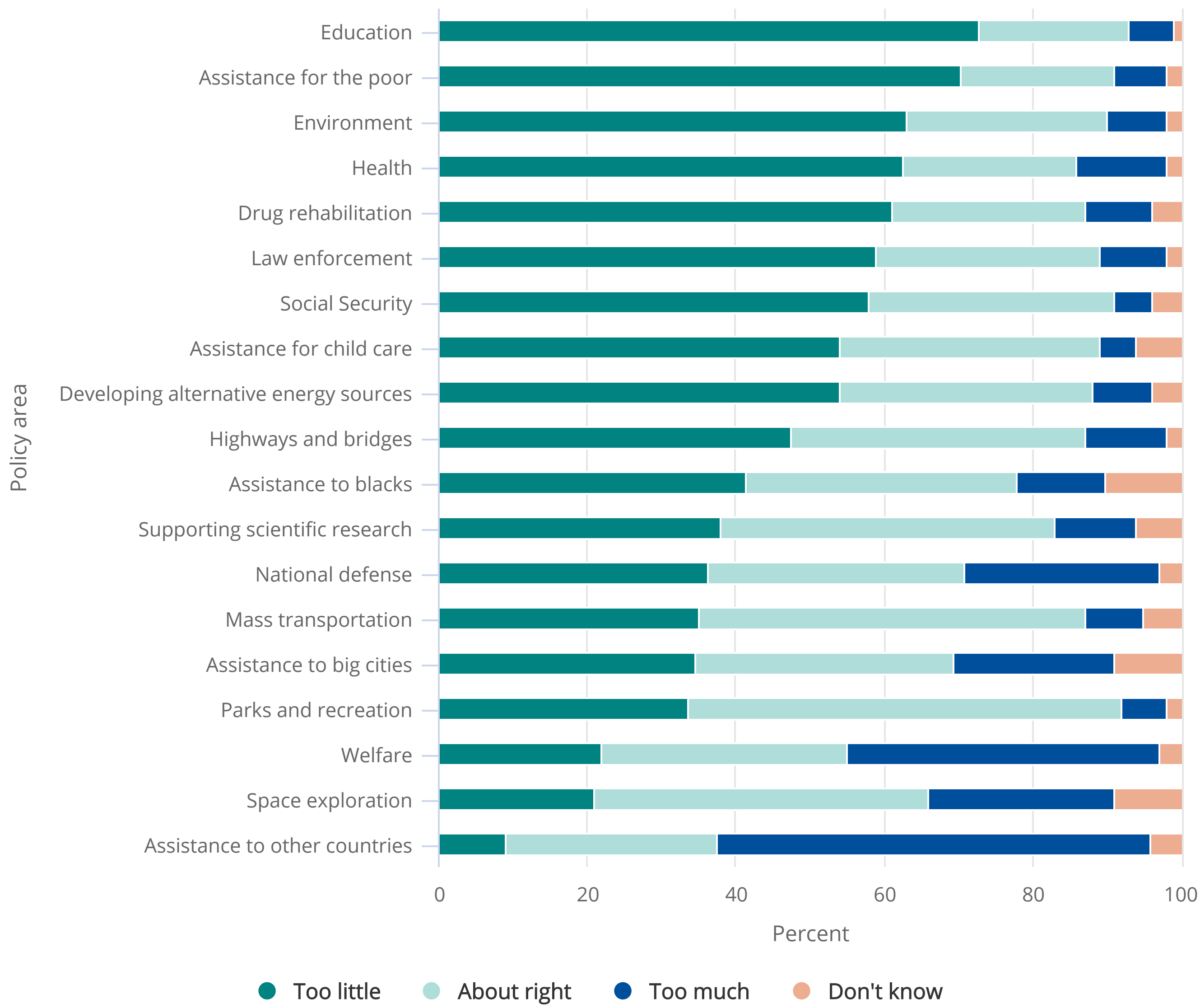
Science and Engineering Indicators 2018

Other S&T domains in which Americans consistently think there is too little spending according to the 2016 GSS include health (62%) (Appendix Table 7-25), improving the environment (63%) (Appendix Table 7-26), and space (21%) (Appendix Table 7-27). Space exploration is one of the areas for which the smallest proportion of Americans see too little spending (Figure 7-13).

Compared with support for spending in other areas, however, support for spending on scientific research may not be especially strong. In the 2016 GSS, Americans were more likely to say several other policy domains need spending more than does S&T (Figure 7-13). Although 38% of Americans say we spend “too little” on scientific research, education has consistently been the domain that Americans are most likely to say receives too little funding, with 72% giving this response in 2016.

FIGURE 7-13

Public attitudes toward spending in various policy areas: 2016



Note(s)

Responses to the following: *We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one I'd like you to tell me if you think we're spending too little money on it, about the right amount, or too much.* Percentages may not add to 100% because of rounding.

Source(s)

NORC at the University of Chicago, General Social Survey (2016). See Appendix Table 7-23.

Science and Engineering Indicators 2018

International Comparisons

Respondents in all other countries for which there are data, including both developed and developing countries, also support funding for scientific research. In China, 77% said science should be funded, even if it provides no benefits (compared to 83% for the equivalent question in the United States). In Germany, 49% indicated that, even if the government had to cut spending, it should try to maintain funding for scientific research. Another 45% said research for funding should be cut about the same amount as cuts to other areas (Wissenschaft im dialog 2016). In Switzerland, 73% gave a response of 4 or 5, where 5 indicated "total approval" and 1 indicated "complete disapproval" when presented with a statement about the need to fund science, even without immediate returns. The same proportion (73%) indicated approval for a more general statement that the government should fund scientific research (Schafer and Metag 2016). In Finland, 74% said they believe that investing in science was worthwhile (FSSI 2016). In South America, 91% of Chilean respondents said they agreed that the government should increase funding for scientific research, similar to surveys over the previous decade (CONICYT 2016).

More generally, a broad survey of Europeans found strong support for spending on scientific research in the past. For example, in 2010, 72% of Europeans agreed that scientific research should be supported even in the absence of immediate benefits (European Commission 2010a). A 2013 survey of Canadians similarly found that 76% of respondents said they thought the government should support scientific research (CCA 2014).

Confidence in the Science Community's Leadership

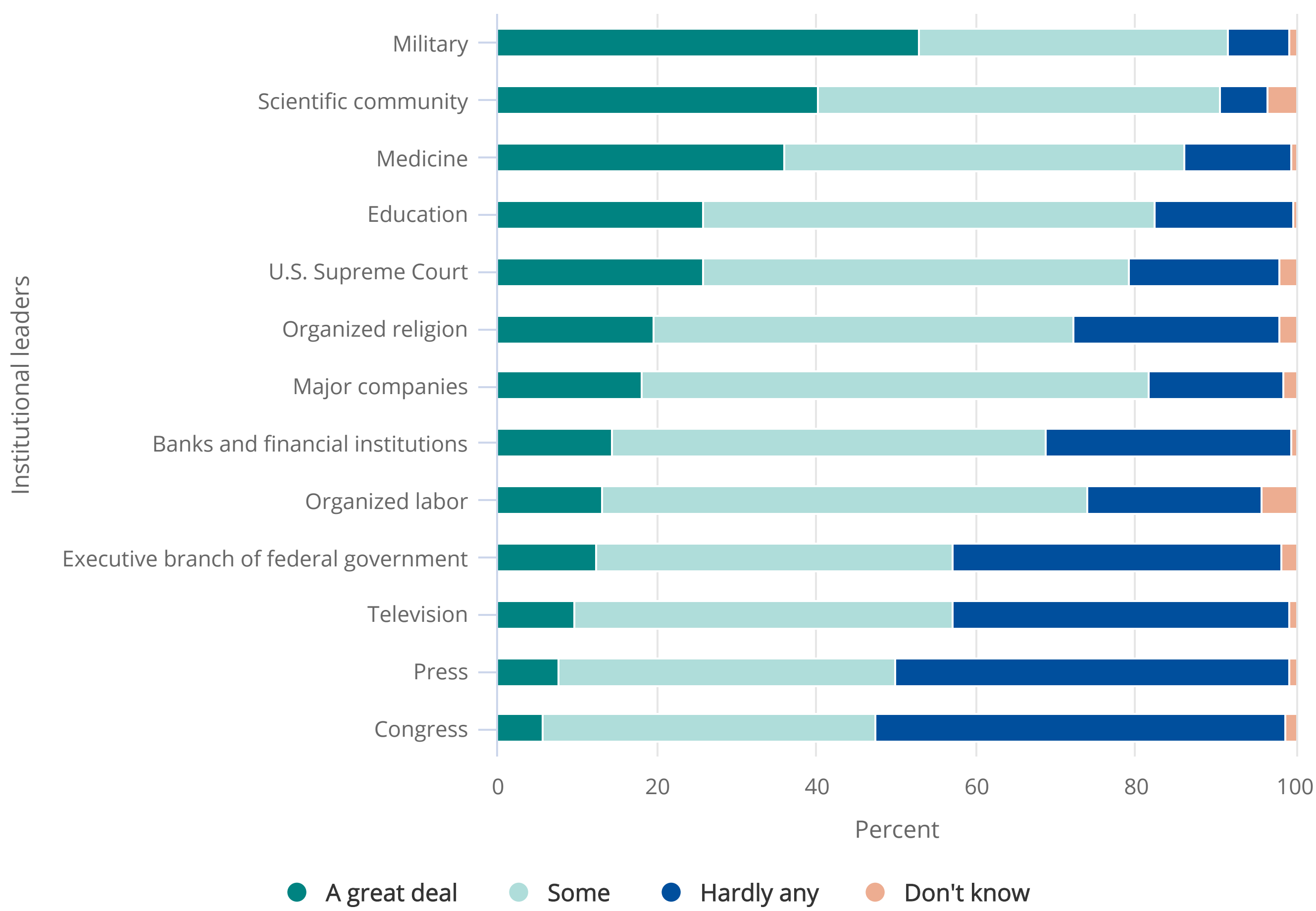
U.S. Patterns and Trends

Few members of the public have the background knowledge or resources to fully evaluate evidence related to scientific questions in the public sphere. People, therefore, often rely on how they perceive decision makers and other cues as decision aids (Fiske and Dupree 2014). The public is also more likely to pay attention to quality information communicated by sources they see as trustworthy in terms of expertise, honesty, and shared identity (Kruglanski and Thompson 1999; Roskos-Ewoldsen, Bichsel, and Hoffman 2002). Public confidence in leaders of the scientific community should therefore increase the likelihood of public acceptance of findings and conclusions based on scientific research, although other factors also matter.

Since 1973, the GSS has tracked public confidence in the leadership of various institutions, including the scientific community. The GSS asks respondents whether they have "a great deal of confidence," "only some confidence," or "hardly any confidence at all" in the leaders of different institutions. In 2016, 40% of Americans expressed "a great deal of confidence" in leaders of the scientific community, 50% expressed "only some confidence," and 6% expressed "hardly any confidence at all" (Figure 7-14). These results are nearly identical to recent years (Figure 7-15; Appendix Table 7-28). In general, men (45%) are more likely to have a "great deal of confidence" in the scientific community than women (36%). Also, those with more education and income are more confident than those with less, and young respondents are more confident than older respondents (Appendix Table 7-29). Some recent research suggests that political views are increasingly related to confidence in science (Gauchat 2012; McCright et al. 2013). Other research suggests a racial gap in confidence (Plutzer 2013).

FIGURE 7-14

Public confidence in institutional leaders, by type of institution: 2016



Note(s)

Responses to the following: *As far as the people running these institutions are concerned, would you say that you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?* Percentages may not add to 100% because of rounding.

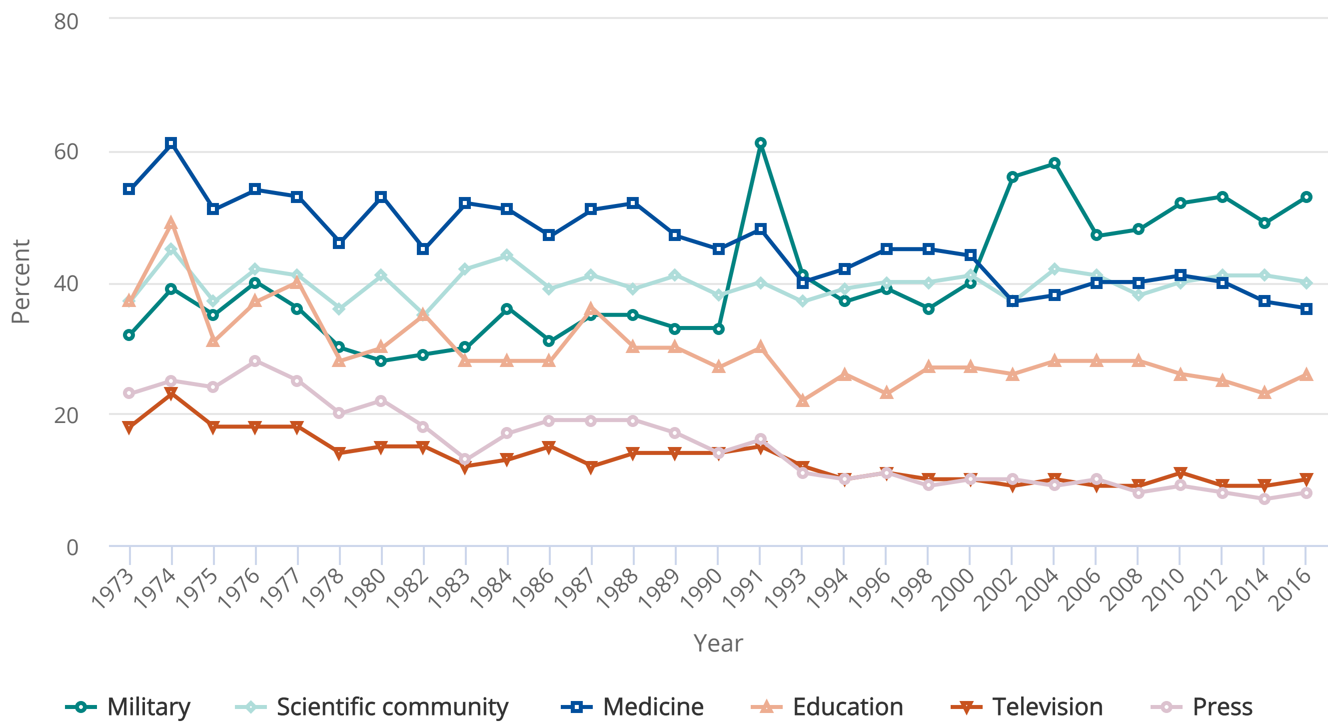
Source(s)

NORC at the University of Chicago, General Social Survey (2016). See Appendix Table 7-28.

Science and Engineering Indicators 2018

FIGURE 7-15

Public confidence in institutional leaders, by selected institution: 1973–2016



Note(s)

Responses to the following: *As far as the people running these institutions are concerned, would you say that you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?* Figure shows only responses for "a great deal of confidence."

Source(s)

NORC at the University of Chicago, General Social Survey (1973–2016). See Appendix Table 7-28.

Science and Engineering Indicators 2018

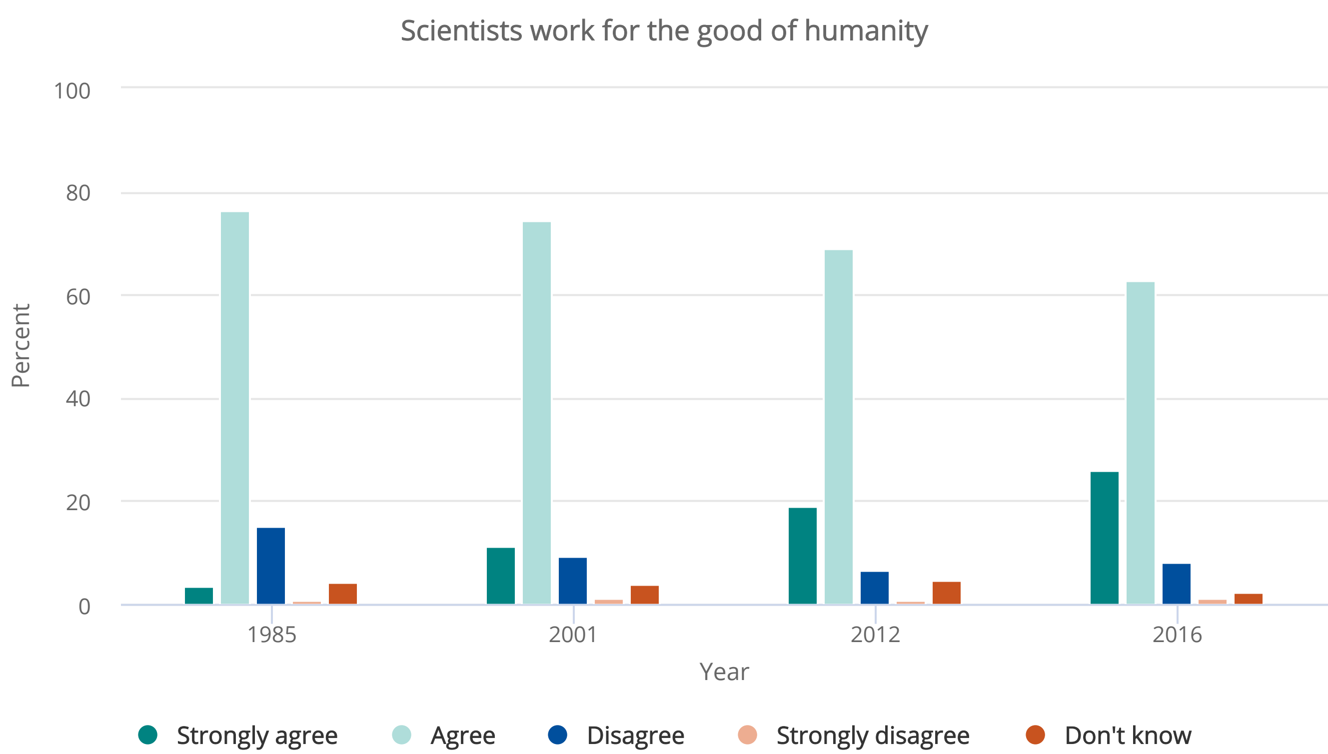
These results also suggest that leaders of the scientific community compare well with leaders of other institutions in America. Only military leaders held greater public confidence in 2016, with 53% of Americans saying they had a “great deal of confidence” in them (Figure 7-14). Most other groups, unlike scientists and the military, have also seen an erosion in public confidence, with the most substantial decreases occurring between the 1970s and 1990s (Appendix Table 7-28 and Appendix Table 7-29).

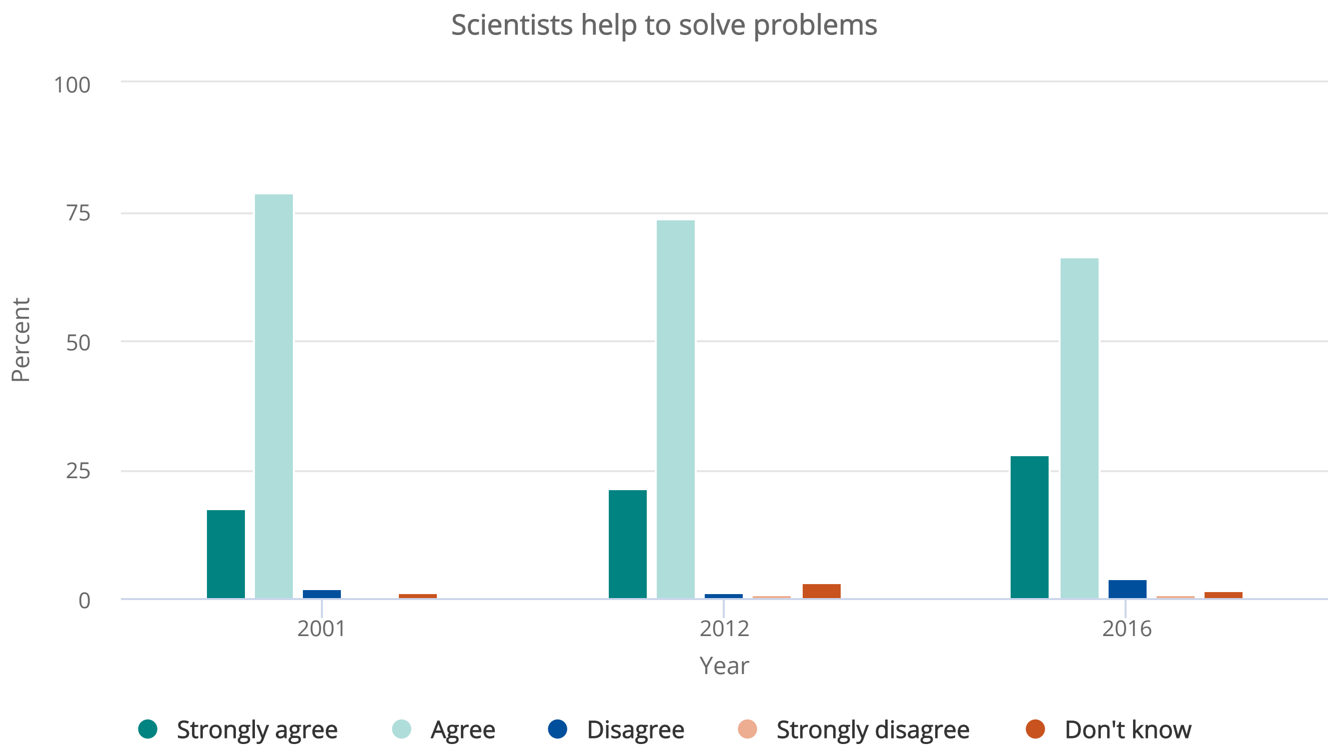
The medical community, which is the only group besides scientists in the survey with a clear S&T focus, is one of the institutions that has seen a substantial decline in perceived confidence. Whereas the percentage of Americans saying they place a “great deal of confidence” in the scientific community has stayed relatively stable since the 1970s, the percentage expressing such confidence in the medical community has fallen from consistently above 50% in the 1970s and 1980s to 37% in 2014 and 36% in 2016 (Figure 7-15).

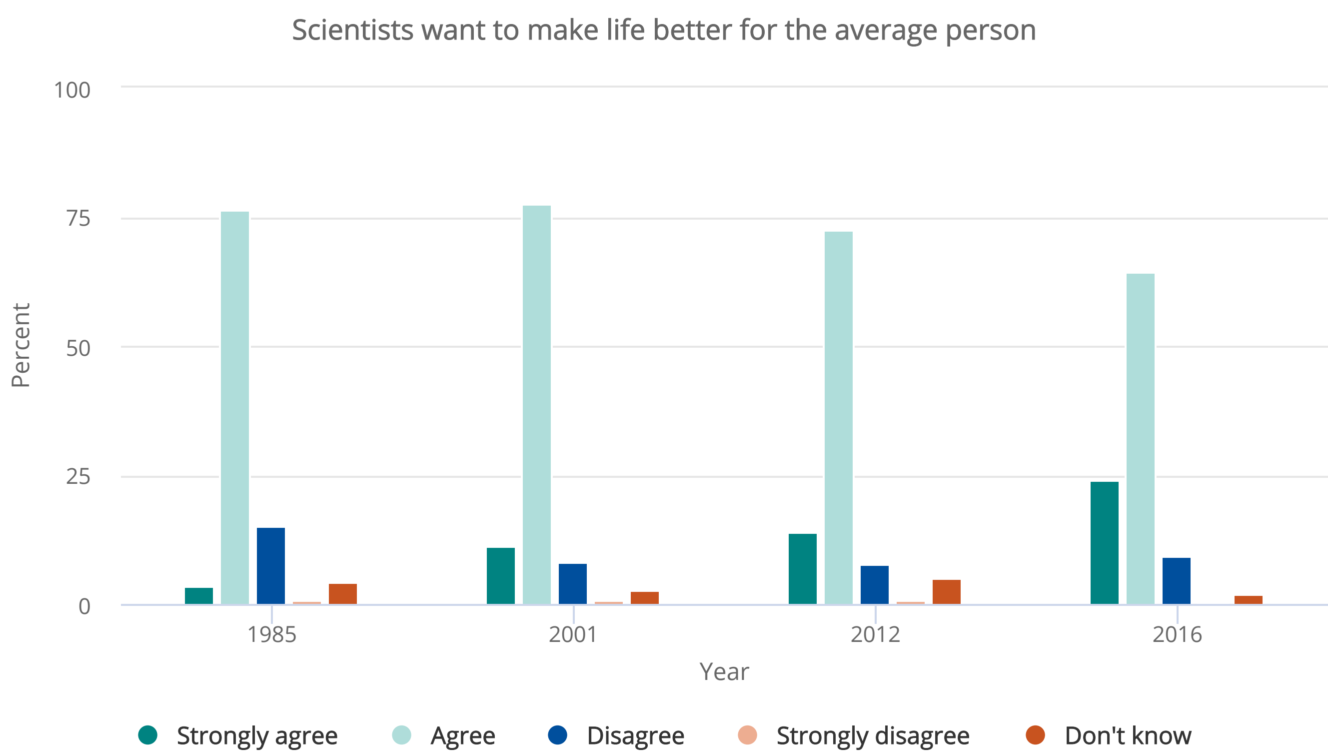
The 2016 GSS also included a set of specific questions aimed at capturing a more detailed understanding of how Americans see scientists. The responses to these questions reinforce the idea that scientists are seen as both competent and working to benefit society. Specifically, in 2016, 89% of Americans agreed that scientists were working toward the public good, and 88% agreed that scientists wanted to make life better for the average person (Figure 7-16; Appendix Table 7-30 and Appendix Table 7-31). Similarly, 94% of Americans agreed that scientists are "helping to solve challenging problems." Further, while the overall percentage of respondents agreeing has generally stayed stable or improved over time, the percentage "strongly" agreeing has increased substantially. For example, in 2001, 17% of respondents "strongly" agreed that scientists help solve problems, but 28% gave this response in 2016. The percentage of Americans "strongly" agreeing that scientists work for the good of humanity and make life better has also increased since 2001.

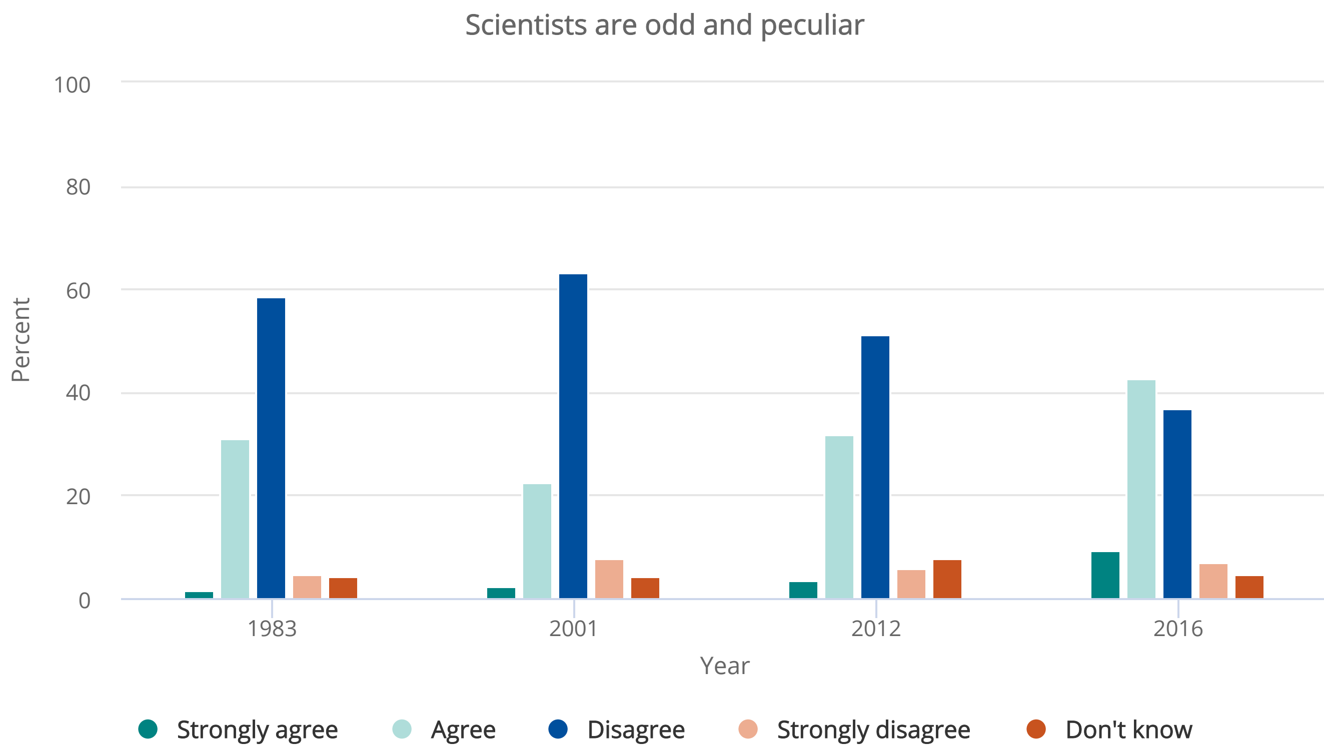
FIGURE 7-16

Public views about scientists: Selected years, 1983–2016




Scientists help to solve problems
100
75
50
25
0
Percent
2001
2012
2016
Year
Strongly agree
Agree
Disagree
Strongly disagree
Don't know


Scientists want to make life better for the average person
100
75
50
25
0
Percent
1985
2001
2012
2016
Year
Strongly agree
Agree
Disagree
Strongly disagree
Don't know



Note(s)

Responses to the statements *Scientific researchers are dedicated people who work for the good of humanity*; *Scientists are helping to solve challenging problems*; *Most scientists want to work on things that will make life better for the average person*; *Scientists are apt to be odd and peculiar people*. Percentages may not add to 100% because of rounding and because refusals to respond are not shown.

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1983, 1985, 2001); NORC at the University of Chicago, General Social Survey (2012, 2016). See Appendix Table 7-30.

Science and Engineering Indicators 2018

One less positive trend for how scientists are viewed emerged, however, for a question focused on whether Americans see scientists as “odd and peculiar people.” In 2016, about 52% of Americans “strongly agree[d]” (9%) or “agree[d]” (43%) that “scientists are apt to be odd and peculiar people.” This is up from 36% in 2012 and 24% at its lowest, in 2001. Further, in 2016, 58% of those whose highest degree was high school agreed that scientists are “odd and peculiar,” compared to 37% of those with graduate or professional degrees.

The Pew Research Center has also asked about trust in science in specific contexts across three 2016 surveys and has generally found that scientists are more trusted than other groups. For example, 78% of respondents said they had “a lot” (35%) or “some” (43%) trust in scientists to give “full and accurate information about the health risks and benefits of eating genetically modified food.” In comparison, if the categories “a lot” and “some” are combined, 45% said they would trust the “news media,” 42% said they would trust “food industry leaders,” and 25% said they would trust “elected officials” (Funk and

Kennedy 2016b). In another study, 78% said they trusted "climate scientists" to give complete information about "the causes of global climate change," whereas 44% said they would trust the news media, 41% said they would trust "energy industry leaders," and about 29% said they would trust "elected officials" (Funk and Kennedy 2016a). Finally, the same pattern was evident when Americans were asked about childhood vaccines for measles, mumps, and rubella. About 90% of Americans said they would trust "medical scientists," compared to 42% for the "news media," 49% for pharmaceutical industry leaders," and 32% for "elected officials" (Funk, Kennedy, and Hefferon 2017).

International Comparisons

Residents of other countries also typically indicate they have positive views about scientists, although the available questions vary substantially, making direct comparison difficult. In China, 41% of respondents said they saw science as an occupation with a positive reputation, and 31% said the same about engineers (CRISP 2016). Only teachers (56%) and doctors (53%) were seen more positively than scientists. In Switzerland, using a 5-point scale, 57% of respondents indicated that they had confidence in scientists, in general, while 63% indicated they had confidence in university scientists and 35% indicated they had confidence in industry scientists (Schafer and Metag 2016). In Finland, 75% of respondents said they had "very" or "fairly" high trust in universities and colleges, and 66% of respondents said they trusted scientific research and the scientific community (FSSI 2016). In South America, 80% of Argentinians said they have a lot of confidence in scientists as sources of information, and 65% said they see being a scientist as prestigious (MCTIP 2015). In Chile, 79% indicated they saw S&E careers as prestigious, with only medicine (85%) being seen as more prestigious (CONICYT 2016).

Some surveys also found evidence of concern about the degree to which scientists communicate with the broader public. In Germany, only 39% of respondents agreed that scientists communicate enough about their work (Wissenschaft im dialog 2016). Similarly, in Switzerland, 45% of survey respondents indicated that they thought scientists should listen more to what ordinary people think (Schafer and Metag 2016). In South America, 62% of Chilean respondents indicated that they felt scientists do not adequately inform the public about the scientists' research (CONICYT 2016).

The German survey did not include questions about general trust in scientists and instead focused on trust related to specific issues (Wissenschaft im dialog 2016). The survey found that while 53% of respondents said they trusted scientists on the topic of renewable energy, trust dropped to 40% when respondents were asked about climate change and 17% when respondents were asked about genetic engineering of plants (i.e., genetically modified foods).

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[1] Methodological issues make fine-grained comparisons of data from different survey years particularly difficult for this question. For example, although the question content and interviewer instructions were identical in 2004 and 2006, the percentage of respondents who volunteered "about equal" (an answer not among the choices given) was substantially different. This difference may have been produced by the change from telephone interviews in 2004 to in-person interviews in 2006 (although telephone interviews in 2001 produced results that are similar to those in 2006). More likely, customary interviewing practices in the three different organizations that administered the surveys affected their interviewers' willingness to accept responses other than those that were specifically offered on the interview form, including "don't know" responses.

Public Attitudes about Specific S&T-Related Issues

In addition to general views about S&T, people also develop views about specific issues and topics, and these views can shape behavior. While Americans appear to have relatively stable, positive views about science in general, there is less stability in how they think and feel about specific issues. The available data suggest that Americans may be increasingly worried about the environment and specific areas of technology with potential health or environmental implications. Such specific attitudes are often shaped by general attitudes and knowledge, but this is not always the case (see sidebar The Relationship between General and Specific Attitudes about S&T). Attitudes about emerging areas of research and new technologies may influence innovation activity in important ways. For example, the climate of opinion about research areas such as biotechnology, energy, or other topics can shape public and private investment in these areas. Ultimately, such views might affect the individual or societal adoption of new technologies and the growth of industries based on these technologies.

Nevertheless, public opinion about new S&T developments rarely translates directly into actions or policy. Instead, institutions attempt to assess what the public believes and may magnify or minimize the effects of divisions in public opinion on policy (Jasanoff 2005). The public's attitudes about specific S&T issues such as climate change and biotechnology can differ markedly from the views of scientists, according to the Pew Research Center (Funk, Rainie, and Page 2015). This is partly because attitudes toward S&T involve a multitude of factors, not just knowledge or understanding of the relevant science (NASEM 2016a). Values, attitudes, and many other factors come into play, and judgments about scientific facts may become secondary or even be shaped by those values or attitudes (Kahan, Jenkins-Smith, and Braman 2011).

This section describes views on environmental issues, including global climate change, nuclear power, and energy development; genetically engineered food; nanotechnology; cloning and stem cell research; and animal research. A sidebar also addresses views about privacy in a digital world, a subject for which public opinion data are only beginning to become available (see sidebar Americans' Attitudes toward Information Privacy in the World of Big Data). Previous versions of *Indicators* have also included data on topics such as synthetic biology and views about science education, but these are not included here because of a lack of new national data from representative surveys. As with the rest of *Indicators*, the focus is on descriptive statistics for key indicators that became available since the previous report (NSB 2016), including trends and between-group differences. Where appropriate, academic research on the origins of opinions or their effects is cited to provide context. International data are provided, where possible, but there are several issues for which there is little recent available information.

SIDEBAR

The Relationship between General and Specific Attitudes about S&T

Attitudes about specific issues, such as genetic engineering, nanotechnology, and genetically modified (GM) food, can be based on general attitudes and knowledge, but this is not always the case. An analysis of the relationship between general and specific attitudes about S&T finds that the association between the two is, at best, small.

The NSF S&T survey on which the current chapter is largely based has typically focused on general knowledge and attitudes toward science, and the chapter has relied on data from organizations such as Gallup and the Pew Research Center to discuss specific S&T attitudes. However, the 2016 NSF S&T survey included several questions about specific issues that were drawn from past rounds of the GSS.

In looking at the relationship between general and specific attitudes, no attempt is made to suggest that one type of attitude caused the other because it seems possible that respondents may sometimes use their views about specific S&T issues and technologies to develop an overall view about S&T, and vice versa.

Researchers interested in the relationship between the two types of survey questions examine how closely the two move together, on average.

The NSF S&T survey has a 5-point measure of whether the respondent believes that scientific research has produced benefits or harmful results. Each respondent is marked as choosing 1 of 5 responses ranging from believing the harm benefit balance is "strongly in favor" of harm or "strongly in favor" of benefits (see Perceived Promise and Reservations about S&T).

Similarly, respondents in the current survey could indicate the degree to which they believed that pollution of America's rivers, lakes, and streams was between "not dangerous" and "extremely dangerous" using 1 of 5 response options.

There is little relationship between these two measures, however. On average, when a respondent's belief in the benefits of science goes up by a point, there is less than a 0.01-point shift in views about the danger of water pollution. Similarly, a 1-point change in views about the benefits or harms of science is associated with a less than 0.01-point average shift in views about the danger of industrial air pollution and global warming.

There was also no meaningful relationship between the three environment-focused questions and the degree to which respondents said they disagreed or agreed that science was making life change too fast or creating opportunities for future generations (see Perceived Promise and Reservations about S&T for the exact questions).

There were, however, small meaningful relationships between general science attitudes and attitudes about specific technologies such as nuclear energy, genetic engineering, and nanotechnology (all of which were measured with 5-point response options focused on perceived danger).

For GM foods and nuclear energy, a 1-point change in perceived general benefits of S&T was associated with about a 0.2-point average decrease in perceived technological danger. Similarly, 1-point changes in the belief that S&T would result in more opportunities for future generations or that science was *not* making our life change too fast were associated with about 0.2-point changes in perceived danger of GM foods and nuclear energy.

For nanotechnology, a 1-point change in perceived benefits (versus harms) was associated with a 0.3-point increase in belief that science would make life better and a 0.5-point decrease in the belief that science is making life change too fast.

The slightly larger relationship between views about nanotechnology and general attitudes about science may reflect the fact that respondents are more likely to draw on their general attitudes when faced with questions about a relatively novel technology.*

* Also of note is that the relationships between general attitudes about science and attitudes about specific technologies tend to remain statistically meaningful even after statistically controlling for general education level and the number of mathematics and science courses the respondent took in high school and college.

SIDEBAR

Americans' Attitudes toward Information Privacy in the World of Big Data

Public and private organizations are collecting an unprecedented amount of data, what many call *big data*, on Americans through social media, Internet logs and trackers, sensor networks, and, increasingly, the Internet of Things (i.e., Internet-connected refrigerators, thermostats, lamps, watches, transportation systems, smart city sensor networks, surveillance devices, etc.). These developments offer the promise of a future in which government and business can more easily identify and address consumer and citizen needs and understand societal problems. Simultaneously, however, big data raises questions about the protection of privacy and possible adverse uses of personal information.

Surveys indicate that Americans highly value information privacy, both in terms of what is gathered and by whom. Trust in the integrity of the data gathering agents is low. Most Americans claim to have reduced their online visibility, but more than half—and up to three-quarters—register lack of knowledge of privacy tools and how to employ them. Despite saying they value information privacy, Americans readily share information, a puzzle that researchers call the *privacy paradox*.

The Importance of Privacy

Most Americans indicate in surveys that information privacy is "very important" to them. In a 2015 survey, about three-fourths of respondents (74%) indicated it was very important for them to control *who* can get information about them, and 65% considered it very important to control *what* information is collected about them (Madden and Rainie 2015). Ninety percent or more said that these types of control are somewhat important to very important.

Perceived Privacy Threats

While Americans view privacy as important, they also believe their privacy is threatened. In 2013, only 9% of Americans surveyed said they believed they have "a lot" of control over the information collected about them by electronic means in daily life. About half of Internet users among those surveyed worried about how much information is available about them online in 2013, an increase over the 33% who said they were worried in 2009 (Rainie et al. 2013).

In a 2014 poll, few people trusted that various organizations would keep their personal information secure. Two percent of Americans expressed trust in social networking websites or applications; 6% trusted online retailers; and 12%–19% trusted federal or state governments, e-mail providers, and cellphone carriers. At the high end, 26% trusted health insurance companies, and 39% banks and credit card companies (Fleming and Kampf 2016; Madden and Rainie 2015).

Adaptation

Given their belief in the importance of privacy and concerns about threats to privacy, Americans may adapt their behavior to improve their privacy. The vast majority (86%) of Internet users said they had taken steps to reduce their visibility online (Rainie et al. 2013). Further, people's reported willingness to share private information appears to vary by context, including which organization is getting the information, what the organization will do with it, and what the consumer gets in return (Rainie and Duggan 2016). Young adults (18–29 years old) reported being more likely than other age groups to seek greater anonymity online (Madden and Smith 2010; Rainie et al. 2013).

The Challenges of Adaptation

Despite saying they have taken steps to improve their privacy online, Americans feel they should do more but are unclear on just what to do. In a 2014 survey, about 61% of respondents said they felt they "would like to do more" (Madden 2014). In a 2015 survey, however, 54% indicated that finding tools to improve their privacy was "somewhat" or "very" difficult, and many said they were unaware of specific privacy tools (Rainie and Madden 2015). Seventy-four percent disagreed or strongly disagreed that it was easy for them to be anonymous online, with larger percentages of more knowledgeable users disagreeing more strongly (Madden 2014). Nearly half of Americans in a 2015 survey indicated they were not confident they understood how their data would be used when deciding whether to share it (Pew Research Center 2015b).

Researchers who study privacy have found a *privacy paradox*—while people indicate strong general concern over privacy, observations of their actual behavior show that they readily divulge personal information (Smith, Diney, and Heng 2011; Wilson and Valacich 2012). They give such information in exchange for small discounts, personalization, online social interaction, and other inducements (Chellappa and Sin 2005; Norberg, Horne, and Horne 2007; Pötzsch 2009; Spiekermann, Grossklags, and Berendt 2001).

Privacy researchers have proposed several potential explanations for this apparent paradox, including concerns that conventional surveys do not obtain adequately considered opinions, thus giving an exaggerated impression of people's privacy concerns in real decision making (Baek 2014). When divulging private information, people get few indications about potential privacy dangers but do receive clear indications about benefits and the apparent trustworthiness of the organization asking for information (Acquisti, Brandimarte, and Loewenstein 2015; Li, Sarathy, and Xu 2011; Norberg, Horne, and Horne 2007; Pötzsch 2009; Wilson and Valacich 2012). People are not sufficiently knowledgeable or certain about how technology affects privacy (Acquisti, Brandimarte, and Loewenstein 2015; Pötzsch 2009). Also, people ignore future risk or are unable to weigh the complex benefits and costs of sharing information (Acquisti 2009; Acquisti and Grossklags 2003; Tsai et al. 2011; Wilson and Valacich 2012). Researchers disagree as to whether people's attitudes or behaviors are better guides to their rational preferences.

Many technology experts believe that the public will experience greater difficulty protecting their privacy as technology progresses (Rainie and Anderson 2014). In 2014, 64% of the public said they wanted government to "do more to regulate what advertisers do with customers' personal information," according to the Pew Research Center (Madden 2014).

Environment

This section provides information on the public's views about the environment, specific environmental issues, energy technologies, and climate. Overall, the evidence suggests that, while general views about S&T are largely stable, Americans recently have become more concerned about a wide range of environmental issues. Some of these issues—especially climate change and energy technologies—are often the subject of public policy debate and news interest.

Overall Concern about Environmental Quality

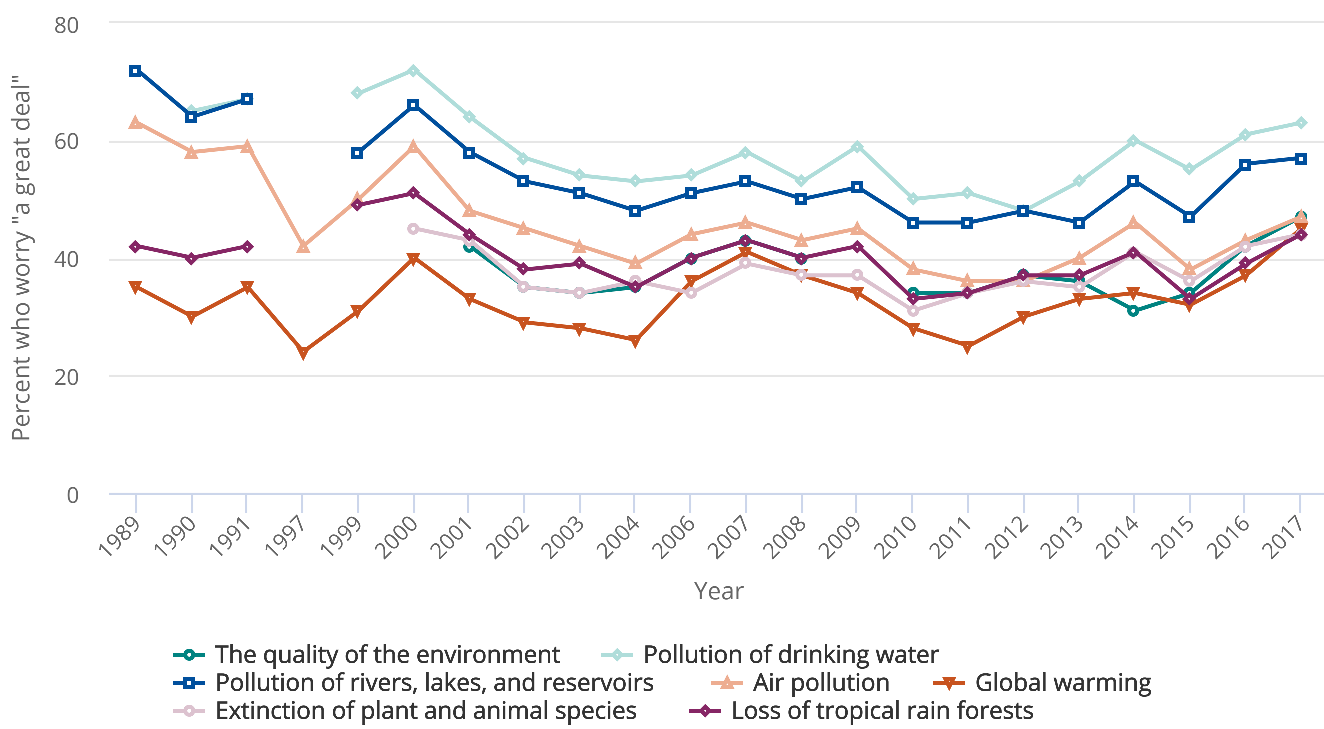
U.S. Patterns and Trends

Overall, measured U.S. concern about the environment appeared to reach a new high in 2017, just 3 years after hitting a historic low. In 2017, about 47% of respondents said that they personally worry a "great deal" about the quality of the environment (Gallup 2017b) (Figure 7-17). Another 30% said they worried a "fair amount." The previous high had been the 43% who expressed a "great deal" of worry in 2007, while the previous low had been 31% in 2014. The percentage of Americans saying that the quality of the environment is getting worse grew to 56% in 2016 and 57% in 2017 after hovering between 49% and 51% between 2009 and 2015. The current level of belief in a worsening environment is still relatively low compared to 2008, when 68% of Americans said they thought the environment was getting worse. And, while worry about the future is high, Americans' rating of the current overall quality of the environment was similar to historical averages in 2016. About 46% rated the environment as excellent (6%) or good (40%), similar to previous years.

For comparison, the availability and affordability of health care was the issue with which the highest proportion of Americans expressed a "great deal" of worry in 2017 (57%) (Newport 2017). The percentage expressing a "great deal" of worry about the environment (47%) was similar to a number of other issues, including crime and violence (47%), hunger and homelessness (47%), the economy (46%), and federal spending and the budget deficit (49%).

FIGURE 7-17

Concern about specific environmental issues: 1989–2017



Note(s)

Data are not available for all years. Responses to the following: *How much do you personally worry about [specific environmental issues]: a great deal, a fair amount, only a little, or not at all?* Figure shows only responses for "a great deal." Poll is conducted annually in March.

Source(s)

Gallup, Climate Change: Environment, http://www.gallup.com/poll/1615/environment.aspx#, accessed 12 April 2017.

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International Comparisons

Within Europe, a 2014 Eurobarometer survey on the environment included a broad range of questions about attitudes and behavior (European Commission 2014b). As is often the case with international data, these questions are not always directly comparable to those for the United States in terms of wording and how respondents are selected for inclusion in a survey. Overall, 95% of Europeans said that protecting the environment was “very important” (53%) or “fairly important” (42%), similar to 2011 (94%). About three-quarters of respondents (77%) also indicated that they “totally agreed” (35%) or “tend[ed]” to agree that environmental issues have a direct impact on their daily life. This was also stable from 2011 when 76% agreed (see [NSB 2016] for a discussion of specific countries).

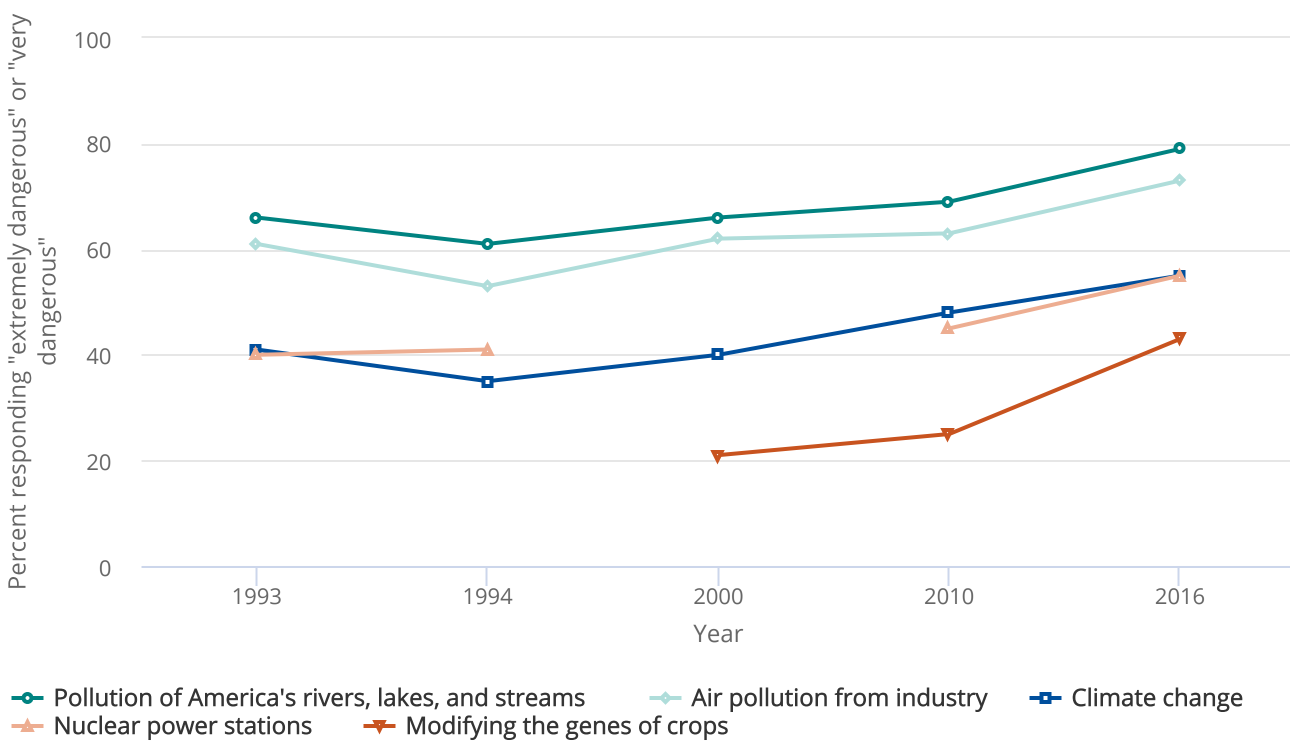
Assessment of Specific Environmental Problems

U.S. Patterns and Trends

The 2016 GSS included several questions about specific environmental issues. These questions had previously appeared as part of the GSS in 1993, 1994, 2000, and 2010, and this makes it possible to provide a limited discussion of possible changes over time (Figure 7-18; Appendix Table 7-32 and Appendix Table 7-33). Gallup collects annual data on public opinion about a wide range of environmental issues against which the GSS can sometimes be compared. In addition to the specific findings, it is noteworthy that worry about specific environmental issues move together over time along with worry about the overall quality of the environment.

FIGURE 7-18

Perceived danger of specific health and environmental issues: Selected years, 1993–2016



Note(s)

Data are not available for all years. Data show the percentage of respondents giving a response of "extremely dangerous" or "very dangerous" to the following questions: *In general, do you think that pollution of America's rivers, lakes, and streams is...*; *In general, do you think that air pollution caused by industry is...*; *In general, do you think that a rise in the world's temperature caused by the 'greenhouse effect' is...*; *In general, do you think that nuclear power stations are...*; and *Do you think that modifying the genes of certain crops is....*

Source(s)

National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1993, 2000); NORC at the University of Chicago, General Social Survey (2010, 2016).

Science and Engineering Indicators 2018

Water pollution is the environmental issue that most concerns Americans. According to the GSS, about 79% of Americans in 2016 said they thought water pollution was “extremely” or “very” dangerous to the environment; this proportion has grown since 1994, when the percentage was 61% (66% in 1993) (Appendix Table 7-32). Gallup (2017b) also found that water issues were the environmental topics that most concerned Americans. About 61% of Americans expressed a “great deal” of worry about drinking-water pollution in 2016, and 63% expressed this level of worry in 2017. In 2016 and 2017, respectively, about 56% and 57% of Americans reported similar levels of worry about pollution of rivers, lakes, and reservoirs.

After water pollution, air pollution was the next issue about which the highest proportion of Americans worried. Within the GSS data, 73% of Americans said they felt that industrial pollution presented a high level of danger in 2016, and this percentage grew from a low of 53% in 1994 (61% in 1993) (Appendix Table 7-33). Gallup (2017b) found that 43% of Americans expressed a "great deal" of worry about air pollution in 2016, and this grew to 47% in 2017.

Concern about water and air pollution is fairly evenly distributed across demographic groups within the GSS, although those with relatively lower levels of education have somewhat lower average concern. Higher levels of science knowledge were also associated with more concern about water (Appendix Table 7-32 and Appendix Table 7-33). For example, about 67% of those in the lowest quartile of knowledge said they thought water pollution was "extremely or very dangerous," whereas 84% of those in the top quartile of science knowledge had such views (Appendix Table 7-32). For industrial air pollution, only those in the lowest quartile of science knowledge were substantially different, with 67% indicating they saw such pollution as "extremely dangerous or very dangerous" compared to 73% of those in the second quartile of knowledge, 75% of those in the third quartile, and 76% of those in the top quartile (Appendix Table 7-33).

Gallup also collects data on public concern about extinction and the loss of tropical rain forests. In 2017, 44% of Americans said they worried "a great deal" about the extinction of plant and animal species, and the same percentage said they worried "a great deal" about the loss of tropical rain forests. These responses are somewhat lower than worry about water or air pollution but higher than worry about climate change.

One noteworthy difference between the Gallup data (Figure 7-17) and the NSF data within the GSS (Figure 7-18) is that the Gallup data show a drop in concern about various environmental issues between about 2000 and 2010. In contrast, the NSF data show no such pattern. However, both Gallup and NSF data show increasing concerns after 2010.

International Comparisons

The 2014 Eurobarometer on the environment asked respondents to indicate the 5 main environmental issues that they were worried about from a list of 14. Although water pollution was the issue most worried about in the United States, air pollution (56%) was the most commonly named issue in Europe. This was followed by water pollution (50%), the growing amount of waste (43%), the health effect of chemicals used in everyday products (43%), and the depletion of natural resources (36%). Climate change was not included on the list because it was the focus of a separate report earlier in 2014 (European Commission 2014).

Climate Change

U.S. Patterns and Trends

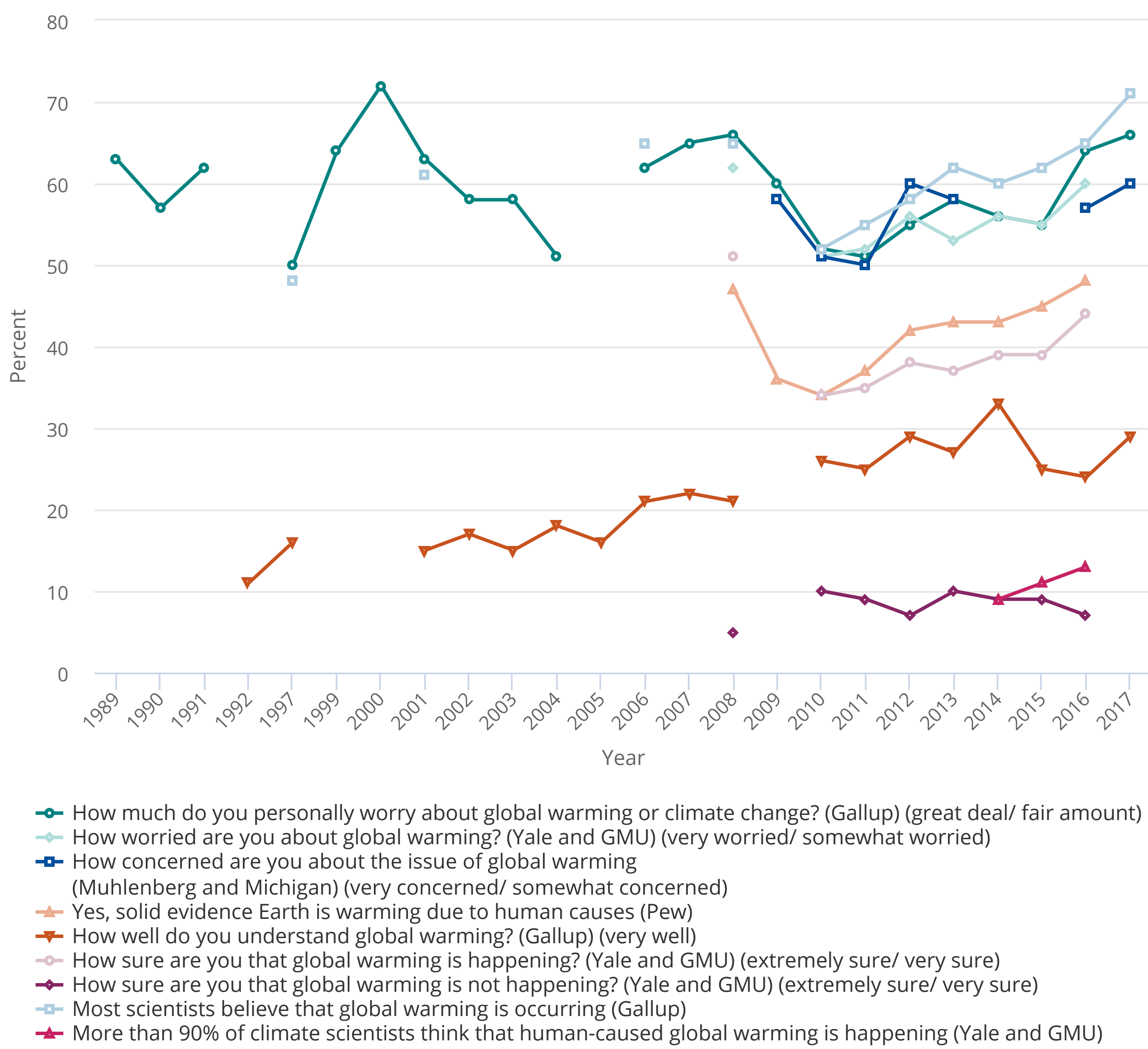
Climate change (often referred to as *global warming, especially in past decades*) remains a central, and often divisive, environmental issue for many Americans, even though scientists point out that scientific evidence overwhelmingly supports the conclusion that climate change is already occurring, that it will have a wide range of negative effects on Americans and residents of other countries, and that it is largely the result of human activities (NAS and Royal Society 2014). The importance of this issue to national and international debates about policy and economic implications means that it has also been the subject of widespread polling over more than two decades.[1] Overall, the available data suggest that the percentage of Americans in 2017 who accept that climate change is partly caused by humans and who are concerned about this phenomenon are approaching past highs. This is consistent with overall increasing concern about the environment in recent years. Different question wording, however, can result in somewhat different results, and it is therefore helpful to look for patterns of response over time and across surveys. It is also worth separately considering overall concern about climate change, belief that climate change is occurring, and views about whether scientists agree among themselves.

With regard to concern, a single question in the GSS about climate change suggests that 55% of Americans think that a rise in the world's temperature caused by the *greenhouse effect*—an earlier term used in discussions of climate change that is used here to preserve comparability over time—is either "extremely dangerous or very dangerous" (Appendix Table 7-34). This is up from the low of 35% in 1994 (and from 41% in 1993 and 40% in 2000). The 2016 percentage is also higher than the results of a 2010 GSS question—using the term *climate change*—that found that 48% of Americans saw high levels of danger from the phenomenon.

The relatively high levels of concern about climate change seen in the GSS data are consistent with data from Gallup (Saad 2017). Gallup has polled on "global warming" since 1989, when it found that 63% of Americans worried a "great deal" (35%) or a "fair amount" (28%) about the issue. In March 2017, the comparable statistic was similar with 66% saying they either worry a "great deal" (45%) or a "fair amount" (21%) (Figure 7-19). This indicator, however, has fluctuated between a low of 51% (2004) and a high of 72% (2000). A data series from the University of Michigan and Muhlenberg College (2017) that began in 2009 also suggests a similar pattern within recent years. According to these surveys, the percentage of Americans who were "very" or "somewhat concerned" fell from 58% in 2009 to 50% in 2011 but then increased to 60% in 2012.

FIGURE 7-19

Belief in global warming and confidence in that belief: 1989–2017



GMU = George Mason University.

Note(s)

Questions were not asked in all years. *How concerned are you about the issue of global warming?* (Muhlenberg and Michigan) was asked in 2017, 2016, 2012, 2011, and 2009 only of respondents who answered yes to the question *From what you've read and heard. Is there solid evidence that the average temperature on earth has been getting warmer over the past four decades?* In 2013, a split sample of the entire sample (*n* = 947) was used, with 477 respondents asked about "global warming" and 470 respondents asked about "climate change." However, responders to *How concerned are you about the issue of global warming?* are shown as percentages of the total population.

Source(s)

Pew Research Center, *The Politics of Climate,* http://www.pewinternet.org/2016/10/04/the-politics-of-climate/, accessed 16 February 2017, *Public and Scientists' Views on Science and Society* (2015), http://www.pewinternet.org/files/2015/01/PI_ScienceandSociety_Report_012915.pdf, accessed 16 February 2017, and *Catholics Divided Over Global Warming* (2015), http://www.pewforum.org/files/2015/06/Catholics-climate-change-06-16-full.pdf, accessed 16 February 2017; Gallup, Climate Change: Environment, https://www.gallup.com/poll/1615/environment.aspx#, accessed 16 February 2017, and Gallup Social Series: Environment, Final Topline 1–5 March 2017; Leiserowitz A, Maibach E, Roser-Renouf C, Rosenthal S, Cutler M, *Climate Change in the American Mind: November 2016*, Yale University and George Mason University, New Haven, CT: Yale Program on Climate Change Communication (2017), http://climatecommunication.yale.edu/wp-content/uploads/2017/01/Climate-Change-American-Mind-November-2016.pdf, accessed 16 February 2017; Leiserowitz A, Maibach E, Roser-Renouf C, Feinberg G, Rosenthal S, *Climate Change in the American Mind: March 2015,* Yale University and George Mason University, New Haven, CT: Yale Program on Climate Change Communication (2015), https://environment.yale.edu/climate-communication/files/Global-Warming-CCAM-March-2015.pdf, accessed 16 February 2017; Muhlenberg College and the University of Michigan, National Surveys on Energy and Environment, http://closup.umich.edu/national-surveys-on-energy-and-environment/nsee-survey-pages.php, accessed 22 June 2017.

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It is also noteworthy that, within these data, the percentage saying they worry a “great deal” about climate change reached a new high of 45% in 2017. Much of the shift seems to come from the percentage saying that they worry a “fair amount,” which shrank from 27% in 2016 to 21% in 2017. A similar percentage of people are not particularly concerned about climate change. The percentage saying they worry about climate change “only a little” stayed about the same (18% in 2017, similar to previous years). The percentage reporting “no worry at all” about climate change went from 19% in 2016 to 16% in 2017, having dropped from a high of 29% in 2010.

Also, while about two-thirds of Americans say they worry about global warming, 42% told Gallup in 2017 that they believed “global warming would pose a serious threat” to their way of life in their lifetime. This suggests that some of those who worry about global warming perceive the negative impacts of climate change to be more long term rather than immediate. As with the question about *worry about global warming*, responses to the “serious threat” question have fluctuated over time, although the level has stayed between 31% (2001) and 40% (2008) since 2001. In the short term, this number has risen from 34% in 2013 (Saad 2017).

Data from researchers at Yale University and George Mason University (GMU) (Leiserowitz et al. 2017) and the Pew Research Center (Funk and Kennedy 2016a) show similar patterns. The Yale-GMU scholars also found that Americans think that a range of negative events are becoming more likely because of climate change, including more severe weather (Leiserowitz et al. 2017). The Pew Research Center further found that about 78% said they thought storms were “very” (42%) or “fairly” (36%) likely to become more severe. Similar proportions of Americans said they thought it was at least “fairly” likely that climate change would cause rising sea levels that erode beaches and shorelines (76%), more drought or water shortages (76%), damage to forests and plant life (77%), and harm to animal wildlife and their habitats (77%) (Funk and Kennedy 2016a).

Scientific research points to humans as a primary force behind climate change. However, while most Americans agree climate change may be occurring, many believe that these changes are part of natural cycles. Data from the Pew Research

Center (Funk and Kennedy 2016a) show that 48% of respondents tended to believe that the Earth is getting warmer, mostly because of human activity, such as burning fossil fuels. Another 26% said they thought the Earth is getting warmer "mostly because of natural patterns." The percentage pointing to "human activity" as the cause of temperature changes represents an increase from the Pew Research Center's (2015a) data for recent years, where belief in a human cause dipped as low as 36% in 2011, but is largely consistent with public attitudes from the mid-2000s, when belief in a human cause of climate change peaked at 50% (2006). Gallup reported in 2017 that 68% of Americans believe that human activities are the most important cause of climate change, while 29% attributed warming to natural causes (Saad 2017). In 2016, 63% of Gallup respondents attributed global warming to humans. The previous high had been 61% (a high reached in 2001, 2003, and 2007). The differences between the Pew Research Center and Gallup data likely reflect question wording. The Gallup question asks respondents to choose between human or natural causes, whereas the Pew Research Center provides a range of options.

Many Americans also do not appear to know that the vast majority of scientists believe there is solid evidence of climate change and that humans are the dominant cause. The extent to which Americans are unaware of this, however, varies based on the survey; again, question wording likely accounts for much of the difference in the responses. The Yale-GMU research (Leiserowitz et al. 2017) found that only 15% of their respondents said that they thought more than 90% of climate scientists "have concluded human-caused global warming is happening." The Pew Research Center reported that about 27% of its respondents believed that "almost all" climate scientists say that "human behavior is mostly responsible for climate change" (Funk and Kennedy 2016a). Gallup found that 71% of Americans said they thought "most scientists" believe "global warming is occurring" (Saad 2017). This surpasses the previous high of 65% in 2015.

International Comparisons

The most recent internationally comparable, representative data on public views about climate change continue to suggest that, on average, about 7 in 10 of those surveyed in a range of countries see climate change as serious. In this regard, Americans appear relatively less concerned about the issue than residents of most other countries. A 2015 multicountry study by the Pew Research Center found that the United States, countries in the Asia-Pacific region such as China, and countries in the Middle East had relatively low levels of concern about global change compared to residents of Europe, Africa, and Latin America (Stokes, Wike, and Carle 2015). For example, 74% of American, 75% of Chinese, and 79% of Jordanian respondents said "global climate change" was at least "somewhat" serious, while 93% of French, 87% of German, and 91% of Italian respondents gave such a response. Further, in South America, 98% of Brazilians, 98% of Chileans, and 93% of Mexicans said they saw climate change as serious. In Africa, 92% of Ugandans, 89% of Kenyans, and 84% of Nigerians said they saw climate change as serious. Related questions showed similar patterns of response, although there were typically some countries in each region (except South America) where attitudes about the seriousness of climate change were more like those held in the United States. These countries were among the least concerned within their regions and included, for example, the UK (77%), Turkey (74%), Indonesia (74%), and South Africa (73%). The countries where the smallest percentage of people said they saw climate change as serious were Pakistan (65%) and Israel (67%), although Pakistan had an unusually high number of respondents (19%) who chose not to answer the question or said they did not know if climate change was a serious problem.

Within Europe, the European Commission (2015) conducted a special Eurobarometer in 2015 on climate change that found that 91% of Europeans see climate change as a problem. Specifically, respondents were asked to use a 10-point scale, where 1 indicated "not at all a serious problem" and 10 indicated "an extremely serious problem," and found that 69% chose a number between 7 and 10 and another 22% chose 5 or 6. The overall numbers were nearly identical to the results of surveys in 2011 and 2013, but there were still changes within countries. There was also substantial variation between countries. For example, 87% of Greeks, 81% of Italians, and 80% of Bulgarians gave an answer of 7 or higher, but only 37% of Latvians, 53% of those in the UK, and 58% of the Dutch gave such a response. Many of the largest European countries were near the European average. For example, about 69% of French, 72% of Germans, and 79% of Spaniards chose between 7 and 10. The biggest changes were in Eastern Europe. In Bulgaria, the responses between 7 and 10 increased 13 percentage points to 80%; in Romania, the responses rose 11 percentage points to 74%. The biggest declines were in Austria and Slovakia. Austria declined 8 percentage points to 69%, and Slovakia declined 12 percentage points to 68%.

Energy

U.S. Patterns and Trends

Public opinion about energy has also fluctuated in recent years in response to accidents such as the 2011 nuclear accident in Fukushima, Japan, changing energy prices, and the emergence of issues such as hydraulic fracturing (sometimes termed *fracking*) as a technique to extract natural gas from the Earth. The range of energy events and issues, however, means that although specific events may have short-term effects, consistent long-term trends in public opinion about energy are rare. Overall, 23% of Americans said that "the energy situation in the United States" was "very serious" in 2017 (Newport 2017), down from recent highs of 45% in 2011 and 46% in 2008—when, for example, gasoline prices were relatively high. The 2017 figure is thus close to a historic low in concern. Similarly, the percentage of Americans saying that they worried "a great deal" about "the availability and affordability of energy" matched historic lows of 27% in both 2016 and 2017, a period of relatively low gas prices compared to recent years. The last time worry was as low was 2003, a year in which gas prices were also relatively low (EIA 2017).

Gallup (2017a) also reported that, in both 2016 and 2017, a majority of Americans (59%) said "protection of the environment should be given priority, even at the risk of limiting the amount of energy supplies—such as oil, gas, and coal—which the U.S. produces." In contrast, 34% said that the "development of U.S. energy supplies…should be given priority, even if the environment suffers to some extent." The percentage choosing the environment over development of energy supplies was the highest it has ever been but is similar to the 58% who gave this response in 2007.

Americans also appear to support energy alternatives to fossil fuels. Gallup respondents are asked annually how they think the country should deal with "the nation's energy problems" and then asked to choose between emphasizing production of "oil, gas and coal supplies" or "conservation by consumers." The percentage choosing to "emphasize conservation" has risen from a low of 48% in 2011 to 61% in 2017 (Gallup 2017a). This is approaching the previous high of 64% that Gallup found in 2007. An alternative question asks respondents to choose between fossil fuel production and "the development of alternative energy such as wind and solar power." With this question, Gallup found that 71% of Americans chose alternative energy in 2017, up from 59% in both 2012 and 2013 and similar to the high of 73% in 2016. A similar question by the Pew Research Center (2014) found that prioritizing alternative energy sources such as "wind, solar, and hydrogen" started at 63% in 2011 and then dipped to 47% in 2012 before climbing back to about 60% in late 2014 after a high of 65% in early 2014.

Alternative energy and conservation also do well when comparing questions that ask about specific energy options. In 2016, 89% of Americans told the Pew Research Center (Funk and Kennedy 2016a) that they favored "more solar panel 'farms,'" and 83% said they would favor more "wind turbine 'farms.'" In contrast, 43% said they would support more "offshore oil and gas drilling," 42% said they would favor "more hydraulic fracturing…for oil and natural gas," and 41% said they would favor "more coal mining." The Pew Research Center (Funk and Kennedy 2016a) found, however, that there were substantial differences on views about the questions related to oil, gas, and coal by political party preference. Gallup similarly found that 35% "favor[ed]…'fracking'" in 2017, whereas 53% opposed the technique, similar percentages to those from 2016.

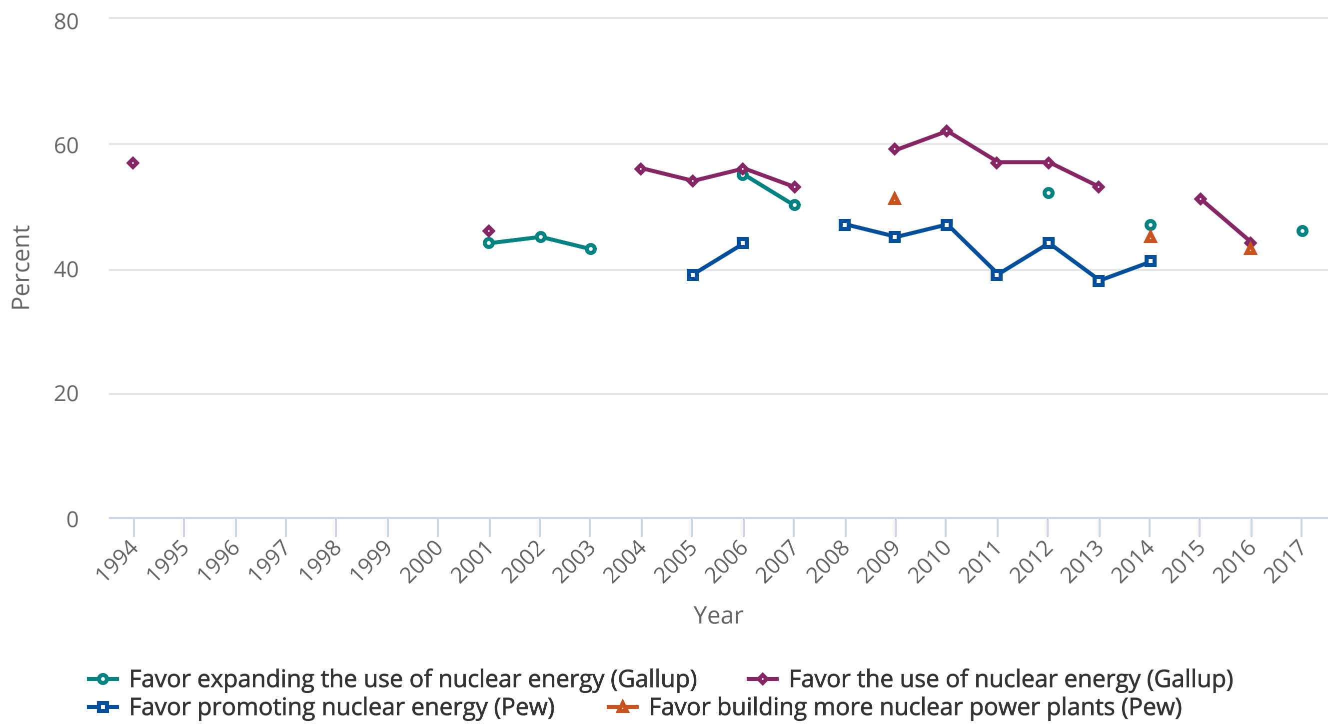
Attitudes about nuclear energy have become more negative in recent years. Support for nuclear energy likely peaked around early 2010. At that time, 62% of Americans told Gallup that they "strongly" or "somewhat" favored nuclear energy as "one of the ways to provide electricity for the United States." In 2011, just prior to the nuclear accident in Fukushima, Japan, support had fallen to 57%. Gallup again assessed support at 57% in 2012, and support further fell to 44% by 2016 (Figure

7-20) (Gallup 2017b). The fact that attitudes about nuclear energy started becoming more negative prior to Fukushima and that support did not drop substantively in the Gallup data between 2011 and 2012 led the organization to argue that "energy prices and perceived abundance of energy sources" may be behind declines in nuclear support (Riffkin 2016). It may also be relevant that worry about other environmental issues began to increase around 2010 (see the discussion above about attitudes regarding the environment).

Surveys by the Pew Research Center (2014) similarly found the start of a decline in nuclear energy support prior to the Fukushima accident (Figure 7-20). Pew pegged support for "government" policies aimed at "promoting the increased use of nuclear power" at 52% in early 2010. By mid-2010, support appeared to have fallen to the mid-40% range (e.g., 45% in October 2010). Support immediately after the 2011 Fukushima accident dipped to 39% and remained around this level through several surveys until 2014, when support was at 41%, the last time the same question was used. A second question wording used by the Pew Research Center (Funk, Rainie, and Page 2015) found that 51% of Americans said they "favor building more nuclear power plants to generate electricity" in 2009, and this percentage fell to 45% by 2014.

FIGURE 7-20

Views on nuclear energy: 1994–2017



Note(s)

Data are not available for all years. Responses to:

I am going to read some specific environmental proposals. For each one, please say whether you generally favor or oppose it. How about [e]xpanding the use of nuclear energy?

Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity for the U.S.? (Figure shows combined responses for "strongly favor" and "somewhat favor.")

As I read some possible government policies to address America's energy supply, tell me whether you would favor or oppose each. [W]ould you favor or oppose the government promoting the increased use of nuclear power? (The 2010 data point is the average of responses to four surveys conducted that year. The 2011 data point is the average of responses to two surveys conducted that year.)

Do you favor or oppose building more nuclear power plants to generate electricity?

Source(s)

Gallup, Social Series: Environment, https://www.gallup.com/file/poll/168221/Energy_I_140402.pdf, accessed 17 February 2017, Social Series: Environment, https://www.gallup.com/poll/2167/energy.aspx, accessed 17 February 2017, and Gallup Social Series: Environment, Final Topline 1–5 March 2017; Pew Research Center, *December 2014 Political Survey*, http://www.people-press.org/files/2014/12/12-18-14-Energy-topline-for-release.pdf, accessed 17 February 2017, *General Public Science Survey, August 15-25, 2014,* http://www.pewinternet.org/files/2015/07/2015-07-01_science-and-politics_TOPLINE.pdf, accessed 17 February 2017, and *Americans strongly favor expanding solar power to help address costs and environmental concerns*, http://www.pewresearch.org/fact-tank/2016/10/05/americans-strongly-favor-expanding-solar-power-to-help-address-costs-and-environmental-concerns, accessed 17 February 2017.

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Responses to a nuclear energy question included in the GSS are also relatively consistent with the pattern found by Gallup and the Pew Research Center. In 1993, about 40% of respondents said that they thought nuclear energy was either “extremely” or “very dangerous.” By 2016, the percentage seeing substantial danger had grown to 55%. Another 30% said nuclear energy was “somewhat dangerous,” and 13% said “not very dangerous” or “not dangerous” (Appendix Table 7-35). About 2% said they did not know how dangerous nuclear energy is. Women, younger respondents, and those with relatively high levels of science knowledge and science and mathematics education were more likely to see higher levels of danger, but the pattern is not as clear as it is with other specific attitude questions. For example, 58% of those in the lowest quartile of knowledge saw nuclear energy as “extremely dangerous” or “very dangerous,” whereas 42% of those in the top quartile held this view. Those in the second and third quartile, however, were more similar to those with less knowledge than those with the most knowledge. Similarly, for science and mathematics education, 58% of those with relatively low science and mathematics education and 59% of those with mid-level science education said they saw nuclear energy as “extremely dangerous” or “very dangerous,” whereas 44% of those with relatively high levels of science education felt this way. As noted, the percentage saying that nuclear energy is dangerous is also relatively high compared to previous years. For example, 40% said they saw nuclear energy as “extremely dangerous” or “very dangerous” in 1993, and 45% gave these responses in 2010.

International Comparisons

Europe’s 2015 Eurobarometer climate change survey (European Commission 2015) also included several questions about energy. Across European countries, between 97% (Cyprus) and 78% (Bulgaria) of residents said that it was “very important” or “fairly important” for national governments to “set targets to increase the amount of renewable energy used, such as wind or solar power, by 2030” (European Commission 2014a:55). The average across the 28 European countries surveyed was 91%. The five largest European economies were relatively similar, with Spain at 93%; Germany, the UK, and Italy at 91%; and France at 90%. The Eurobarometer report suggested that support for renewables was up slightly from 2013 but that there were few differences across demographic groups. However, those who saw climate change as a more serious problem were more likely to see renewable energy targets as important. Almost all EU respondents (92%) similarly indicated that they thought it was “very” or “fairly important” for government to provide support “for improving energy efficiency.” In China, 79% of respondents indicated that they supported funding research on “low carbon” technology (CRISP 2016). The 2014 edition of *Indicators* also reported the results of a 2010 international survey of a wide range of countries that suggested that the United States was relatively favorable toward nuclear energy when compared to the other countries surveyed (NSB 2014).

Genetically Engineered Food

U.S. Patterns and Trends

The most recent data suggest that negative views about genetically engineered (GE) food have increased in recent years in the United States. This pattern is consistent with increasing concern about various environmental issues and nuclear energy. GE food—also sometimes called genetically modified (GM) food or genetically modified organisms (GMOs)—remains an active issue for public debate around the world as new products continue to enter the market. Some scholars also point to the emergence of genetic engineering concerns as something that proponents might have limited through better communication with the public during the early research and commercialization phases (Einsiedel and Goldenberg 2006). Surveys from across many years and studies, however, suggest that many Americans question the safety of genetic engineering of food despite consensus statements from leading scientific groups. For example, the National Academies argue that there is no evidence that GM crops have caused substantial health or environmental problems since the technology emerged commercially in the 1990s (NASEM 2016b). Almost all members (88%) of the world's largest scientific society surveyed by Pew in 2015 also said they saw GM foods as "generally safe" (compared to 37% of Americans, overall) (Funk, Rainie, and Page 2015). A summary of surveys from the 1980s through 2000 (Shanahan, Scheufele, and Lee 2001) found that between one-third and one-half of Americans saw risks from genetic engineering, whereas a similar number saw benefits. This summary also found that few people felt that they knew a lot about the subject but that there was, nevertheless, broad support for labeling GE food.

GSS data suggest that concern about GE food is increasing. The percentage of Americans who said genetically modifying crops are either "extremely dangerous" or "very dangerous" has climbed from 21% in 2000 and 25% in 2010 to 43% in 2016. Another 36% said such crops were "somewhat dangerous." About 18% said they were "not very dangerous" or "not dangerous at all" (Appendix Table 7-36). Conversely, the percentage that says they see genetic modification as "not very dangerous" or "not dangerous at all" has declined from 25% in 2000 and 26% in 2010 to 18% in 2016.

There are, nevertheless, several important demographic differences in how people perceive genetic modification. For example, 53% of women said that modifying genes is "extremely dangerous" or "very dangerous," compared to 30% of men. Only those in the highest science knowledge group had meaningfully different views than those with lower knowledge. Specifically, 45% of those in the lowest quartile of science knowledge, 44% of those in the second quartile, and 47% of those in the third quartile of science knowledge indicated that they thought genetic modification was "extremely" or "very dangerous." Only 31% of those in the top quartile of science knowledge held such views. The pattern for education is similar but less pronounced. There was no meaningful variation by age.

Whereas the GSS question focuses only on danger to the environment from "crops," a 2016 survey by the Pew Research Center (Funk and Kennedy 2016b) included a battery of questions about GM foods that also showed that many Americans have concerns about the technology, even though knowledge levels likely remain low. First, about 29% of Americans said they had heard "a lot" about GM foods, 52% said they heard a little, and 19% said they had heard "nothing at all." Another question found that 6% of Americans said they cared about the issue of GM foods "a great deal," while 37% said they cared "some."

With regard to food safety, 48% of Pew Research Center (Funk and Kennedy 2016b) respondents said they thought GM foods and non-GM foods were equally healthy, and 39% said they thought GM foods were less healthy. Another 10% of respondents said they thought that food with GM ingredients is healthier than non-GM foods. About 20% of all respondents (i.e., 51%–39% who saw risks) said they thought the health risks of genetic modification were "high" or "very high." Another question found that 49% of respondents said they thought that GM foods were "very" or "fairly" likely to "lead to health problems for the population as a whole." About 49% also said that genetically modified foods will likely "create problems for the environment." On the positive side, 69% of respondents said they thought GM foods would be likely to increase the "global food supply," and 56% said they thought the technology would lead to "more affordably-priced food." As noted above in the discussion of confidence in the scientific community, 78% of Americans told the Pew Research Center (Funk and Kennedy 2016b) that they trusted scientists to "give full and accurate information about the health risks and benefits of eating genetically modified food," the highest percentage of any other group alongside small farm owners. Previously, the Pew Research Center (Funk, Rainie, and Page 2015) had found that only 37% of Americans think that GE foods are "generally safe" to eat (compared to 57% who said it was "generally unsafe"), and only 28% think that "scientists have a clear understanding" of the "health effects of genetically modified crops."

It is also important to consider the limitations of the available data in this area. Given low knowledge about the particular topic of GE food, other factors—such as general worldview or positive views about science and scientists (Frewer et al. 2013; McComas, Besley, and Steinhardt 2014)—may play a central role in shaping views about genetic engineering. In other words, when many respondents answer questions about genetic engineering, they are likely reporting their general views about science or nature rather than fully answering questions based on consideration of genetic engineering. The reasons for using genetic engineering may also affect whether people report favorable views. When the Pew Research Center (Funk, Rainie, and Page 2015) asked about genetic modification to "create a liquid fuel replacement for gasoline," 68% of Americans and 78% of scientists said they would "favor" such a move.

International Comparisons

A previous analysis of worldwide views on genetic engineering concluded that respondents were more opposed to animal modification than plant modification, that Europeans saw more risks and fewer benefits than Americans or Asians, and that moral concerns are highest in the United States and Asia (Frewer et al. 2013). The 2014 version of *Indicators* also reported the results of a 2010 international survey of a wide range of countries that suggested that the United States was relatively favorable toward genetic modification compared with other countries, with only 25% of Americans saying they thought such crops should be seen as "extremely dangerous to the environment." Several other countries, including some European countries (e.g., Belgium, Norway, Denmark), were also relatively favorable toward the technology (NSB 2014). Some of the countries in which residents were least favorable to genetic engineering included Turkey, Chile, and Russia. More recently, 59% of Chinese respondents said they thought that GM foods created an "unpredictable safety risk" (CRISP 2016).

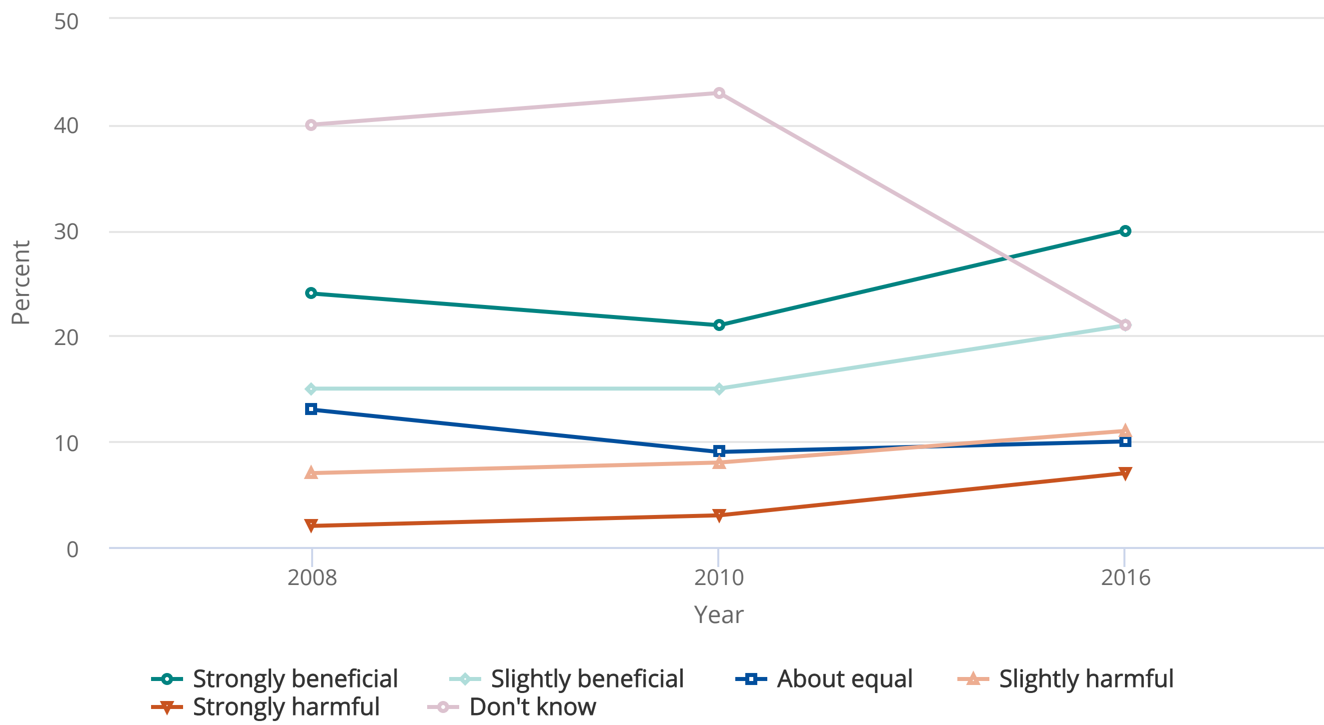
Nanotechnology

Nanotechnology involves manipulating matter at very small scales to create new or improved products that can be used in a variety of ways. Government and the private sector have made relatively large investments in this area in recent years, and innovations based on this work are now common (PEN 2015).

Recent data on public opinion about nanotechnology are limited, but the most recent GSS included a set of questions aimed at updating information previously collected by the NSF in 2006, 2008, and 2010, when there was concern that some Americans might come to see nanotechnology in the way that many people see GE food (e.g., [Einsiedel and Goldenberg 2006]). This does not appear to have happened yet. In 2016, 51% of respondents said they think that the benefits of nanotechnology will be greater than the harms (Figure 7-21; Appendix Table 7-37). This includes 30% who say they expect strong benefits and 21% who expect slight benefits. Another 18% said that they thought the "harmful results" would be greater, including 7% who expect strong harms and 11% who expect slight harms. About 10% volunteered that the benefits and harms would be about equal, and 21% volunteered that they did not know whether benefits or harms were more likely. In other words, these individuals asked to have their views recorded as seeing the benefits and harms as about equal or insisted they could not choose between benefits and harms, even though the survey questionnaire did not provide this option.

FIGURE 7-21

Views on nanotechnology: 2008, 2010, 2016



Note(s)

Responses to the two-tiered question *Nanotechnology works at the molecular level atom by atom to build new structures, materials, and machines. People have frequently noted that new technologies have produced both benefits and harmful results. Do you think the benefits of nanotechnology will outweigh the harmful results or the harmful results will outweigh the benefits?* and *Would you say that the balance will be strongly in favor of the benefits/harmful results, or only slightly?* Percentages may not add to 100% because of rounding.

Source(s)

NORC at the University of Chicago, General Social Survey (2008–16).

Science and Engineering Indicators 2018

The percentage saying they do not know whether nanotechnology is likely to produce harms or benefits rose from 2006 to 2010 but dropped in 2016 (Appendix Table 7-37). In 2006, 32% of respondents gave a “don’t know” response, 40% gave this response in 2008, and 43% gave this response in 2010 but then only 21% said they did not know in 2016 (Appendix Table 7-37). Of those who expressed an opinion, the percentage of people saying they expect benefits from nanotechnology has been fairly stable, with 64% in 2016, 65% in 2010, 64% in 2008, and 59% in 2006. The percentage who expect harms among those who expressed an opinion, however, has also climbed from 13% in 2006 to 23% in 2016. This is possible because the proportion volunteering that they expect about equal benefits and harms has fallen from 28% of those who expressed an opinion in 2006 to 13% in 2016. This increase in uncertainty and concern seems broadly consistent with increased concern about the environment, nuclear energy, and GM foods.

Men, younger respondents, those with more education, and those with higher levels of income were more likely to report that they expected nanotechnology benefits. For example, in 2016, 61% of men said they expected benefits, while only 41% of women gave this response (Appendix Table 7-37). About the same number of men (10%) and women (11%) said they thought the benefits and harms would be equal, and similar proportions (16% of men and 19% of women) said they expected harms. However, about 12% of men said they did not know whether harm was more likely than benefits, but 29% of women said they did not know.

As with the data on GE food, it is important to recognize that people's low levels of knowledge about nanotechnology may mean that they are largely responding to questions about the issue based on such factors as their overall trust in science or their worldview. Additional factors such as the content or wording of the questions or the context of the survey may contribute to such processes.

Stem Cell Research and Cloning

U.S. Patterns and Trends

Stem cell and cloning research focus on understanding how to use biological material to produce living cells, tissues, and organisms. Such research creates opportunities for enhanced understanding of life and opportunities to develop new health care treatments. The intersection of health, human life, and the destruction of human embryos, however, raises ethical issues that have spurred public debate.

Most Americans appear to support the use of embryonic stem cells for medical research. Annual Gallup data showed that, in 2016, 60% of Americans saw using stem cells from human embryos in medical research as "morally acceptable" (Jones and Saad 2016; Swift 2016). The percentage of those who saw such research as morally acceptable is down 4 percentage points from 2015, but over the last 10 years the percentage of respondents saying such research was morally acceptable has fluctuated between a high of 65% in 2014 and a low of 57% in 2009. The lowest level of perceived moral acceptability was 52% in 2002, the first year for which Gallup has data.

Gallup also asks about the morality of human and animal cloning. In 2016, 13% of Americans said that it was morally acceptable to clone humans, and 34% said it was morally acceptable to clone animals (Jones and Saad 2016; Swift 2016). The percentage saying that cloning animals is acceptable has stayed relatively stable—between 29% and 36%—since 2001, when Gallup first asked about the subject. The percentage saying that it is morally acceptable to clone humans hit a high of 15% in 2015 and increased from a low of 7% since Gallup first asked about the subject in 2001.

International Comparisons

The last time a large sample of Europeans was asked about cloning was in 2010, when a Eurobarometer survey found that 63% of respondents across 27 European countries supported the use of stem cells from human embryos, either with no special laws (12%) or "as long as this is regulated by strict laws" (51%). The use of adult stem cells, in contrast, was supported by 69% of Europeans, including 15% who saw no need for special laws and 54% who would approve if use was regulated by strict laws (European Commission 2010b).

Animal Research

U.S. Patterns and Trends

The medical research community conducts experiments on animals for many purposes, including testing the effectiveness of drugs and procedures that may eventually be used to improve human health and advance scientific understanding of biological processes.

Most Americans support at least some kinds of animal research, but this support has fallen in recent years. According to Gallup, about 53% of Americans in 2016 said they saw “medical testing on animals” as “morally acceptable” (Jones and Saad 2016; Swift 2016). This is the lowest it has been and is down from 65% in 2001, when Gallup first asked the question. A different question by the Pew Research Center (Funk, Rainie, and Page 2015) found that, in 2014, 47% of Americans said they “favor” “the use of animals in scientific research,” down from 52% in 2009.

International Comparisons

The most recent similar data from Europe are from a 2010 survey showing that, on average, Europeans oppose animal testing, but these views vary widely. Respondents were asked whether “scientists should be allowed to experiment on animals like dogs and monkeys if this can help sort out human health problems.” About 44% of Europeans said they “totally agree” or “tend to agree” that such experiments should be allowed, whereas 37% said they “totally disagree” or “tend to disagree” (European Commission 2010a).

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[1] There is some evidence from a large-scale experimental study that the wording used in such questions (“global warming” or “climate change”) can have an effect on reported beliefs about global climate change (Schuldt, Konrath, and Schwarz 2011). Other studies, however, suggested that such wording differences have limited effect (Dunlap 2014; European Commission 2008; Villar and Krosnick 2010).

Conclusion

Overall, the survey results presented here continue to indicate that interest in, general knowledge of, and general attitudes about S&T remain relatively positive and stable in the United States. As in previous years, Americans express relatively high levels of interest in various S&T issues, with the one change being that they continue to shift their focus toward getting that information online. The results also show that many Americans know basic facts about science, although many still get the NSF trend questions wrong. For attitudes, a substantial majority of Americans continue to see substantially more benefits than harms from science, have relatively high levels of confidence in the scientific community, and would like to see science supported.

However, whereas interest, knowledge, and general S&T attitudes may be stable, indicators of attitudes about specific S&T issues—including environmental, energy, and emerging technologies—suggest that many Americans are increasingly concerned about pollution and new technologies. The fact that the available indicators for different environmental issues have moved together suggest a common source of concern. There also remain, however, many Americans who see the opportunity for substantial continued progress through S&T or who have relatively low environmental concern. Overall, the majority of Americans appear concerned about the state of the environment and the degree to which advanced technology areas, such as nuclear energy, genetic engineering, and nanotechnology, may create new dangers and yet remain generally supportive of S&T and scientists. Further, while there are limited data, it appears that Americans tend to have lower average levels of concern about S&T issues, and higher average levels of optimism, than the populations of other countries.

In reviewing this chapter, it is important to recall that the purpose of the types of indicators described here is to allow a data- and evidence-based discussion about what Americans think and know about topics related to science, technology, and engineering. The emphasis on between-group comparisons, over-time comparisons, and between-country comparisons is not to rank groups or countries but to provide the type of context that allows a discussion about the nature of the global landscape within which the United States operates. Such comparisons can tell us where the United States may have had success and where there might be potential for improvement. For example, the fact that Americans appear to visit more S&T museums and centers than residents of many other countries might suggest an area of strength on which we might build. As an *Indicators* chapter, the current report, however, highlights the nature of and trends in public views without assessing why changes may have occurred. This leaves to others the challenge of determining the causes of the patterns and trends described. Some of this literature is cited here, but the work of better understanding public attitudes and knowledge about science is ongoing.

Further, in reading the chapter, it is important to consider the overall mosaic that can be assembled from all of these indicators and to avoid putting too much emphasis on any specific statistic. Survey data are powerful tools for understanding the world but, as with all surveys, the indicators discussed are subject to random variation, and it is therefore important to analyze long-term trends and multiple related questions before drawing strong conclusions. Another ongoing limitation of the available indicators is that many of the international comparison data come from Europe, with only limited recent data from the Asia-Pacific region, where there is a high level of S&T activity. Data from Africa and South America are even scarcer. Similarly, the questions asked vary by country in small and large ways. As such, international comparisons should be made with caution, and thoughtful consideration should be given to what we may know and what we do not know.

Despite such concerns, one pattern in the surveys reviewed continues to stand out. The data show quite consistently that Americans who have had more exposure to S&T—including those who are college educated and have completed college courses in science and mathematics—tend to understand more about S&T, see S&T in a more positive light, and engage with S&T more often. Although it is not clear whether these associations are causal, the pattern underscores the potential role of formal science, technology, engineering, and mathematics (STEM) education in shaping how people think about S&T. It is also important, however, to recognize that Americans interact with science beyond formal education systems through channels such as museums, a range of media (television, websites), and daily interactions with others in their personal or professional lives. Data on these types of exposure pathways are not generally as available as data related to formal education.

Those who would seek to change knowledge and attitudes about S&T now have a wide range of formal and informal channels through which to reach Americans. Attracting young people to S&T professions and cultivating positive attitudes about the value of S&T will be important for the United States to remain a world leader in S&T. Efforts to engage with the public on such matters are occurring through a range of online tools and community locations (e.g., schools, museums, festivals, restaurants), workplaces, and homes. The challenge for those who see progress on S&T as important to economic and social development is to ensure that the members of the S&T community engage their fellow citizens actively, openly, and respectfully in the best traditions of science.

Glossary

Definitions

Biotechnology: The use of living things to make products.

Climate change: Any distinct change in measures of climate lasting for a long period of time. Climate change means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change may result from natural factors or human activities. Global warming is often the focus of climate change discussion.

Cloning: Reproductive cloning involves using technology to generate genetically identical individuals with the same nuclear DNA as another individual. Therapeutic cloning involves medical research to develop new treatments for diseases.

European Commission: The governance body for the European Union (EU) that is responsible for the Eurobarometer series of surveys. As of February 2017, the EU comprised 28 member nations: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Unless otherwise noted, data on the EU include all of these 28 members. In this regard, Eurobarometer data from earlier years often do not include recently added members.

Genetically engineered (GE) food: A food product containing some quantity of any GE organism as an ingredient. Also sometimes called genetically modified (GM) food, genetically modified organisms (GMOs), or agricultural biotechnology.

Global warming: An average increase in temperatures near the Earth's surface and in the lowest layer of the atmosphere. Increases in temperatures in the Earth's atmosphere can contribute to changes in global climate patterns. Global warming can be considered part of climate change along with changes in precipitation, sea level, and so forth.

Nanotechnology: Manipulating matter at unprecedentedly small scales to create new or improved products that can be used in a wide variety of ways.

Key to Acronyms and Abbreviations

EU: European Union

GE: genetically engineered

GM: genetically modified

GMO: genetically modified organism

GMU: George Mason University

GSS: General Social Survey

NSF: National Science Foundation

R&D: research and development

S&E: science and engineering

S&T: science and technology

STEM: science, technology, engineering, and mathematics

UK: United Kingdom

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