Chapter 7
Science and Technology: Public Attitudes and Understanding

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Highlights

Information Sources, Interest, and Involvement

Television and the Internet are Americans' primary sources of science and technology (S&T) information.

- More Americans select television as their primary source of S&T information than any other medium.
- The Internet ranks second among sources of S&T information, and its margin over other sources is large and growing.
- To learn about specific scientific issues, more than half of Americans choose the Internet as their main information source.
- Internet users do not always assume that online S&T information is accurate. About four of five surveyed said they had checked on the reliability of information at least once.

Surveys have long shown that most Americans express substantial interest in S&T. However, other indicators suggest a lower level of interest.

- In surveys conducted annually from 2001 to 2006, between 83% and 87% of Americans said they had "a lot" or "some" interest in new scientific discoveries.
- Survey data indicate that, relative to other topics, interest in S&T is not particularly high. However, some topics that rank higher than S&T, such as new medical discoveries, include extensive S&T content.
- As with many news topics, the percentage of Americans who say they follow S&T news closely has declined over the past 10 years, but S&T's decline has been more pronounced.
- Recent surveys indicate that elsewhere in the world, including Japan and Europe, public interest in S&T is lower than in the United States. China is a notable exception.
- In 2006, about three of five Americans said they had visited an informal science institution, such as a zoo or museum, in the past year. This proportion is generally consistent with results from surveys conducted since 1979.

Public Knowledge About S&T

Many Americans do not give correct answers to basic factual questions about science and questions about the scientific inquiry process.

- Americans' factual knowledge about science has not changed much over time. Factual knowledge is positively related to level of formal schooling, income level, and number of science and math courses taken.
- People who score well on long-standing survey questions that test for information typically learned in school also appear to know more about nanotechnology and the Earth's polar regions, topics that historically have not been central to the standardized content of American science education.
- Levels of factual knowledge of science in the United States are comparable with those in Europe and appear to be better than those in Japan, China, or Russia.
- Americans' understanding of the scientific process appears to have improved slightly in recent years. Their level of understanding is strongly associated with factual knowledge of science and with level of education.

U.S. scores on questions about the theory of evolution and the "big bang" are lower than those in other countries, and many Americans are receptive to including nonscientific views in science classrooms.

- Many Americans appear skeptical of established scientific ideas in these areas, even when they have some basic familiarity with them.
- Americans' responses to questions about evolution have remained virtually unchanged over the past 25 years.
- More Americans approved than disapproved of instruction about three explanations of the origins of life (evolution, intelligent design, and creationism) in public school science classes. However, many were unsure.

Public Attitudes About S&T in General

Americans consistently and by large margins endorse the past achievements and future promise of S&T. This support has been evident in surveys conducted since 1979.

- In 2006, more than half of Americans said that the benefits of scientific research have strongly outweighed the harmful results, and only 6% said the harms slightly or strongly outweighed the benefits. Other indicators yield similar results.
- Americans' positive attitudes about S&T cross demographic boundaries: men and women, college graduates and high school dropouts, and blacks and whites all express support.
- Americans also express some reservations about S&T. A majority agree that "scientific research these days doesn't pay enough attention to the moral values of society," although the proportion agreeing dropped substantially in annual surveys between 2001 and 2006. Nearly half believe that science makes life change too fast.
- Attitudes about the benefits of S&T are somewhat more favorable in the United States than in Europe, Russia, and Japan. Attitudes in China and South Korea, however, are comparable with and perhaps even more favorable than those in the United States.

Support for government funding of scientific research is strong and growing.

- In 2006, 87% of Americans expressed support for government funding of basic research, up from levels around 80% in past surveys dating back to 1979.
- The percentage of Americans who said that the government spends too little on scientific research grew from 34% to 41% between 2002 and 2006.
- Other kinds of federal spending, however, generate even stronger public support.

The public consistently expresses confidence in science leaders.

- In 2006, more Americans expressed a great deal of confidence in leaders of the scientific community than in the leaders of any other institution except the military. Despite a general decline in confidence in institutional leaders since the early 1970s, confidence in science leaders has remained relatively consistent.
- On science-related public policy issues (including global climate change, stem cell research, and genetically modified foods), Americans believe that science leaders, compared with leaders in other sectors, are relatively knowledgeable and impartial and should be relatively influential. However, they also perceive a significant lack of consensus among scientists on these issues.

In deciding whether a study is scientific, most Americans rely on criteria related to the research process: whether results are evidence based, carefully interpreted, and replicated.

- Research process characteristics are especially important among more highly educated Americans, who are less likely than others to rely on other criteria such as researchers' credentials, institutional settings, and consistency with common sense or with religious beliefs.
- Americans and Europeans both see medicine as more scientific than other fields, with physics and biology following close behind it.

Public Attitudes About Specific S&T Issues

Americans have recently become more concerned about environmental quality.

- In 2007, 43% of Americans expressed strong concern about the environment, up from 35% in 2005. However, concern about the environment ranks somewhere in the middle among 12 issues.
- Global warming has recently become more prominent among environmental issues of concern to the public, although it still ranks 8th among 10 issues.

Many Americans are unfamiliar with emerging technologies and research topics, and many have significant misconceptions about them.

- Few Americans (about 1 in 10) consider themselves "very familiar" with biotechnology.
- Most Americans (60%) believe they have not eaten genetically modified foods, although in fact processed foods commonly contain genetically modified ingredients.
- More than half of Americans (54%) have heard "nothing at all" about nanotechnology.
- Most Americans say they are "not very clear" (35%) or "not clear at all" (35%) about the distinction between reproductive and therapeutic cloning.

A majority of Americans support medical research that uses stem cells from human embryos. However, Americans are wary of innovations using cloning technology, and they overwhelmingly oppose reproductive cloning.

- In three surveys conducted between 2004 and 2006, a majority agreed with the statement that it was more important to continue with stem cell research than to avoid destroying human embryos used in the research.
- About half of Americans oppose using human cloning technology even if it is limited to helping medical research develop new treatments for disease.
- Four of five Americans oppose using "cloning technology to produce a child."

Americans, Europeans, and Canadians share similarly favorable attitudes about biotechnology and nanotechnology.

- In 2005, 71% of Americans and 67% of Canadians expressed support for products and processes involving biotechnology. Almost two-thirds of Europeans said they expected biotechnology to positively affect their way of life in the next 20 years.
- When told about nanotechnology, about half of Americans surveyed in 2005 foresaw substantial or some benefit from it, and 14% expected substantial or some risk. Canadian response to the same question was similar. Among Europeans, 48% expected positive effects from nanotechnology, whereas only 8% expected negative effects.

Introduction

Chapter Overview

In today's America, science and technology (S&T) are everywhere. Americans encounter S&T in their roles as citizens, workers, and consumers. As citizens, they vote for candidates with different views about global warming, stem cell research, and deficit spending, issues about which atmospheric scientists, microbiologists, and macroeconomists claim expertise. As workers, they compete for jobs in technology-driven sectors of the economy that did not exist a generation ago, where familiarity with recently invented devices and emerging scientific disciplines makes them more competitive. As consumers, in their leisure time, they rely on new technologies to entertain themselves, build relationships with others, and keep informed about the world around them.

It is increasingly difficult for Americans to be competent as citizens, workers, and consumers without some degree of competence in dealing with S&T. Because competence begins with understanding, this chapter presents indicators of how Americans get S&T news and information and how much they know about S&T. How the American citizenry collectively deals with public issues that centrally involve S&T in turn affects whether America will continue to be a fertile environment for developing scientific knowledge and applying it in practical contexts. It also affects the kinds of S&T development America will support. The chapter therefore includes indicators of attitudes about S&T-related issues. Because citizens often rely on trusted leaders to shape their attitudes on contested issues, the chapter includes indicators of public perceptions concerning the influence scientific experts ought to have on S&T-related policies.

Indicators of what Americans know and think concerning S&T may be considered in two essentially different ways. They may be compared to a benchmark that suggests what people ought to know or how they ought to apply their knowledge. These indicators may also be compared with similar indicators for past years or other countries. In an increasingly globalized world, international comparisons become increasingly relevant: a culture in which S&T flourish can give a country a competitive advantage, and public understanding of and support for S&T are components of such a culture.

Chapter Organization

The chapter is divided into four major sections. The first includes indicators of the public's sources of information about, level of interest in, and active involvement with S&T. This section contains data on public use of the mass media for science news and information and on involvement with informal science in museums, science centers, zoos, and aquariums. The second section of the chapter reports on indicators of public knowledge, including measures of factual knowledge and understanding of the scientific process. The third and fourth sections of the chapter are about attitudes toward S&T. The third section contains data on attitudes about S&T in general, including support for government funding of basic research, confidence in the leadership of the scientific community, perceptions of the prestige of S&E as occupations, and opinions about how much influence science and scientists ought to have in public affairs. The fourth section addresses attitudes on specific S&T-related issues. It includes indicators of public opinion about several emerging lines of research and new technologies, including biotechnology, genetically modified food, nanotechnology, stem cell research, and cloning.

A Note About the Data

Throughout, the chapter emphasizes trends over time, patterns of variation within the U.S. population, and international patterns. It gives less weight to the specific percentages of survey respondents who gave particular answers to the questions posed to them. Although, inevitably, the chapter reports these percentages, they are subject to numerous sources of error and should be treated with caution. Caution is especially warranted for data from surveys that omit significant portions of the target population, have low response rates, for which significant methodological information is unavailable, and have topics that are particularly sensitive to subtle differences in question wording (see sidebar, "Survey Data Sources"). In contrast to specific percentages, consistent and substantial trends and patterns warrant greater confidence. However, international comparisons, where language and cultural differences affect how respondents interpret questions and can introduce numerous complexities, also require special care.

Information Sources, Interest, and Involvement

Because S&T are relevant to so many aspects of daily life, information about S&T can help Americans make better decisions and develop more confidence in their ability to make sense of the world around them. In addition to opening up avenues to the intrinsic satisfactions that S&T offer, interest in and involvement with S&T can be paths to acquiring more information and achieving greater understanding.

S&T Information Sources

U.S. Patterns and Trends

More Americans get most of their information about current news events from television than any other source. About half report television as their main information source, with substantial percentages reporting newspapers (23%) and the Internet (14%) as their main source (appendix table 7-1). These figures have not changed substantially since 2004 (NSB 2006). Marked changes in media use for current news occurred throughout the 1990s, including rapid growth in Internet use and sharp declines in regular local and network news viewership and in newspaper readership. However, these trends appear to have slowed or stopped in recent years (Pew Research Center for the People and the Press 2006a).

Survey Data Sources

Primary topic	Sponsoring organization	Title	Years used	Information used	Data collection method	Number of respondents/ margin of error of general population estimates
U.S. (general)	National Science Foundation	NSF surveys on public attitudes toward and understanding of science and technology	1979–2004	Information sources, interest, knowledge, general attitudes	Random digit dialing (RDD) computer-assisted telephone survey	*n* = ~1,600–2,000 ±2.47% – ±3.03%
	University of Chicago, National Opinion Research Center	General Social Survey S&T module	2006	Information sources, knowledge, general attitudes, nanotechnology attitudes	Face-to-face interviews	*n* = 1,864 ±2.68%
	The Gallup Organization	Various ongoing surveys	1984, 1990–92, 1995, 1997–2007	Evolution, environment, stem cell	RDD	*n* = ~1,000 each for U.S., Canada, Great Britain
	Virginia Commonwealth University Center for Public Policy	VCU Life Sciences Survey	2001–06	Stem cell research, interest in S&T, general attitudes	RDD	*n* = ~1,000 ±3.0%
International	European Commission	Eurobarometer 224/Wave 63.1: *Europeans, Science and Technology*; Eurobarometer 225/Wave 63.1: *Social Values, Science and Technology* (2005)	1992, 2005	Various knowledge and attitude items, including public support for basic research and trust in scientists	Face-to-face interviews	*n* = 32,897 total (~1,000 each for 27 countries; ~500 each for 4 countries) ±1.9% – ±3.1%
	Canadian Biotechnology Secretariat	Canada-U.S. Survey on Biotechnology	2005	Attitudes toward technology, including biotechnology and nanotechnology (includes U.S. data on specific issues)	RDD	Canada: *n* = 2,000 ±2.19% U.S.: *n* = 1,200 ±2.81%
	British Council, Russia	*Russian Public Opinion of the Knowledge Economy* (2004)	1996, 2003	Various knowledge and attitude items	Paper questionnaires	*n* = 2,107 (2003)
	Chinese Ministry of Science and Technology	*China Science and Technology Indicators 2002* (2002)	2001	Various knowledge and attitude items	Information not available	*n* = 8,350
	Japan National Institute of Science and Technology Policy	The 2001 Survey of Public Attitudes Toward and Understanding of Science & Technology in Japan	2001	Various knowledge and attitude items	Face-to-face interviews	*n* = 2,146
	Korea Science Foundation	Survey of Public Attitudes Toward, and Understanding of Science and Technology 2006	2006	Various knowledge and attitude items	Face-to-face interviews	*n* = 1,000 ±3.1%
	Malaysian Science and Technology Information Centre	*Public Awareness of Science and Technology Malaysia 2004* (2005)	2004	Various knowledge and attitude items	Face-to-face interviews	*n* = 6,896 ±2.0%
	Indian National Science Academy	India Science Survey 2004	2004	Various knowledge and attitude items	Face-to-face interviews	*n* = 30,255

Americans report a somewhat different pattern of primary sources for S&T information than for information about current news events (Horrigan 2006) (figure 7-1; appendix table 7-2). For both kinds of information, more Americans select television as their primary source than any other medium. Unlike for current news, though, the Internet is the second most common primary source of S&T information, and its margin over other sources is large and growing. The Internet, magazines, and books or other printed material loom larger as primary information sources for S&T than for current news; the opposite is true for television, newspapers, and radio (figure 7-2).

To learn about specific scientific issues, over half of Americans choose the Internet as their main information source (figure 7-1; appendix table 7-3). Television (19%) is the only other medium that more than 10% of Americans choose as their primary source. Considering that about one-fourth of Americans lack access to the Internet at home or work (Harris Interactive 2006c), the overall proportion who rely on it for specific S&T information is especially noteworthy. However, presumably because of limited access, the percentage of Americans who say they ever get science information from the Internet is lower than the comparable figures for television, newspapers, or magazines (Horrigan 2006).

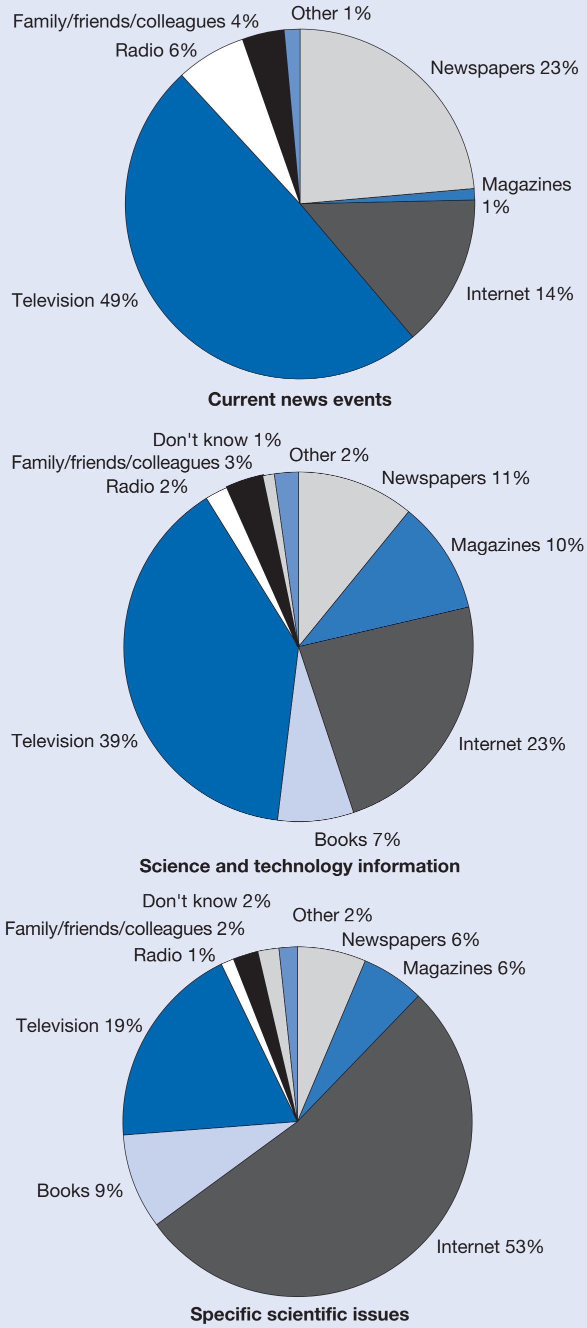
Survey Data Sources—continued

Primary topic	Sponsoring organization	Title	Years used	Information used	Data collection method	Number of respondents/ margin of error of general population estimates
Information sources, interest, and involvement	Pew Research Center for the People and the Press	Biennial News Consumption Survey	1996–2006	Information, interest	RDD	Biennial News Consumption Survey *n* = 3,204 (2006) ±2.0%
	Pew Research Center for the People and the Press	News Interest Index	2002–06	Information, interest	RDD	*n* = ~1,000 ±3.5%
	Pew Internet and American Life Project	Pew Internet and American Life Project Survey	2006	Information, interest, involvement	RDD	*n* = 2,000 ±3.0%
	USC Annenberg School Center for the Digital Future	Surveying the Digital Future	2000–06	Internet use	RDD	*n* = ~2,000
	Institute of Museum and Library Services	InterConnections: The IMLS national study on the use of libraries, museums, and the Internet	2006	Involvement	RDD	*n* = 1,057–5,082 ±1.47% – ±3.01%
Public attitudes in general	University of Chicago, National Opinion Research Center	General Social Survey	1973–2006	Government spending, confidence in institutional leaders	Face-to-face interviews	Government spending: *n* = 1,574–2,992 ±2.12% – ±2.84% Confidence in institutional leaders: *n* = 876–1,989 ±2.60% – ±3.80%
	Harris Interactive	The Harris Poll	1977–2006	Occupational prestige, Internet use	RDD	*n* = ~1,000 ±3.0%
Public attitudes about specific issues	Pew Initiative on Food and Biotechnology	Various ongoing surveys	2006	Biotechnology, genetically modified foods	RDD	*n* = 1,000 ±3.1%
	Research!America	Various ongoing surveys	2005	Stem cell research	RDD	*n* = 800–1,000 ±3.5%
	Public Agenda	Reality check 2006: Are parents and students ready for more math and science? (2006)	2005	S&E education	RDD	*n* = 1,379 ±3.8%

Recent trends in how Americans say they learn about specific scientific issues suggest the possibility of a declining reliance on longer printed sources, such as books and magazines (but not newspapers), and an increased use of television.[1] Reliance on the Internet, which had grown substantially over the past decade, is still growing but has shown signs of leveling off (figure 7-3).[2]

These trends are open to various interpretations. One possibility, consonant with the idea that the lengthy narrative in printed materials facilitates in-depth analysis of complex issues, is that Americans are increasingly seeking relatively brief and convenient overviews of such issues. This interpretation is consistent with data on recent trends in news consumption, which indicate that availability of Internet news has not increased overall news consumption and that Internet news users more often look for quick updates on the Web than for detailed information (Pew Research Center for the People and the Press 2006a). There are other possibilities, however. For example, because America's media environment is increasingly segmented, the assumption that a particular information source provides a particular kind or quality of information is becoming increasingly problematic. Thus television includes a range of science-related material, presented in specialized programs (e.g., *Nova*) and channels (e.g., the Science Channel) that cater to people with a sustained interest in science; outlets (e.g., news magazines) that offer occasional, ordinarily reliable scientific information; and even entertainment programs that indiscriminately

Figure 7-1
Primary source of information, by use: 2006

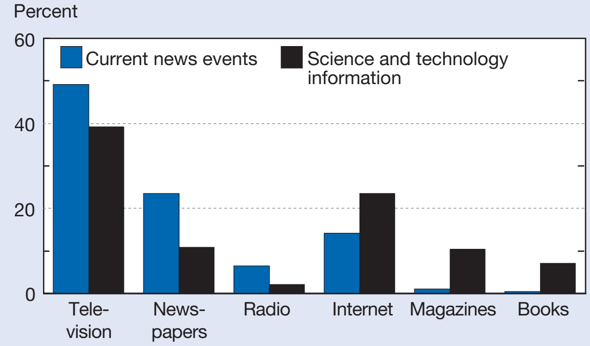


NOTES: Government agencies included in “other” category. For current news events, books included in “other” category, and “don’t know” not shown because <1.0% response. Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix tables 7-1, 7-2, and 7-3.

Science and Engineering Indicators 2008

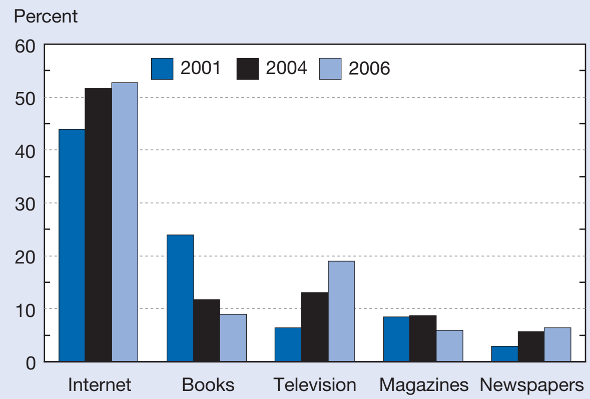
Figure 7-2
Primary source of current news events and science and technology information: 2006



SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix tables 7-1 and 7-2.

Science and Engineering Indicators 2008

Figure 7-3
Primary source of information about specific scientific issues: 2001, 2004, and 2006



SOURCES: National Science Foundation, Division of Science Resources Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (2001); University of Michigan, Survey of Consumer Attitudes (2004); and University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-3.

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mix scientific information with fantasy speculations about the physical and biological worlds. Other media also present heterogeneous content. By this interpretation, then, a user who moves from magazines to television may be doing it for a variety of reasons and is not necessarily choosing information of lesser quality.

In general, people who rely more on television for news and information, including S&T information, tend to be older and have fewer years of education than those who rely on the Internet and other sources (appendix tables 7-1 and 7-2). Access to high-speed Internet connections is also associated with more extensive reliance on the Internet for news and information (Cole 2005; Horrigan 2006).

Perhaps because S&T information is not easily separable from the general flow of information in the mass media, national data that address the processes through which Americans acquire and sort through such information are scarce. A Pew Internet and American Life Project survey (Horrigan 2006) probed how Americans use the Internet to acquire information about science. It found that a clear majority of Internet users had engaged in some information search activities, including "look up the meaning of a particular scientific term or concept" (70%), "look for an answer to a question you have about a scientific concept or theory" (68%), and "learn more about a science story or scientific discovery you first heard or read about offline" (65%). In addition, just over half had used the Internet to "complete a science assignment for school, either for yourself or for a child" (55%) or "check the accuracy of a scientific fact or statistic" (52%). Fewer had used the Internet to "download scientific data, graphs or charts" (43%) or "compare different or opposing scientific theories" (37%). How skillfully or how often Americans engage in the search for scientific information, whether on the Internet or elsewhere, remains unknown.

Using information well involves more than finding it. In an information-saturated society, Americans need to make critical assessments of the information they encounter and somehow determine whether it is credible.

Survey data provide some indications of how Americans assess the credibility of public information. For the past two decades, Americans have been becoming more skeptical of the information they encounter in the major broadcast and print media generally, although this trend has leveled off somewhat recently (Pew Research Center for the People and the Press 2006a). Americans' judgments of media credibility appear to be shaped by more than their critical thinking skills and the quality of the information provided. For example, judgments of the credibility of particular mass media information sources are associated with political party affiliations (Pew Research Center 2005; Pew Research Center for the People and the Press 2006a). (For data on perceived credibility of biotechnology information sources, see section on "Biotechnology and Its Medical Applications.")

Compared with survey results on the credibility of the major broadcast and print media, data on the credibility of Internet information suggest greater public confidence, most likely because the survey questions are asked in a context that makes respondents think of information that is neither value laden nor controversial.[3] For example, a majority of Internet users considered most or all online information to be accurate and reliable. In a survey on Internet use, approximately three-quarters of Internet users rate government websites and websites associated with established print and broadcast media as reliable (Cole 2006). These same established media fare less well in survey contexts that are more likely to invite respondents to ponder the reliability of politically sensitive information in the media (Pew Research Center for the People and the Press 2006a).

Evidence about how Americans judge the credibility of S&T information in the media is scant. Pew's study of how Americans acquire science information indicates that Internet users who seek science information online do not always assume that the information they find there is accurate (Horrigan 2006). Eighty percent report that they have "ever" done at least one of the following kinds of checks:

- Compare it to other information you find online to make sure it's correct (62%)
- Compare it to an offline source like a science journal or encyclopedia (54%)
- Look up the original source of the information or the original study it's based on (54%)

It is natural to assume that people's choice of media sources affects how they think about S&T. However, it is difficult to design research that clearly isolates the effects of the media and establishes causal linkages. One reason is that people's preexisting opinions and orientations are likely to affect their media choices; another is that media content often affects people indirectly, filtered through the views of trusted friends and relatives (see sidebar, "Media Effects").

International Comparisons

Data collected between 2001 and 2004 on sources of S&T information used by people in other countries, including the European Union (EU) states, Japan, Russia, South Korea, and China, uniformly identify television as the leading source of S&T news and information. Newspapers generally ranked second. Relatively few survey respondents cited the Internet as an important source of S&T information, perhaps in part because many lacked access to the Internet. However, national differences in how questions were asked make precise comparisons among different countries impossible. In a 2006 South Korean survey, more respondents named the Internet (23%) as their primary source of S&T information than named newspapers (16%) (Korea Gallup 2007). More recent data on the other countries do not exist; further details on these older data are presented in the 2006 edition of *Science and Engineering Indicators* (NSB 2006).

Television is also the dominant source of S&T information in India, where about two-thirds of survey respondents in 2004 said it was their main information source (Shukla 2005). Radio (13%) and friends/relatives (12%) ranked ahead of written sources such as newspapers, books, and magazines, which together accounted for 9% of responses. India's relatively low literacy rate (144th of 176 countries in a 2005 ranking) is useful context for these findings.

Media Effects

Citizens of economically advanced societies live in a world that is permeated by mass media of communication. A large social science literature probes how these media operate, what kinds of messages they send, how they tailor their messages to reach different audience segments, and how those messages relate to public opinion. Mass media messages interact with the opinions of the American public in complex ways, and teasing out the reciprocal effects is complicated (Perse 2001).

Providers of media content are not free to supply whatever content they prefer. In making content decisions, the people who own and manage media organizations take into account the views of the segments of the public that purchase their products and are well aware that their audiences can select other content providers. Likewise, the journalists who gather information and report stories for mass media transmission, whatever their personal views, are guided by the standards of the organizations for which they work and the professions in which they are trained. In addition, they are typically motivated by the desire to make an impact on a large audience by presenting stories in compelling and dramatic ways.

At the same time, the mass media do not simply reflect the public they serve. Members of the public are dependent on mass media for much of their information about public issues, either through direct exposure or second hand from friends and relatives. Because Americans tend to rely on sources of information that typically adopt a perspective akin to their own, the ways trusted mass media pose new or less familiar issues can assume great importance. Moreover, even for members of the public who search out multiple points of view on an issue, the shared terms and assumptions in the media shape how they think about issues. Interested parties, including newsmakers, are increasingly sophisticated in crafting messages to capture media attention and appeal to the public.

Studies that seek to isolate the effects of mass media face numerous challenges:

- Laboratory research, which can control for factors other than media exposure that influence people's opinions, has an uncertain relationship to real world situations, in which people choose media programs, interpret media messages through conversations with others, and pay varying degrees of attention to what is said in the mass media. It is difficult to recreate these conditions in laboratories.
- Even when research can demonstrate short-term effects of media exposure, it is hard to know how much these persist over time or affect behavior in natural settings.
- People interpret a media message differently depending on the beliefs they bring to it and the attention they give it. Thus, media messages may affect individuals, but, because the effects are not uniform and can run in opposite directions, aggregate opinion may be left almost unchanged.
- Media messages may have more to do with motivating people who already hold an opinion to become more active in civic and political contexts than with persuading people to adopt new opinions. Surveys may have difficulty capturing this kind of effect.
- In a society with multiple sources of media content, even highly influential media sources, such as programs on major television networks, reach only a fraction of the population and, at any given time, change the perspectives of only a fraction of the people they reach.
- Mass media messages are significantly shaped by events—what is actually taking place in the situations about which they are reporting. Although facts are open to various interpretations and presentations, they set limits beyond which media organizations cannot go without losing credibility.
- It is easy to demonstrate correlations between media content and shifts in public opinion, but hard to demonstrate causation. Sometimes, changes in media content reflect changes in elite opinion or actual circumstances, rather than changes initiated or caused by the mass media themselves.
- Media exposure may have threshold effects, in which a certain amount of repetition is necessary for a message to get through, but beyond that amount further repetition has little or no impact. Compared with effects that work incrementally, threshold effects are harder to isolate.

Recent research in communications has stressed the role of the mass media in shaping the agenda for public debate and political action (*agenda-setting*) and the terms in which the public sees an issue (*framing*) (Scheufele and Tewksbury 2007). Agenda-setting works largely through making a topic more salient and accessible to memory by frequent or more prominent mention of it, thereby increasing the public's sense that the topic is important. Framing refers to ways that mass media construct stories to make a topic comprehensible and relevant to the public. Frames stress some aspects of a topic and minimize others. Some kind of framing is necessary to reduce complexity and provide a focus to make sense of what would otherwise be undigested facts. Interested parties vie to get the mass media to present topics in their preferred frames. Research on how S&T are discussed in the mass media has identified competing frames that have been used to present contested issues (Gamson and Modigliani 1989; Nisbet and Lewenstein 2002). Recognizing that most members of the public pay limited attention to S&T information, some researchers have argued that representatives of the scientific community need to do more to influence how the mass media frame issues (Nisbet and Mooney 2007; Scheufele 2006). In their view, when it comes to influencing public opinion, influencing the frames through which the public processes and understands science-related issues may be more important than increasing the scientific and technical content of news coverage.

Public Interest in S&T

U.S. Patterns and Trends

In surveys, Americans consistently express high levels of interest in S&T. Asked in 2006 whether "I enjoy learning about science and new science discoveries" describes them, about three-fourths of Americans said it describes them either very (43%) or somewhat (31%) well (Horrigan 2006). Likewise, in six annual surveys conducted between 2001 and 2006, between 83% and 87% of Americans reported that they had either "a lot" or "some" interest in new scientific discoveries, with the remaining small minority expressing less interest (table 7-1). In 2006, 47% claimed they had "a lot" of interest. More highly educated people tend to express greater interest in S&T (Pew Research Center for the People and the Press 2004).

High levels of expressed interest in S&T are part of a long-standing pattern, evidenced in the results of 11 National Science Foundation (NSF) surveys conducted between 1979 and 2001 (NSB 2002). In each survey, more than 80% of Americans reported that they were either "very" or "moderately" interested in "new scientific discoveries" and "new inventions and technologies."

However, the NSF surveys also give reason to doubt the strength and depth of Americans' interest in S&T. Relative to interest in other topics, interest in S&T in these surveys was not particularly high. S&T interest ranked in the middle among the 10 areas frequently listed in the surveys: above space exploration, international and foreign policy, and agriculture and farming; below new medical discoveries, local schools, and environmental pollution; and similar to economic and business conditions and military and defense policy. Of course, a more inclusive concept of S&T might treat several of the topics in this list, such as space exploration and new medical discoveries, as part of the S&T category; furthermore, other topics often include substantial S&T content (see sidebar, "What Are Science and Technology?").

Survey responses about S&T news also raise questions about how interested Americans are in S&T in general. For 10 years, Pew (Pew Research Center for the People and the Press 2006a) has collected data on categories of news that Americans follow "very closely." In 2006, S&T news was followed closely by 15% of the public and ranked 10th among 14 topics, ahead of only business and finance, entertainment, consumer news, and culture and the arts (table 7-2). As is the case for many other news topics, the percentage of Americans who say they follow S&T closely has declined over this period. But S&T's decline has been more pronounced, with the result that its relative standing in the list of topics has also slipped over the decade: whereas S&T ranked ahead of seven topics in 1996, three of these had surpassed it by 2002 and have remained ahead since then.

Among regular newspaper readers, articles on "health and medicine" and "technology" rank relatively high as portions of the newspaper that Americans spend "some time" or "a lot of" time reading (table 7-3). Data on these topics might

Table 7-1
Public interest in new scientific discoveries: 2001–06
(Percent)

Level of interest	2001	2002	2003	2004	2005	2006
A lot	43	39	44	42	45	47
Some	44	44	43	42	42	40
Not much	8	12	10	10	8	9
Not at all	4	4	3	5	4	4
Don't know	1	0	0	0	1	0

NOTE: Responses to: *How much are you personally interested in new **scientific** discoveries?*

SOURCE: Virginia Commonwealth University (VCU), Center for Public Policy, Survey and Evaluation Research Laboratory, VCU Life Sciences Survey 2006, http://www.vcu.edu/lifesci/centers/cen_ lse_surveys.html.

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What Are Science and Technology?

When Americans refer to science and technology (S&T), they rarely define their terms. Ordinary language rests on the assumption that terms such as these, even if their precise meanings are not quite the same for everyone, invoke a bundle of associations that are similar enough to enable people to communicate. Survey research gathers attitude data about how people respond to the ill-defined linguistic bundles, such as S&T, that people use in ordinary conversation.

For purposes of analysis and comparison, research studies usually classify topics in the news in a way that makes space, environment, and health and medicine separate from S&T. The meaning respondents ascribe to a topic category, such as S&T, is affected by the context in which it appears and the other categories listed with it.

In interpreting survey data that use these terms, it is important to take into account the uncertainties surrounding the meaning of S&T. For example, it is not clear how often survey respondents who are asked about "science and technology" think they are being asked about two separate entities about which they might have different interests or attitudes, rather than about a single complex whole. Likewise, although engineers often think of technology as a broad category of devices and systems that humans construct to solve problems and interact with their environments, there is some evidence that for many people the term technology refers more narrowly to electronic information technology, especially computers (Cunningham, Lachapelle, and Lindgren-Streicher 2005; Rose and Dugger 2002).

Table 7-2
News followed very closely by American public: 1996–2006
(Percent)

Type of news	1996	1998	2000	2002	2004	2006
Weather	NA	NA	NA	NA	53	50
Crime	41	36	30	30	32	29
Community	35	34	26	31	28	26
Health	34	34	29	26	26	24
Sports	26	27	27	25	25	23
Local government	24	23	20	22	22	20
Washington news	16	19	17	21	24	17
International affairs	16	16	14	21	24	17
Religion	17	18	21	19	20	16
Science and technology	20	22	18	17	16	15
Business and finance	13	17	14	15	14	14
Entertainment	15	16	15	14	15	12
Consumer news	14	15	12	12	13	12
Culture and arts	9	12	10	9	10	9

NA = not available, question not asked

NOTES: Data reflect respondents who said they followed type of news "very closely." Table includes all years for which data collected.

SOURCE: Pew Research Center for the People and the Press, Online papers modestly boost newspaper readership: Maturing Internet news audience broader than deep (30 July 2006), Biennial News Consumption Survey (27 April–22 May 2006), http://people-press.org/reports/display.php3?ReportID=282, accessed 26 April 2007.

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Table 7-3
What people read in the newspaper: 2006
(Percent)

Type of news	2006
News stories about one's city, town, or region	91
National news stories	88
International news stories	84
Articles on health and medicine	77
Articles about technology	63
Editorial and opinion pages	60
Business and financial news	60
Articles about food, diet, cooking	55
News stories and columns about religion	51
Consumer tips on products and services	50
Sports section	48
Entertainment news	46
Obituaries	42
Comics, puzzles, and games	41
Articles and reviews about travel	39
Advertisements	35
Real estate section	32
TV/movie/entertainment information and schedules	29
Personal advice columns	28
Society pages, weddings/engagements/births	24

NOTES: Based on respondents reading newspaper "just about every day" or "sometimes." Data reflect those saying they spent "some time" or "a lot of time" reading type of news in newspaper.

SOURCE: Pew Research Center for the People and the Press, Online papers modestly boost newspaper readership: Maturing Internet news audience broader than deep (30 July 2006), Biennial News Consumption Survey (27 April–22 May 2006), http://people-press.org/reports/display.php3?ReportID=282, accessed 26 April 2007.

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be interpreted as indicating relatively high S&T interest; at a minimum, these topics can spur readers to learn about human biology and advances in engineering. Conversely, interest in these topics may be limited to information that is immediately related to personal and family well-being or news about computer technology. The available data do not indicate how survey respondents themselves define the focus or scope of their interest.[4]

Since 1986, the Pew Research Center for the People and the Press has maintained a news interest index that tracks individual stories that make headlines. The index is based on frequent surveys that record the proportion of Americans who, when asked about a news story, say they are following it "very closely." Stories that attract considerable public interest are often included in several surveys, and results from each survey appear separately several times on the news interest index. For 2002–06, high gasoline prices, the impact of hurricanes Katrina and Rita, and debates on the war in Iraq comprise all but one of the top 20 items on the list (the Washington, DC area sniper shootings was the other item) (Pew Research Center for the People and the Press 2007a). If S&T content were what generated sustained high levels of public interest in a news story, a different set of stories would be at the top of the list.

However, top stories may not be the best indicator of public interest and exposure. S&T stories rarely feature the evolving human drama of wars and disasters or the immediate personal effects of gasoline prices, making it harder for them to capture widespread and sustained attention in the population at large. It is safe to say that all of the top stories at times focused public attention on S&T issues and that Americans who had a sounder understanding of S&T were better able to comprehend at least some aspects of them. Thus, the geology, chemical engineering, and economics involved in finding gasoline, refining it, and getting it to market are at times part of news coverage of gas prices; the atmospheric science, civil engineering, and sociology involved in disasters and disaster response are at times part of news coverage of hurricanes; and the chemistry and biology of weaponry and the political science of building democracy are at times part of the coverage of the Iraq war. The survey data cannot discriminate finely enough to determine how much the public engages with the more scientific and technological aspects of stories like these.

A different kind of news indicator is the amount of coverage news organizations devote to S&T. This indicator can involve either sheer quantity (e.g., newspaper space, broadcast time) or prominence (e.g., lead stories). For 20 years, the Tyndall Report has tracked the time that the three major broadcast networks devoted to 18 categories of news on their nightly newscasts (Tyndall Report 2007). Two categories with large S&T components are science, space, and technology, and biotechnology and basic medical research.[5] Neither category has ever occupied a large percentage of the approximately 15,000 minutes of newscast coverage on the networks; science, space, and technology, the larger of the two categories, garnered 752 minutes in its peak year (1999). Both categories began the period at relatively low levels of coverage, climbed sharply beginning some time in the mid to late 1990s, dropped off even more sharply very early in the new century, and then showed signs of rebounding, but ending well below their peak levels (figure 7-4). Trends in the science, space, and technology category, along with recent annual lists of leading individual stories in that category, suggest that the advent of the Internet and the significance of developments in the nation's space program affected the amount of news coverage (table 7-4). The importance of competing stories, such as terrorist attacks, also plays a role. Data on front-page newspaper stories suggest that science figured somewhat more prominently in 2004 than in 1977, when it was hardly visible (Project for Excellence in Journalism 2005).

International Comparisons

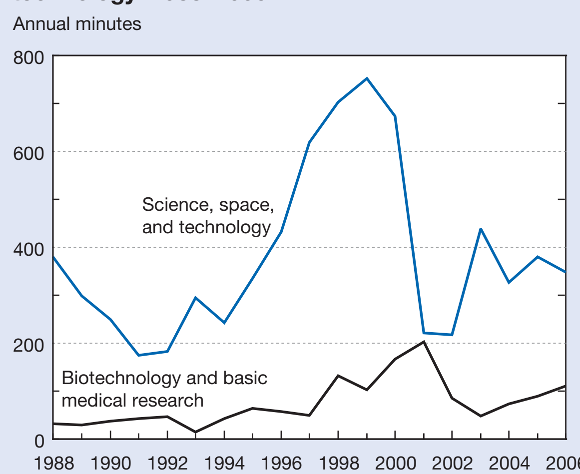
Recent surveys conducted in other countries indicate that the overall level of public interest in S&T is less than that in the United States. In 2005, 30% of survey respondents in Europe said they were very interested in new scientific discoveries, about half (48%) said they were moderately interested, and one-fifth said they were not at all interested. Comparable 2001 U.S. numbers were substantially higher for "very interested" and substantially lower for "not at all interested." The distribution of European responses about interest in new inventions and technologies was almost identical to that for scientific discoveries. There was considerable variation in interest among European countries, and the overall level of interest was down somewhat from 1992, the last time these questions were asked. Survey respondents who said they were not at all interested in either new scientific discoveries or new inventions and technologies most often gave "I don't understand it" or "I do not care about it" as reasons (European Commission 2005a). As in the United States, men in Europe showed more interest in S&T than women. Unlike in the United States, S&T interest in Europe appears to have declined between 1992 and 2005.

Residents of several Asian countries, including Japan, South Korea, and Malaysia, seem to express less interest than Americans and Europeans in S&T. However, China is a notable exception: interest levels for China were about the same as those for the United States (Chinese Ministry of Science and Technology 2002; European Commission 2005a, b; Korea Gallup 2007; Korea Science Foundation 2004; Malaysian Science and Technology Information Centre 2004; National Institute of Science and Technology Policy 2002).

Like Americans, Europeans are more interested in medicine than in S&T in general. In the United States, in particular, nearly everyone is interested in new medical discoveries. In contrast, interest in new medical discoveries seems to be much lower in Asian countries than in the West.

Relative to other topics, including S&T-related topics, interest in space exploration has consistently ranked low both in the United States and around the world. Surveys in Europe, Russia, China, and Japan document this general pattern.

Figure 7-4
Network nightly news coverage of science and technology: 1988–2006



NOTES: Data reflect annual minutes of story coverage on these topics by major networks ABC, CBS, and NBC out of approximately 15,000 total annual minutes on weekday nightly newscasts. Excluded from science, space, and technology are forensic science; math, science, and math education in schools; and media content. Excluded from biotechnology and basic medical research are stories on clinical research and medical technology.

SOURCE: Tyndall Report, special tabulations (March 2007), http://www.tyndallreport.com.

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Involvement

Involvement with S&T outside the classroom in informal, voluntary, and self-directed settings such as museums, science centers, zoos, and aquariums is an indicator of interest in S&T.[6] By offering visitors the flexibility to pursue individual curiosity, such institutions provide a kind of exposure to S&T that is well suited to helping people develop further interest. Professional scientists and engineers often stress the role of their informal S&T experiences in motivating them to pursue S&T careers (Bayer 2007).

Surveys conducted for the Pew Internet and American Life Project and the Institute for Museum and Library Services (IMLS) indicate that about three of five American adults visited an informal science institution in the year preceding the survey (Griffiths and King 2007; Horrigan 2006). In the Pew survey, almost half said they had visited a zoo or aquarium; the IMLS data indicate that a little more than one-third had done so.[7] The two surveys produced comparable estimates for “natural history museum” and “science or technology museum,” with percentages in the low to mid-twenties. The IMLS survey reported similar attendance figures for “nature center” (28%), “arboretum or botanical garden” (23%), and “children’s or youth” museum (20%). Fewer Americans (14% in the Pew survey) said they had visited a planetarium. Data from these surveys are generally consistent with NSF data collected between 1979 and 2001.[8]

When adults visit science-related informal learning institutions, they are more likely to be accompanied by family members and children than when they visit non-science-related institutions such as art or history museums. The IMLS survey asked parents who had visited a museum in the past year about whether their children had also made visits. For children between 3 and 17 years old, over two-thirds visited a zoo or aquarium in 2006. About half visited S&T museums, nature centers, and children’s or youth museums. Comparable figures for history museums and historic sites were about 40%, and the percentage for art museums (22%) was even lower.[9] Although similar percentages of adults (almost half) visited S&T museums and art museums, a much larger percentage of the children of those adults visited S&T museums (55%) than art museums (22%) (Griffiths and King 2007).

Americans who have more years of formal education are more likely than others to engage in these informal science activities (figure 7-5). Whereas 76% of college graduates engaged in at least one of the four informal S&T-related activities during the year preceding the Pew survey, the comparable figures for adults in other education categories were well below this (Horrigan 2006). Similar education differences also exist among visitors to public libraries and art museums. Education patterns in the IMLS data are similar (Griffiths and King 2007). Among Americans who visit these informal science institutions, younger adults and parents of minor children were also somewhat overrepresented.

The IMLS survey found that nearly one-third of Americans visited science-related informal learning institutions remotely via the Internet, mostly in conjunction with their in-person visits. Slightly less than half watched television programs that contained content from these institutions. The percentages for non-science-related institutions are similar.

Table 7-4
Leading nightly news story lines on science and technology, by topic area: 2005 and 2006
(Annual minutes of coverage)

Topic area/leading story line	2005	Topic area/leading story line	2006
Science, space, and technology		Science, space, and technology	
NASA Space Shuttle program	146	NASA Space Shuttle program	59
Databases invade privacy: files on individuals	30	Internet used for social networking by teenagers	27
NASA Deep Impact astronomy probe studies comet	10	Digital media: videostreams shared viral networks	23
Internet online commerce volume increases	10	China censors Internet access, e-mail traffic	13
Internet hardcore pornography proliferates	9	Computer laptop batteries fire safety recall	12
Digital media: online downloadable music	8	Internet search engine private data sought	11
Computer executive Carly Fiorina fired	8	Solar system astronomy: Pluto disqualified as planet	10
NASA mulls renewed manned missions to moon	7	Cellular telephone use log privacy easily invaded	8
Digital media: online video on demand	7	Internet gambling Websites operate offshore	8
Computer privacy invaded by spyware software	6	NASA Hubble space telescope needs repair	7
Biotechnology/basic medical research		Biotechnology/basic medical research	
Human embryo stem cell biotechnology research	62	War on cancer basic research efforts	50
Animal cloning in agriculture research	8	Human embryo stem cell biotechnology research	36
Animals-to-humans organ transplant research	6	Animal cloning in agriculture research	9

NOTES: Data reflect annual minutes of story coverage on these topics by major networks ABC, CBS, and NBC, out of approximately 15,000 total annual minutes on weekday nightly newscasts. Shown are the 10 science, space, and technology story lines receiving most minutes of coverage in 2005 and 2006 and the 3 biotechnology and basic medical research story lines receiving more than 5 minutes of coverage. Excluded from science, space, and technology are stories on forensic science; math, science, and engineering education in schools; and media content. Excluded from biotechnology and basic medical research are stories on clinical research and medical technology.

SOURCE: Tyndall Report, special tabulations (March 2007), http://www.tyndallreport.com.

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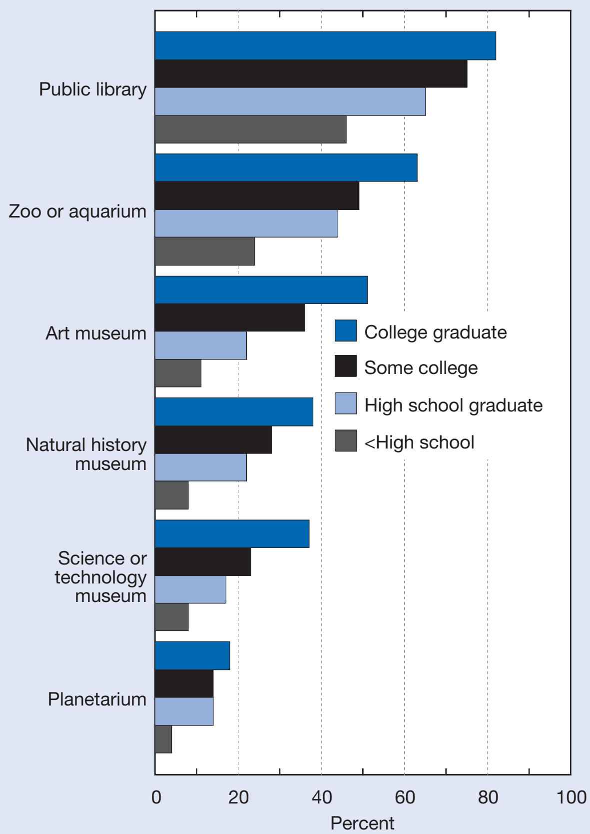
Fewer Europeans report visits to informal science institutions (European Commission 2005a). In the EU-25, about 27% of adults said they had visited a zoo or aquarium, 16% said they had visited a "science museum or technology museum or science centre," and 8% said they had attended a "science exhibition or science 'week'." As in the United States, older and less-educated Europeans reported less involvement in these activities. In addition, European adults in households with more inhabitants more often reported informal science activities; insofar as household size indicates the presence of minor children, this probably indicates another parallel with the United States. One demographic pattern is notably different between Europe and the United States: whereas European men (19%) are much more likely than women (13%) to visit informal science or technology museums and centers, in the United States visitors are drawn about equally from both sexes.

Europeans who said they had not visited S&T museums often mentioned lack of time (35%) or interest (22%) in doing so. Reasons relating to lack of awareness, for example, "I didn't think about it" (21%) and "I do not know where these museums are" (9%), also suggest an absence of strong interest in this kind of activity. However, lack of involvement can stem from factors unrelated to interest, too. Many respondents appeared to consider these institutions relatively inaccessible, either because they were "too far away" (23%) or too expensive (7%).[10]

Compared with the United States, visits to informal science institutions are also less common in Japan, South Korea, China, and, especially, Russia (Gokhberg and Shuvalova 2004). It is unclear to what degree these international variations are a result of differences in interest, differences in accessibility, or other factors.

Figure 7-5
Attendance at informal science institutions, by institution type and education level: 2006



SOURCE: Horrigan J, The Internet as a Resource for News and Information about Science, *Pew/Internet* (November 2006); and Pew Internet & American Life Project Survey (January 2006), http://www.pewinternet.org.

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Public Knowledge About S&T

As the scientific and technical content of modern life grows, citizens increasingly need to be more scientifically literate to make sound public policy and personal choices. In developing an internationally agreed upon approach to conceptualizing and measuring scientific literacy, the Organisation for Economic Co-operation and Development (OECD) (2003) noted that literacy had several components:

> Current thinking about the desired outcomes of science education for all citizens emphasizes the development of a general understanding of important concepts and explanatory frameworks of science, of the methods by which science derives evidence to support claims for its knowledge, and of the strengths and limitations of science in the real world. It values the ability to apply this understanding to real situations involving science in which claims need to be assessed and decisions made. . . .
>
> Scientific literacy is 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. (pp. 132–33)

As the reference to changes made through human activity makes clear, the OECD definition encompasses an understanding of technology. In addition, OECD takes the view that literacy is a matter of degree and that people cannot be classified as either literate or not.

A good understanding of basic scientific terms, concepts, and facts; an ability to reason well about issues involving S&T; and a capacity to distinguish science from pseudoscience are indicators of scientific literacy. (For a different perspective on scientific literacy, see sidebar "Asset-Based Models of Knowledge").

Americans need to comprehend common scientific and technological terms such as *DNA* or *molecule* and recall commonly cited facts so they can make sense of what they read and hear about S&T-related matters. Whether they turn their attention to congressional debates over stem cell research or to instructional videos or pamphlets explaining how to use a newly purchased electronic device, the messages they get presuppose some basic knowledge of terms, concepts, and facts. For S&T, as for other topics, even people with superior reasoning and cognitive skills are at a disadvantage when they lack basic information, especially if others take such information for granted and make statements that build on it (Hirsch 2006).

Appreciating the scientific process can be even more important than knowing scientific facts. People often encounter claims that something is scientifically known. If they understand how science generates and assesses evidence bearing on these claims, they possess analytical methods and critical thinking skills that are relevant to a wide variety of facts and concepts and can be used in a wide variety of contexts.

An additional indicator of how well people apply scientific principles in real world contexts is how they assess pseudoscientific claims, which adopt the trappings of science to present knowledge claims that are not grounded in the systematic methodology and testing associated with science.

U.S. survey data indicate that many Americans cannot provide correct answers to basic questions about scientific facts and do not reason well about selected scientific issues. Residents of other countries, including highly developed ones, perform no better, on balance, when asked similar questions. In international comparisons of scientific knowledge and reasoning, then, American adults appear to rank somewhat better than American middle and high school students (see chapter 1, "Elementary and Secondary Education"). Any generalizations about Americans' knowledge of science must, however, be tentative, given the measurement-related uncertainties discussed elsewhere in this chapter.

Asset-Based Models of Knowledge

Many researchers and educators interested in the public's understanding of science advocate studying the assets people bring to bear on scientific issues that they deal with in their daily lives. Because individuals encounter S&T in different ways, they acquire different S&T knowledge "assets," which they then can use to make sense of unfamiliar issues. For researchers and educators who favor an asset-based model of scientific literacy, public understanding of science is less a "generalized body of knowledge and skills that every citizen should have by a certain age" than "a series of specific sets of only moderately overlapping knowledge and abilities that individuals construct over their lifetimes" (Falk, Storksdieck, and Dierking forthcoming). In education, asset-based perspectives on knowledge have been useful in helping teachers build on children's existing strengths to improve their performance.

Generalized assessments of S&T knowledge, by asking questions on topics that may be of little interest to many respondents, may underestimate the assets available to individuals when they deal with S&T matters of greater interest and consequence to them. In contrast, a knowledge assessment that is tailored to an S&T domain with which an individual is familiar might yield very different results. In addition, because people often use their knowledge assets in group interactions, such as a nature outing, some researchers question the value of individual assessments in a test or survey (Roth and Lee 2002).

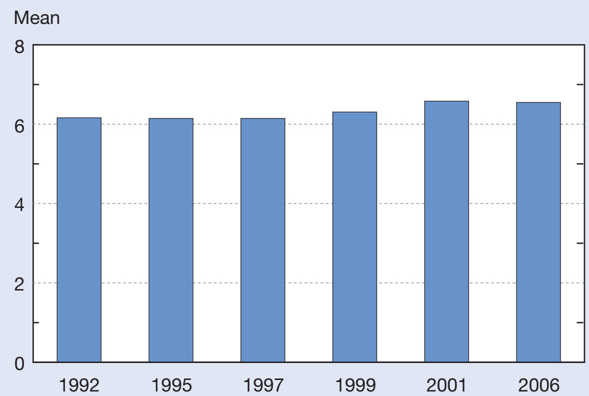
National indicators that evaluate domain-specific knowledge or group problem-solving are not practical. Surveys cannot use different measures to enable gardeners, auto mechanics, and amateur astronomers to demonstrate their different S&T-related assets and then reliably aggregate the results from different S&T domains. Nonetheless, a perspective on scientific literacy that stresses domain-specific or group assets is useful in that it points to a significant limitation of generalized indicators of individual scientific literacy.

Understanding Scientific Terms and Concepts

U.S. Patterns and Trends

U.S. data do not show much change over time in the public's level of factual knowledge about science.[11] Figure 7-6 shows the average numbers of correct answers to a series of mostly true-false science questions in different years (appendix table 7-4).[12] Although performance on individual

Figure 7-6
Correct answers to scientific literacy questions: 1992–2006



NOTES: Number correct of 12 questions. See notes to appendix table 7-4 for explanation of "factual knowledge of science scale 1" used for this figure. See appendix tables 7-5 and 7-6 for responses to individual scientific literacy questions included in scale. Table includes all years for which data collected.

SOURCES: National Science Foundation, Division of Science Resources Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1992–2001); and University of Chicago, National Opinion Research Center, General Social Survey (2006).

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Table 7-5
Correct answers to scientific literacy questions, by sex: 2001, 2004, and 2006
(Percent)

Question	2001	2004	2006
Physical science			
The center of the Earth is very hot. (True)			
Male	85	86	85
Female	76	72	75
All radioactivity is man-made. (False)			
Male	81	82	77
Female	71	66	64
Lasers work by focusing sound waves. (False)			
Male	61	59	62
Female	30	28	32
Electrons are smaller than atoms. (True)			
Male	52	52	61
Female	43	39	48
The universe began with a huge explosion. (True)			
Male	43	41	40
Female	24	27	27
The continents have been moving their location for millions of years and will continue to move. (True)			
Male	83	85	85
Female	74	71	75
Does the Earth go around the Sun, or does the Sun go around the Earth? (Earth around Sun) *How long does it take for the Earth to go around the Sun?* (One year)			
Male	66	NA[a]	66
Female	42	NA	46
Biological science			
It is the father's gene that decides whether the baby is a boy or a girl. (True)			
Male	58	51	55
Female	72	70	72
Antibiotics kill viruses as well as bacteria. (False)			
Male	46	49	50
Female	55	58	61
Human beings, as we know them today, developed from earlier species of animals. (True)			
Male	57	45	47
Female	50	40	40
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. Does this mean that if their first child has the illness, the next three will not? (No)			
Male	85	83	90
Female	83	81	84
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. Does this mean that each of the couple's children will have the same risk of suffering from the illness? (Yes)			
Male	76	76	76
Female	74	71	74
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? Why is it better to test the drug this way? (The second way because a control group is used for comparison)			
Male	39	49	42
Female	38	43	41

NA = not available

[a]Not asked in 2004, so composite percentage not computed.

SOURCES: National Science Foundation, Division of Science Resources Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (2001); University of Michigan, Survey of Consumer Attitudes (2004); and University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix tables 7-5 and 7-6.

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questions varies somewhat over time (appendix table 7-5), overall scores are relatively constant.

Factual knowledge of science is positively related to level of formal schooling, income level, and number of science and math courses taken. In addition, the oldest respondents are less likely than others to answer the questions correctly (appendix tables 7-4 and 7-6). Especially for questions outside the biological sciences, men tend to answer correctly more often than women (table 7-5).

The factual knowledge questions that have been repeatedly asked in U.S. surveys involve information that was being taught in grades K–12 when most respondents were young. Because science continually generates new knowledge that reshapes how people understand the world, scientific literacy requires lifelong learning so that citizens become familiar with terms, concepts, and facts that emerged after they completed their schooling. In 2006, the General Social Survey (GSS) asked Americans questions that tested their knowledge of two topics that historically have not been central to the standardized content of American science education: nanotechnology and the Earth's polar regions. For all but the youngest respondents, several of the questions concerned knowledge that was too new for them to have learned it in school. Nonetheless, survey respondents who scored relatively well on the questions that have been asked repeatedly over the years also exhibited greater knowledge of these two topics (figure 7-7).[13] Likewise, the educational and demographic characteristics associated with higher scores on the knowledge questions that have been repeatedly asked are also associated with higher scores for these two new topics (appendix table 7-7). These data suggest that the knowledge items used to measure trends, although focused on the kind of factual knowledge learned in school, are a reasonable indicator of factual science knowledge more generally, including knowledge that is acquired later in life.

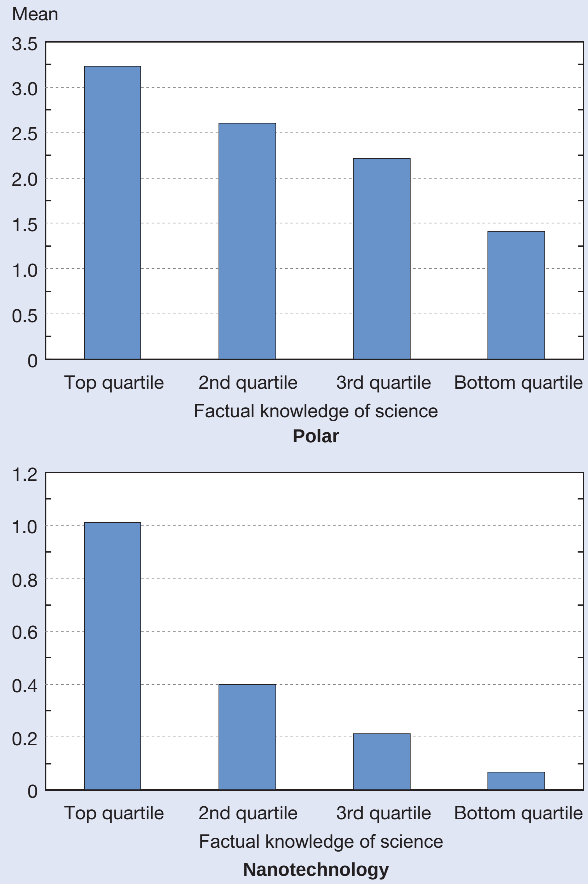
If Americans' performance in answering factual knowledge questions concerning science can be deemed disappointing, the same is true for their performance in other areas of knowledge (see sidebar, "Science Knowledge and Civic Knowledge"). Survey data of varying quality have been interpreted to indicate that Americans, especially the young, do not know enough about history, civics, geography, and politics, and are not sufficiently interested in these and other domains of knowledge that, like scientific knowledge, can serve as a foundation for understanding the world around them (Bauerlein 2006; Gravois 2006).

International Comparisons

Adults in different countries and regions have been asked identical or substantially similar questions to test their factual knowledge of science.[14] Knowledge scores for individual items vary from country to country, and no country consistently outperforms the others (figure 7-8). For the widely asked questions reported in figure 7-8, knowledge scores are relatively low in Russia, China, and Malaysia. Compared with the United States and the highly developed countries in Europe, Japanese scores are also relatively low.[15]

Science knowledge scores vary considerably across the EU-25 countries (figure 7-9), with northern European countries, led by Sweden, recording the highest total scores on a set of 13 questions. For a smaller set of four items that were administered in both 1992 and 2005 in 12 European countries, each country performed better in 2005 (appendix table 7-8); in contrast, the U.S. data on science knowledge do not show upward trends over the same period. In Europe, as in the United States, men, younger people, and more highly educated people tend to score higher on these questions.

Figure 7-7
Correct answers to polar and nanotechnology questions, by factual knowledge of science: 2006



NOTES: Number correct of five polar questions and two nanotechnology questions. See notes to appendix table 7-4 for explanation of "factual knowledge of science scale 1." Respondents saying they had heard "nothing at all" about nanotechnology not asked two factual questions on nanotechnology; these respondents count as zero (0) correct in nanotechnology panel. See appendix table 7-7 for responses to polar and nanotechnology questions.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006).

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Science Knowledge and Civic Knowledge

Political scientists have collected data on how much Americans know about U.S. civic institutions, politics, and history. In an exhaustive review of 50 years of research on civic knowledge, Delli Carpini and Keeter (1996) find patterns that are very similar to those in the distribution of scientific knowledge. More recent data give no indication that these patterns have changed (Pew Research Center for the People and the Press 2004, 2007b).

The following survey results, culled from a long list of knowledge questions about civic institutions and processes, give a flavor of what Americans do and do not know (Delli Carpini and Keeter 1996:70–1):

- Can correctly define Presidential veto (89% in 1989).
- Know that the First Amendment protects free press/speech (75% in 1985).
- Know that English is not the official national language (64% in 1986).
- Can state the substance of the *Brown v. Board of Education* decision (55% in 1986).
- Know that Congress declares war (45% in 1987).
- Know the length of a term of office in the U.S. House of Representatives (30% in 1978).

These data suggest that limited public mastery of fundamental factual information is not a problem that is unique to S&T.

Patterns in civic knowledge closely parallel those for science knowledge. Thus, much as individuals who demonstrate knowledge of the scientific process (see "Understanding the Scientific Process") also tend to score well on factual knowledge questions, people who are more familiar with the rules that govern civic institutions also tend to be more knowledgeable about political figures, parties, and the substance of public policy. The data on civic knowledge also parallel the data on science knowledge in other respects: political knowledge is strongly associated with formal education, women and minority group members tend to score somewhat less well on knowledge measures, more knowledgeable Americans tend to express more interest in political and civic matters and rely more on longer written sources of information, and political knowledge is associated with higher income.

There are some minor differences, too. Older Americans tend to be better informed about civic matters but not about science. Unlike science knowledge, Americans' civic knowledge shows no signs of increasing over time and appears to be slightly weaker than that in other developed countries.

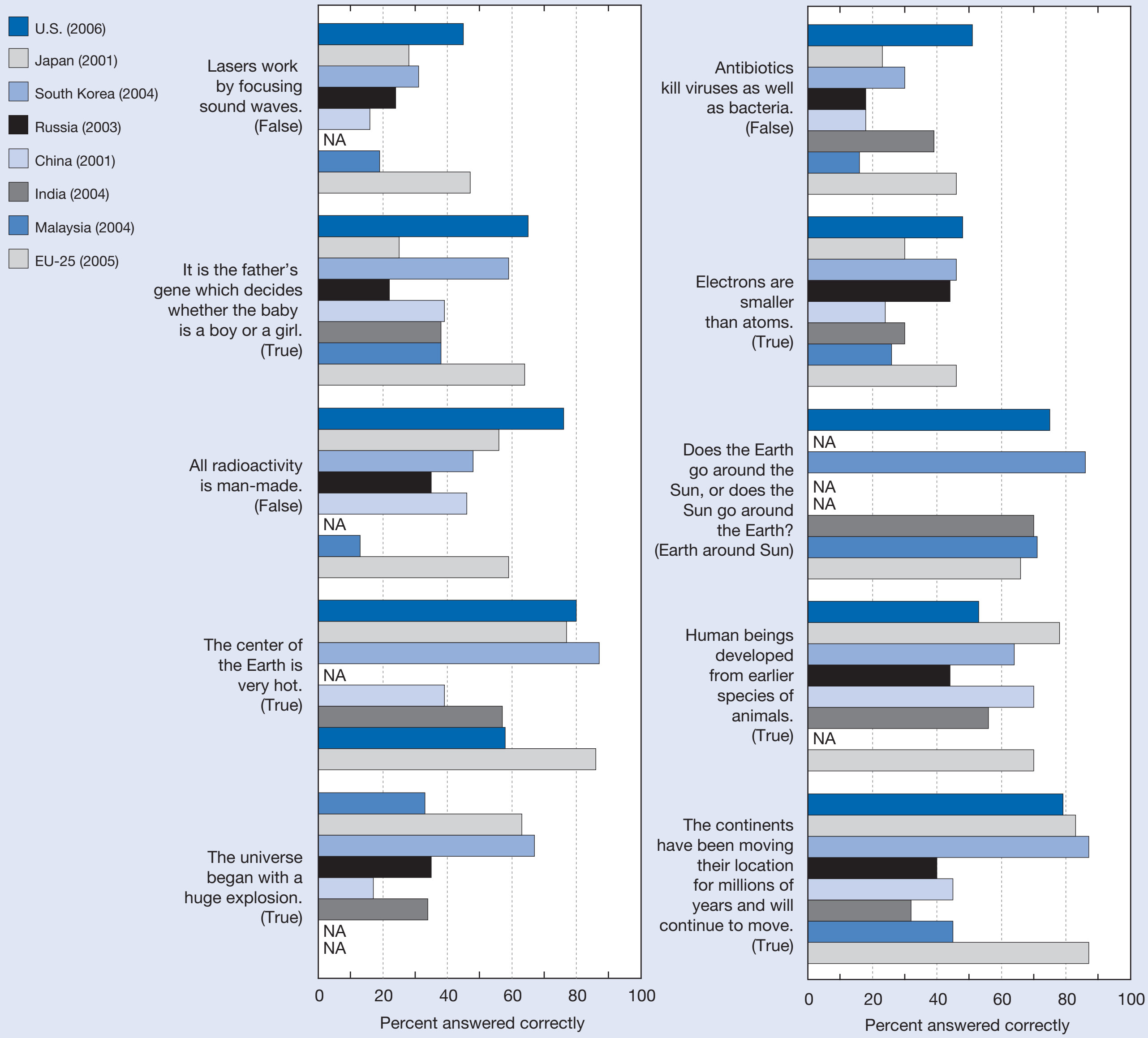
Divisions among scholars over the implications of data on Americans' civic and science knowledge follow similar lines (Delli Carpini and Keeter 1996; Lupia 2006; Nisbet 2003; Toumey 2006). Some stress that by trusting knowledgeable people, Americans can adequately perform necessary tasks without acquiring much civic or scientific knowledge. Others stress that considerable knowledge is required as context for deciding whom and what to trust. Similarly, for some scholars, singling out civic or scientific knowledge as distinctively valuable amounts to imposing elite preferences on people who would rather not spend time learning about either science or politics. To others, however, knowledge of these domains seems central to active problem-solving and participation in the shared cultural life of a modern society.

Evolution and the "Big Bang"

In international comparisons, U.S. scores on two science knowledge questions are significantly lower than those in almost all other countries where the questions have been asked. Americans were less likely to answer true to the following scientific knowledge questions: "human beings, as we know them today, developed from earlier species of animals" and "the universe began with a huge explosion." In the United States, 43% of GSS respondents answered true to the first question in 2006, about the same percentage as in every year (except one) that the question has been asked. In other countries and in Europe, the comparable figures were substantially larger: 78% in Japan, 70% in China and Europe, and more than 60% in South Korea. Only in Russia did less than half of respondents (44%) answer true. Among the individual countries covered in the 2005 Eurobarometer survey, only Turkey's percentage answering true to this question was lower than the U.S. percentage (Miller, Scott, and Okamoto 2006). Similarly, Americans were less likely than other survey respondents (except the Chinese) to answer true to the big bang question. In the most recent surveys, less than 40% of Americans answered this question correctly compared with over 60% of Japanese and South Korean survey respondents.

Americans' responses to questions about evolution and the big bang appear to reflect factors beyond unfamiliarity with basic elements of science. The 2004 Michigan Survey of Consumer Attitudes administered two different versions of these questions to different groups of respondents. Some were asked questions that tested knowledge about the natural world ("human beings, as we know them today, developed from earlier species of animals" and "the universe began with a big explosion"). Others were asked questions that tested knowledge about what a scientific theory asserts or a group of scientists believes ("according to the theory of evolution, human beings, as we know them today, developed from earlier species of animals" and "according to astronomers, the universe began with a big explosion"). Respondents were

Figure 7-8
Correct answers to scientific literacy questions, by country/region: Most recent year



NA = not available; EU = European Union

NOTE: NA indicates question not asked.

SOURCES: University of Chicago, National Opinion Research Center, General Social Survey (2006); Japan—Government of Japan, National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, The 2001 Survey of Public Attitudes Toward and Understanding of Science and Technology in Japan (2002); South Korea—Korea Science Foundation, Survey of Public Attitudes Toward and Understanding of Science and Technology (2004); Russia—Gokhberg L and 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); China—Chinese Ministry of Science and Technology, China Science and Technology Indicators 2002 (2002); India—National Council of Applied Economic Research, India Science Survey (2004); Malaysia—Malaysian Science and Technology Information Centre, Public Awareness of Science and Technology Malaysia 2004 (2005); and EU—European Commission, Research Directorate-General, Eurobarometer 224/Wave 63.1: Europeans, Science and Technology (2005).

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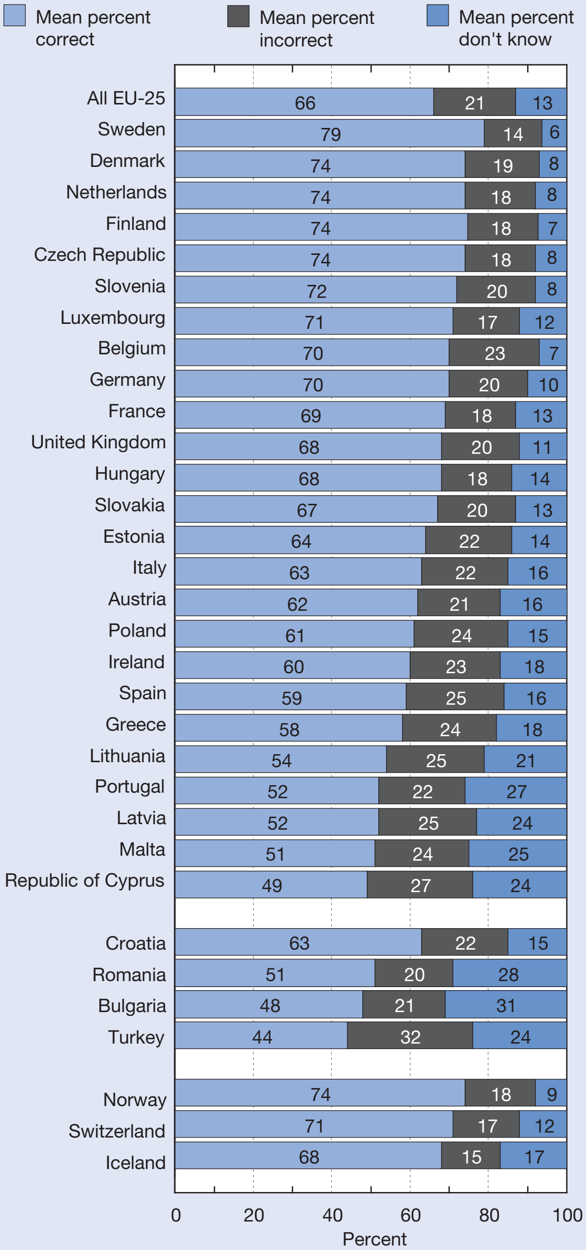
much more likely to answer correctly if the question was framed as being about scientific theories or ideas rather than as about the natural world. When the question about evolution was prefaced by "according to the theory of evolution," 74% answered true; only 42% answered true when it was not. Similarly, 62% agreed with the prefaced question about the big bang, but only 33% agreed when the prefatory phrase was omitted. These differences probably indicate that many Americans hold religious beliefs that cause them to be skeptical of established scientific ideas, even when they have some basic familiarity with those ideas.

Figure 7-9
Scientific literacy in Europe: 2005



EU = European Union

NOTES: See appendix table 7-8. Mean percent for this figure based on responses to 13 factual science questions: (1) *The Sun goes around the Earth.* (True); (2) *The center of the Earth is very hot.* (True); (3) *The oxygen we breathe comes from plants.* (True); (4) *Radioactive milk can be made safe by boiling it.* (False); (5) *Electrons are smaller than atoms.* (True); (6) *The continents on which we live have been moving for millions of years and will continue to move in the future.* (True); (7) *It is the mother's genes that decide whether the baby is a boy or a girl.* (False); (8) *The earliest humans lived at the same time as the dinosaurs.* (False); (9) *Antibiotics kill viruses as well as bacteria.* (False); (10) *Lasers work by focusing sound waves.* (False); (11) *All radioactivity is man-made.* (False); (12) *Human beings, as we know them today, developed from earlier species of animals.* (True); (13) *It takes one month for the Earth to go around the Sun.* (False)

SOURCE: European Commission, Research Directorate-General, Eurobarometer 224/Wave 63.1 (3 January–15 February 2005): Europeans, Science and Technology (2005).

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Surveys conducted by the Gallup Organization provide similar evidence. An ongoing Gallup survey, conducted most recently in 2004, found that only about a third of Americans agreed that Darwin's theory of evolution has been well supported by evidence (Newport 2004). The same percentage agreed with the alternative statement that Darwin's theory was not supported by the evidence, and an additional 29% said they didn't know enough to say. Data from 2001 were similar. Those agreeing with the first statement were more likely to be men (42%), have more years of education (65% of those with postgraduate education and 52% of those with a bachelor's degree), and live in the West (47%) or East (42%).

In response to another group of questions on evolution asked by Gallup in 2004, about half (49%) of those surveyed agreed with either of two statements compatible with evolution: that human beings developed over millions of years either with or without God's guidance in the process. However, 46% agreed with a third statement, that "God created human beings pretty much in their present form at one time within the last 10,000 years or so." These views on the origin of human beings have remained virtually unchanged (in seven surveys) since the questions were first asked in 1982 (Newport 2006).

For almost a century, whether and how evolution should be taught in U.S. public school classrooms has been a frequent source of controversy (see sidebar, "Evolution and the Schools"). The role of alternative perspectives on human origins, including creationism and intelligent design, and their relevance to the teaching of science, has likewise been contentious. When Gallup asked survey respondents in 2005 whether they thought each of three "explanations about the origin and development of life on earth (evolution, creationism, and intelligent design) should or should not be taught in public school science classes" or whether they were "unsure," for each explanation more Americans chose "should" than chose either of the other alternatives (table 7-6).

In other developed countries, controversies about evolution in the schools have also occurred, but more rarely.

Table 7-6
American views on which explanations of human origins should be taught in public school science classes: 2005
(Percent)

Explanation of human origins	Should be taught	Should not be taught	Unsure
Evolution	61	20	19
Creationism	54	22	24
Intelligent design	43	21	36

NOTES: Responses to: *Do you think each of the following explanations about the origin and development of life on earth should or should not be taught in public school science classes, or are you unsure?* Question asked 8–11 August 2005.

SOURCE: Evolution, creationism, intelligent design, The Gallup Poll, http://www.galluppoll.com/content/?ci=21814&pg=1, accessed 25 January 2007.

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Evolution and the Schools

The American Association for the Advancement of Science (AAAS) gave its annual Award for Scientific Freedom and Responsibility for 2006 to 10 people "who have been on the front lines of the battle to prevent introduction of 'intelligent design' into science classrooms as an alternative to evolution" (AAAS 2007). According to Dr. John Marburger, the head of the White House Office of Science and Technology Policy, the theory of evolution is "the cornerstone of modern biology" (Bumiller 2005). In a March 4, 2005, letter to National Academy of Sciences (NAS) members, Dr. Bruce Alberts, then president of NAS, characterized the theory of evolution as "one of the foundations of modern science," urged America's leading scientists to help in their states and localities "to confront the increasing challenges to the teaching of evolution in the public schools," and cited the succession of NAS efforts devoted to ensuring that evolution is taught appropriately (Alberts 2005).

Yet, despite endorsements of evolution from these and other representatives of the scientific and political establishment, controversy over how evolution should be taught in public schools remains a perennial feature of American life and shows no sign of disappearing. Instead, the controversy is evolving.

Eight of the AAAS awardees were science teachers in the Dover, Pennsylvania, school district who fought their school board's decision to require that they read a disclaimer about the theory of evolution to their ninth grade biology students. After stating that evolution was a theory, not a fact, and had "gaps," the disclaimer directed students' attention to intelligent design, "an explanation of the origin of life that differs from Darwin's view."*

The Dover disclaimer was successfully challenged in court (*Kitzmiller* v. *Dover* 2005). The case turned on whether the disclaimer violated the Establishment Clause of the First Amendment to the U.S. Constitution, which deals with the relationship between government and religion. The court concluded that intelligent design was a religious view and not a scientific theory and that, because the school board's policy was animated by a religious purpose and had a religious effect, neither the policy nor the disclaimer that implemented it was constitutional.

In reaching this conclusion, the court reviewed the history of efforts to have biblical views of the origins of life taught in the public schools, the legal decisions that posed obstacles to these efforts, and the subsequent efforts to exclude the teaching of evolution from the schools or undermine the scientific status of the theory in the eyes of high school students. It traced a succession of legal conflicts in which the teaching of creationism and creation science had been found to violate the Establishment Clause and that had led to the development of intelligent design.

The Discovery Institute (2007), a Seattle policy and research organization, is the leading proponent of intelligent design. The Discovery Institute characterizes itself as a secular institution and maintains that intelligent design is not based on the Bible and is not the same as creationism. It does not advocate requiring that intelligent design be taught in schools. Rather, it "recommends that states and school districts focus on teaching students more about evolutionary theory, including telling them about some of the theory's problems." At the same time, it believes "there is nothing unconstitutional about discussing the scientific theory of design in the classroom." Framed in this way, intelligent design may appear to be more distant from religion and less vulnerable to legal challenge than doctrines such as creationism and creation science, which have failed to pass constitutional muster (for a discussion of framing, see sidebar, "Media Effects").

Even where, as in Dover, legal controversies over the teaching of evolution are resolved with affirmations of scientific evidence and criteria, thorough and substantive presentation of the theory of evolution in the schools is by no means guaranteed. The possibility that parents and students may object to the teaching of evolution, let alone evidence of organized efforts to resist it, may discourage some teachers from covering the topic in depth (Dean 2005). In addition, not all high school biology teachers subscribe to the accepted view of evolution or are well versed in the topic (Monastersky 2006).

Numerous efforts are under way in the scientific community to make materials available to middle and high school teachers that will help them do a better job presenting the scientific evidence about evolution (Holden 2006; Monastersky 2006). Niles Eldredge, a prominent researcher in evolutionary biology, has announced plans to initiate a new journal, *Evolution: Education and Outreach*, to serve as a resource for teachers at all levels who wish to improve their treatment of the topic. The journal is scheduled to begin publication in March 2008 (Monastersky 2007).

*Intelligent design "holds that certain features of the universe and of living things are best explained by intelligent cause, not an undirected process such as natural selection." (www.discovery.org)

However, signs of opposition to the theory of evolution are emerging in Europe (*Nature* 2006).

Understanding the Scientific Process

U.S. surveys have used questions on three general topics to assess trends in Americans' understanding of the process of scientific inquiry. One set of questions tests how well respondents apply principles of probabilistic reasoning to a series of questions about a couple whose children have a one-in-four chance of suffering from an inherited disease.[16] 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. An open-ended question probes what respondents think it means to "study something scientifically." Because probability, experimental design, and scientific method are all central to so much research that claims to be scientific, these questions are highly relevant to how respondents evaluate scientific evidence.

There appears to be a modest tendency for Americans to score better on these inquiry questions in recent years, especially when the questions are analyzed together in an inquiry index (appendix table 7-9). However, despite the use of identical coding instructions in different survey years, it is possible that year-to-year variations in coding practices for open-ended items and other subtle methodological differences may have affected this result. Performance on these questions is strongly associated with the different measures of science knowledge and education (appendix table 7-10). Older Americans and those with lower incomes, two groups that tend to have less education in the sciences, also tend to score less well on the inquiry measures.

Pseudoscience

The large numbers of Americans who regard astrology as at least somewhat scientific is an indicator that many Americans do not reliably distinguish between scientific and nonscientific knowledge claims. Available national data cannot differentiate those who misapply what they think are scientific criteria from those who in some respects reject conventional scientific criteria, even though they are familiar with them.

About one-third of Americans in 2006 said they believed that astrology was at least "sort of scientific." This proportion was almost exactly the same as in 2004. However, the 2004 and 2006 surveys indicate an apparent decline in the perception of astrology as scientific: the percentage of Americans who viewed astrology as not at all scientific was higher in these 2 years than it ever was in the 10 other times that this question was asked between 1979 and 2001 (appendix table 7-11). Respondents who have more years of formal education are less likely to perceive astrology to be at all scientific.

Public Attitudes About S&T in General

The U.S. S&E community hopes to improve society by developing knowledge and using it to solve problems and shape the world in which Americans live. U.S. national policy is built on this hope, which underlies the government's broad support for scientific research and technological development. The public's orientation toward S&T in general and toward institutions that are committed to S&T affects America's willingness and capacity to rely on S&T as a major strategy for improving the country's quality of life.

Generalized public support for S&T can make a difference in many ways. Public openness to technological change gives U.S. businesses opportunities to build a domestic customer base, create a foundation for worldwide technical competitiveness, and foster the national advantages that flow from pioneering innovations. Broad public and political support for long-term commitments to S&T research, especially in the face of pressing immediate needs, enables ambitious proposals for sustained federal S&T investments to reach fruition. Public confidence that S&E community leaders are trustworthy, S&E research findings are reliable, and S&E experts bring valuable judgment and knowledge to bear on public issues permits scientific knowledge to have influence over practical affairs. And, in an environment where positive public perceptions of S&E occupations predominate, promising young people are encouraged to pursue S&E careers.

To be sure, not all technological innovations, federal S&T investments, scientific pronouncements, or decisions to pursue S&E careers warrant support. It would be easy to cite instances in which scientific and technological optimism has been carried too far, and hard to dispute the idea that assertions that S&T-led social and economic progress will or has occurred in particular instances should be evaluated critically. But widespread, indiscriminate public skepticism about S&T, going beyond the reasoned examination of particular cases, would represent a radical and consequential change in American public opinion and would affect national strategies that link progress in S&T to overall national progress.

This section presents indicators of public attitudes and orientations toward S&T in general, in America and in other countries. It covers views of the promise of S&T and reservations about S&T; overall support for government funding of research; confidence in the leadership of the scientific community; perceptions of the proper influence of scientists over contested public issues about which the research community claims expertise; perceptions about what it means to be scientific and which disciplines and practices are scientific; and views of S&E as occupations. These indicators reflect general attitudes expressed in response to survey questions and disconnected from real-life decisions. How people apply these general views in practical situations, when attitudes toward science are only one of many considerations, is, of course, uncertain.

Attitudes and Question Wording

In the first paragraph of a May 16, 2006, press release, the Coalition for the Advancement of Medical Research (CAMR) reported that “nearly three-quarters of Americans support embryonic stem cell research.” Two weeks later, the United States Conference of Catholic Bishops (USCCB) issued a press release. The first paragraph of that press release indicated that “48% of Americans oppose federal funding of stem cell research that requires destroying human embryos, while only 39% support such funding” (CAMR 2006; Levin 2006; Nisbet 2004; USCCB 2006).

How could two surveys, conducted by telephone 2 weeks apart and using similar methodologies, arrive at such different results?

The answer lies in wording and context (Schuman and Presser 1996). To their credit, later in their press releases, both organizations provided the wording of the actual questions respondents were asked:

CAMR question: I’m going to read you a brief description of embryonic stem cell research, and then get your reaction. Embryonic stem cells are special cells that can develop into every type of cell in the human body. The stem cells are extracted from embryonic cells produced in fertility clinics and then frozen days after fertilization. If a couple decides that the fertilized eggs are no longer needed, they can choose to donate the embryos for research or the clinic will throw the embryos away. Scientists have had success in initial research with embryonic stem cells and believe that they can be developed into cures for diseases such as cancer, Parkinson’s, heart disease, juvenile diabetes, and spinal cord injuries. Having heard this description, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose medical research that uses stem cells from human embryos?

USCCB question: Stem cells are the basic cells from which all of a person’s tissues and organs develop. Congress is considering the question of federal funding for experiments using stem cells from human embryos. The live embryos would be destroyed in their first week of development to obtain these cells. Do you support or oppose using your federal tax dollars for such experiments?

These two questions provide very different contextual information about stem cell research. To the organizations that sponsored the two surveys, the questions doubtless present the most relevant information for informed decisions. Most members of the public do not follow issues such as stem cell research very closely (Pew Research Center for the People and the Press 2006b), and the way questions are framed can influence their views.

Even neutral survey organizations ask questions in different ways and produce different results. Their questions, although generally more useful for scientific research on public attitudes, neither present a “correct” context, create a situation in which context plays no role in how people respond, nor establish a context that closely approximates the one in which most citizens make decisions. Because survey responses are affected by subtle differences in wording and context, thoughtful researchers pay attention to precisely how questions are asked, give more weight to patterns and trends in survey results than to the percentage of people who choose a particular response, and examine the degree to which responses are stable across different surveys on the same topic.

More than responses to questions about facts or behaviors, responses about attitudes are highly sensitive to the way questions are worded and the context in which they are placed (see sidebar, “Attitudes and Question Wording”). Although this sensitivity affects survey responses about the general attitudes covered in this section, it is probably even more important for the specific, controversial issues, such as stem cell research or global climate change, that are discussed in the next section.

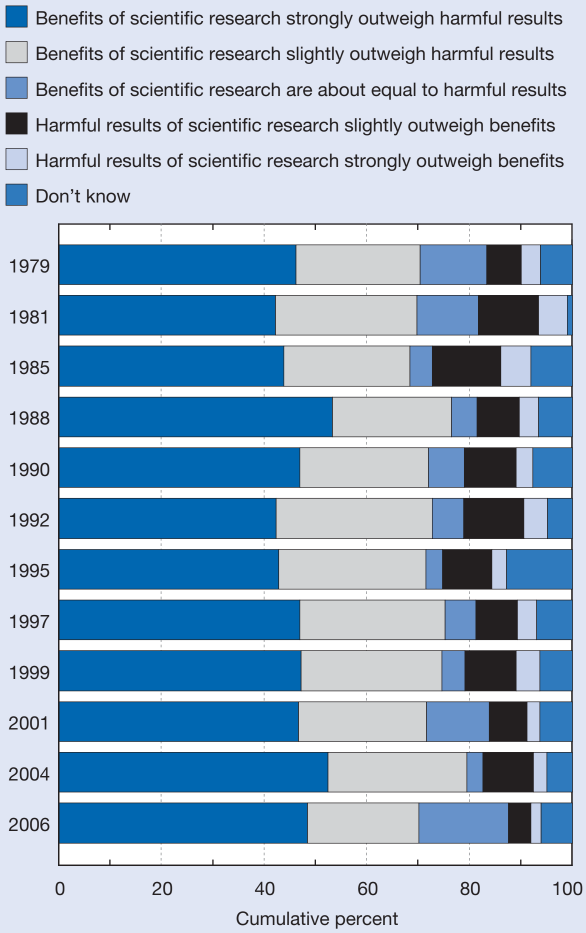
Promise and Reservations

Americans of all kinds—men and women, college graduates and high school dropouts, blacks and whites—consistently endorse the past achievements and future promise of S&T. In practically any major American social grouping, individuals who express serious doubt about the promise of science are a rare breed.

In six annual Virginia Commonwealth University (VCU) Life Science Surveys beginning in 2001, the percentage of respondents who agreed that “developments in science helped make society better” ranged between 85% and 90%. Responses for “developments in new technology” ranged between 83% and 88% in these same surveys. Similarly, between 2002 and 2006, the surveys asked respondents whether they believed “scientific research is essential for improving the quality of human lives” and found that agreement ranged between 87% and 92% (VCU Center for Public Policy 2006).

NSF surveys dating back to 1979 have yielded similar results. In 2006, about half (48%) of GSS respondents said that the benefits of scientific research strongly outweighed the harmful results. Substantial percentages said that benefits either slightly outweighed harms (22%) or volunteered that the two were about equal (17%), and only a small percentage (6%) said that harms either slightly or strongly outweighed benefits. The remainder said they did not know. These numbers were generally in keeping with those from earlier surveys (figure 7-10; appendix table 7-12).[17]

Figure 7-10
Public assessment of scientific research: 1979–2006



NOTE: Table includes all years for which data collected.

SOURCES: National Science Foundation, Division of Science Resources Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1979–2001); University of Michigan, Survey of Consumer Attitudes (2004); and University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix tables 7-12 and 7-13.

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Americans also overwhelmingly agree that S&T will foster "more opportunities for the next generation," with about 90% expressing agreement in the 2006 GSS. Agreement with this statement has been increasing moderately for over a decade.

Americans who have more years of formal education and score higher on measures of science knowledge express more favorable attitudes about S&T. A review of numerous surveys from around the world found, other things equal, a weak but consistent relationship between greater knowledge of science and more favorable attitudes toward it (see sidebar, "How Knowledge Relates to Attitudes").

Although data from other countries are not entirely comparable, they appear to indicate that Americans have somewhat more positive attitudes about the benefits of S&T than Europeans, Russians, and Japanese. Attitudes in China and South Korea, however, are comparable with and perhaps

How Knowledge Relates to Attitudes

In an analysis of data from almost 200 nationally representative surveys conducted in 40 countries between 1989 and 2003, Allum et al. (2008) examined how knowledge of science relates to attitudes toward S&T. Data are mostly from Europe and North America, but suitable surveys from countries in other regions were also included; these tended to be economically developed countries, such as Japan and New Zealand.

The analysis divided knowledge indicators into two groups depending on whether they involved general knowledge of scientific facts and processes or knowledge of a relatively specific scientific domain such as biology or genetics. It grouped attitude indicators by topic, distinguishing among science in general, nuclear power, genetic medicine, genetically modified food, and environmental science.

To isolate the relationship between knowledge and attitudes, the study used statistical techniques to control for factors that might be expected to influence both knowledge and attitudes, such as the age, sex, and education level of the respondent and the country in which the survey was conducted. Controlling for these influences, it reached several conclusions:

- There is "a small positive correlation between [favorable] general attitudes toward science and general knowledge of scientific facts and processes." Though small, this relationship appears consistently across countries.
- The relationship is stronger in the United States than in any of the other countries studied.
- The strength and nature of the relationship between knowledge and attitudes did not vary systematically over time during the period studied.
- Favorable attitudes about topics in a particular domain are more closely related to knowledge in that domain than to general science knowledge. Attitudes about genetically modified food, for example, show a stronger relationship to knowledge about biology and genetics than to general science knowledge.
- Contrary to findings in some other, less comprehensive studies, the relationship between knowledge and attitudes did not vary depending on differences in the level of economic development of the countries studied.

The study does not establish a causal link between knowledge and attitudes. Indeed, the authors conclude that "scholars have overlooked the need to provide a satisfactory account of how knowledge of science relates to preferences regarding its technological implementation in society," and recommend that researchers address "the social and psychological mechanisms that generate the associations we observe."

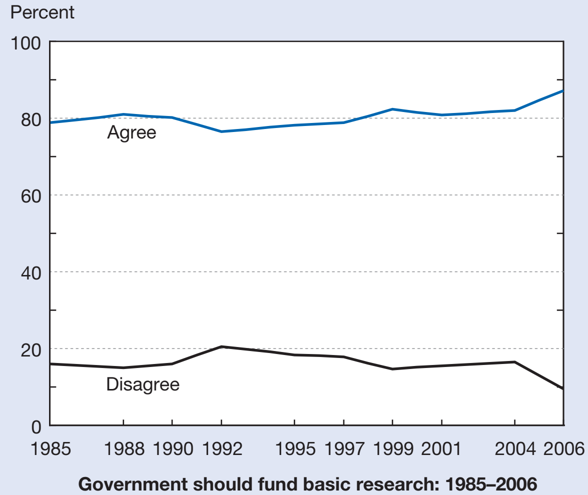
even more favorable than those in the United States (appendix table 7-13). In 2005, for example, Europeans were asked a question about the benefits and harms of science that was very similar to the U.S. question about the benefits and harms of scientific research.[18] The U.S. percentage for more benefits than harms was 18 points higher than the European number, and the European percentage for more harms than benefits was 8 points higher than the U.S. number. However, differentials are less evident for other questions. In all of the countries and regions where survey data exist, statements about the achievements and promise of science elicit substantially more agreement than disagreement.

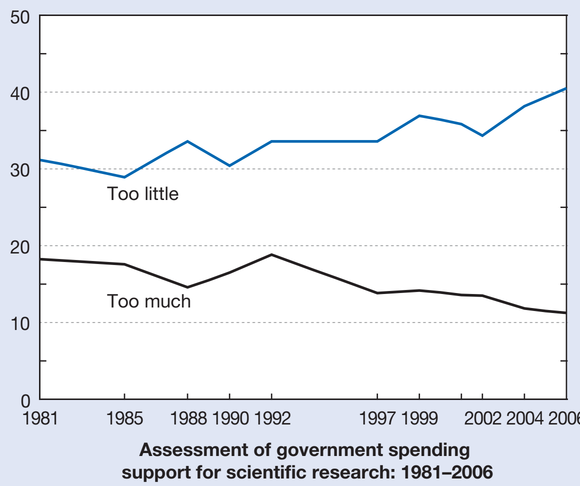
Both in the United States and abroad, respondents also express reservations about S&T. For 6 years (2001–06), VCU Life Sciences Surveys have asked respondents whether they agree that "scientific research these days doesn't pay enough attention to the moral values of society." In each year, a majority has agreed. During this period, though, the percentage that agreed has dropped substantially, going from 73% in 2001 to 56% in 2006. In the 2006 GSS, large minorities of survey respondents registered agreement with other statements expressing reservations about science, including "science is too concerned with theory and speculation to be of much use in making concrete government policy decisions that will affect the way we live" (34% agree, 58% disagree) and "science makes our way of life change too fast" (44% agree, 53% disagree) (appendix tables 7-14 and 7-15). The latter question has been asked in numerous other countries (appendix table 7-13). Although levels of agreement with this statement in the United States appear to be similar to those in Russia, surveys in other countries record much higher levels of agreement.

Federal Funding of Scientific Research

U.S. public opinion consistently and strongly supports federal spending on basic research. NSF surveys have repeatedly asked Americans whether "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." Since 1979, about 80% of Americans have registered agreement in response to this question. In the most recent survey, agreement was even higher than in the past, with 87% favoring federal support in 2006. Responses to a GSS question about federal spending on scientific research provide further evidence of increasing public support for federal spending on scientific research. For the decade beginning in 1992, the percentage of Americans who thought that the government was spending too little on scientific research hovered between 34% and 37%. This percentage then grew from the 34% registered in 2002 to 38% in 2004 and 41% in 2006. In the 2006 survey, only 11% said that the government was spending too much in this area, which is lower than the comparable figure in any of the other 10 NSF or GSS surveys in which this question has been asked since 1981 (figure 7-11; appendix tables 7-16, 7-17, 7-18, and 7-19).

Figure 7-11
Attitudes toward government funding of scientific research: 1981–2006





NOTES: Top panel: survey results in 1985, 1988, 1990, 1992, 1995, 1997, 1999, 2001, 2004, and 2006; other years interpolated. Bottom panel: survey results in 1981, 1985, 1988, 1990, 1992, 1997, 1999, 2001, 2002, 2004, and 2006; other years interpolated.

SOURCES: National Science Foundation, Division of Science Resources Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (years through 2001); University of Michigan, Survey of Consumer Attitudes (2004 in top panel); and University of Chicago, National Opinion Research Center, General Social Survey (2006 in top panel, 2002–06 in bottom panel). See appendix tables 7-16 and 7-17 for top panel and appendix table 7-18 for bottom panel.

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Although support for federal research investment is at historically high levels, other kinds of federal spending generate even stronger public support (appendix table 7-18). Support for increased spending is greater in numerous program areas, including education (73%), health care (72%), assistance to the poor (68%), environmental protection (67%), and Social Security (61%). Scientific research ranks about on a par with mass transit (38%) and well ahead of space exploration (14%) and assistance to foreign countries (10%) in the proportion of the U.S. population favoring increased spending.

In other countries where similar though not precisely comparable questions have been asked, respondents also express strong support for government spending on basic scientific research. In 2005, 76% of Europeans agreed that "even if it brings no immediate benefits, scientific research which adds to knowledge should be supported by government," and only 7% disagreed. Because the European survey offered a middle option ("neither agree nor disagree"), both of these percentages are lower than figures for the United States, where no middle category was offered. Agreement in South Korea, China, Malaysia, and Japan reaches levels generally comparable to those in the United States and Europe. Support for increased government spending on scientific research appears to be relatively common in Europe as well. Over half of Europeans agreed in 2005 that their "government should spend more money on scientific research and less on other things." Although this proportion is nominally higher than the percentage of Americans who support more government spending, numerous context and wording differences between the questions leave responses open to substantially differing interpretations.[19] Public support for increased spending on scientific research was substantially greater in South Korea (67% in 2004) than in the United States (Korea Gallup 2007).

Confidence in the Science Community's Leadership

For the science-related decisions that citizens face, a comprehensive understanding of the relevant scientific research would require mastery and evaluation of more evidence than even working scientists could handle. In addition to relying on direct evidence from scientific studies, citizens who want to draw on scientific evidence must consult the judgments of leaders and other experts who they believe can speak authoritatively about the scientific knowledge that is relevant to an issue.

Numerous questions arise about how, when, and how well citizens rely on others to help shape their opinions on scientific issues. When it comes to scientific questions, do they trust the leaders of the scientific community to provide reliable information and advice? Whom else do they trust to speak with authority about such matters? How, and how well, do they distinguish widely respected experts and consensual views from marginal dissidents and idiosyncratic judgments? Do they recognize the relevance of scientific evidence as often as they should? Do they exaggerate its relevance in some cases? Insofar as they must trust others, do they do so blindly, or do they make critical, though inevitably partial, evaluations of whose scientific claims warrant their trust and what kinds of evidence make those claims trustworthy?

Public confidence in the leaders of the scientific community is one indicator of public willingness to rely on science. At a minimum, such confidence is ordinarily a prerequisite for taking scientific knowledge seriously in personal and public matters.

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 institutional leaders. In 2006, the percentage of Americans expressing "a great deal of confidence" in leaders was higher for the scientific community than for any other institution except the military. Conversely, the percentage expressing "hardly any confidence at all" was lower for scientific leaders than for leaders of any other institution about which this question was asked (table 7-7).

Throughout the entire period in which this question has been asked, the percentage of Americans expressing a great deal of confidence in the leaders of the scientific community has fluctuated within a relatively narrow range, hovering between 35% and 45% (appendix table 7-20). In contrast, for some other institutions, confidence has been more sensitive to current events: the percentage of Americans professing a great deal of confidence in military leaders changed more between 2004 and 2006 than the comparable percentage for science leaders changed between 1973 and 2006.

Science has usually ranked second or third in the public confidence surveys, with medicine or the military ranking first. The consistently high confidence in the leadership of the scientific community is in contrast to a general decline in confidence in institutional leaders over the past three decades. The medical community, for example, has seen a long-term decline in confidence: whereas over half of Americans expressed a great deal of confidence in medical leaders in the mid-1970s, the number has been around 40% in recent years. Since 2002, science has scored as well as or better than medicine on this indicator, although the scores for the two fields remain close.

Influence on Public Issues

Government support for scientific research is predicated in significant measure on the idea that science can play a useful role in many public decisions. For science to play this role, it is helpful for the general public to support judicious efforts to bring scientific knowledge to bear on public matters and share the view that science ought to be considered relevant and influential.[20]

The 2006 GSS contained new batteries of questions that ask about the appropriate influence of science on four contested public issues to which scientific research might be considered relevant—global climate change, research using human embryonic stem cells, federal income taxes, and genetically modified foods. For each issue, survey respondents were asked how much influence a group of scientists with relevant expertise (e.g., medical researchers, economists) should have in deciding about the issue, how well the scientists understood the issue, and to what extent the scientists would "support what is best for the country as a whole versus what serves their own narrow interests."[21] The same questions were asked about elected officials and either religious leaders (for stem cell research) or business leaders (for the other issues). Respondents were also asked a question about their perception of the level of consensus among the scientists regarding a largely factual aspect of the issue and a question that probed their attitude regarding the issue.[22]

The GSS data indicate that Americans believe that scientists should have a relatively large amount of influence on public decisions concerning these issues (table 7-8).[23] For the four issues, the percentage who said that scientists should have either a great deal or a fair amount of influence ranged from 85% (global warming) to 72% (income taxes). For each issue, the

Table 7-7
Public confidence in institutional leaders: 2006
(Percent)

Type of institution	Level of confidence in leaders: A great deal	Some	Hardly any	Don't know
Military	47	39	12	2
Scientific community	41	48	6	5
Medicine	40	49	10	1
U.S. Supreme Court	33	49	15	4
Banks and financial institutions	30	56	13	1
Education	28	57	15	—
Organized religion	24	51	22	3
Major companies	18	62	18	2
Executive branch of federal government	16	45	37	2
Organized labor	12	56	28	5
Congress	12	53	33	2
Press	10	48	40	1
Television	9	49	41	1

— = ≤0.5% responded

NOTE: Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-20.

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Table 7-8
Preferred groups for influencing decisions about public issues: 2006
(Percent)

Public issue/group	Preferred degree of influence: A great deal	A fair amount	A little	None at all	Don't know
Global warming					
Environmental scientists	47	38	7	3	4
Business leaders	10	22	38	25	5
Elected officials	17	33	33	13	4
Stem cell research					
Medical researchers	39	41	11	4	5
Religious leaders	8	21	36	29	6
Elected officials	11	35	32	15	6
Federal income taxes					
Economists	21	51	18	4	6
Business leaders	9	37	36	13	4
Elected officials	21	40	24	11	4
Genetically modified foods					
Medical researchers	41	40	10	3	5
Business leaders	3	16	41	35	5
Elected officials	7	30	37	21	5

NOTES: Responses to: *How much influence should each of the following groups have in deciding: global warming policy; government funding for stem cell research; reducing federal income taxes; restricting sale of genetically modified foods?* Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-21.

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percentage was greater for scientists than for either of the other leadership groups. The contrast among the groups was more pronounced for the three issues that dealt with biological or geophysical phenomena than for income taxes, where elected officials ranked closely behind economists. Even for the tax issue, however, this appears to be as much or more because of greater willingness to accord elected officials substantial influence than because of greater skepticism about economists. Among the three issues in which respondents compared scientists, elected officials, and business leaders, the tax issue stands out as the one where the public believes elected officials and business leaders ought to have the most influence.

Americans also give scientists relatively high marks for understanding the four issues (table 7-9).[24] The GSS asked respondents to rate each leadership group's understanding of a largely factual aspect of each issue on a five-point scale ranging from "very well" to "not at all." For the three issues dealing with biological or geophysical phenomena, the difference in perceived understanding was big: between 64% and 74% of the public placed the relevant scientists in one of the top two categories, whereas only 9% to 14% placed any of the other groups in those categories. The contrast among groups was smaller for the tax issue, with economists (52%) ranking ahead of business leaders (44%) and elected officials (28%). As was the case for influence, this narrower gap among the groups is largely a matter of a relatively favorable perception of business leaders' and elected officials' understanding of the tax issue, although a less positive view of the economists' understanding also plays a role.

Patterns for the question about which groups would "support what is best for the country as a whole versus what serves their own narrow interests" were similar (table 7-10).[25] For each issue, Americans placed the scientific group in one of the top two categories much more often than they placed either of the other leadership groups in those categories. Differences were always at least 30 percentage points, even where comparisons concerned religious leaders, a group that might be expected to be perceived as less narrowly self-interested than elected officials or business leaders.

One factor that may limit the influence of scientific knowledge and the scientific community over public issues is the perception that significant scientific disagreement exists, making scientific knowledge uncertain (Krosnick et al. 2006). GSS respondents were asked to rate the degree of scientific consensus on a largely factual aspect of each of the four issues, using a five-point scale ranging from "near complete agreement" to "no agreement at all."[26] The "importance of stem cells for research" was the only item for which as many as half of respondents (52%) chose one of the two points near the complete agreement end of the scale. Just 20% of respondents chose one of these points when asked about the extent to which "economists agree on the effects of reducing federal income taxes." For all four issues, this set of questions generated many "don't know" responses and many responses at the midpoint of the scale, both of which are consistent with the idea that there is widespread public doubt about exactly how scientists view the issues (table 7-11).

Table 7-9
Perceived understanding of public issues by various groups: 2006
(Percent)

	Degree of understanding (on scale of 1 to 5)					
	Very well				Not at all	Don't
Public issue/group	5	4	3	2	1	know
Global warming						
Environmental scientists	44	22	22	4	4	4
Business leaders	4	8	30	32	22	4
Elected officials	5	7	31	29	24	4
Stem cell research						
Medical researchers	50	24	15	3	3	6
Religious leaders	6	8	26	29	25	6
Elected officials	3	7	35	26	22	6
Federal income taxes						
Economists	33	19	29	7	7	5
Business leaders	15	29	33	12	6	4
Elected officials	10	18	34	19	15	5
Genetically modified foods						
Medical researchers	32	32	18	8	5	6
Business leaders	4	7	24	31	28	6
Elected officials	3	6	24	33	29	5

NOTES: Responses to: *How well do the following groups understand: causes of global warming; importance of stem cell research; effects of reducing federal income taxes; risks posed by genetically modified foods?* Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-22.

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With a few exceptions, responses to these questions do not differ markedly among demographic groups (appendix tables 7-21, 7-22, 7-23, and 7-24). Americans with higher incomes, more education, and more science knowledge tend to have more favorable perceptions of the knowledge, impartiality, and level of agreement among scientists. These differences are especially pronounced for perceptions of economists, despite the fact that the science knowledge and education measures do not test economic knowledge.

The interplay among the various indicators presented in this section cannot be understood without further research and analysis. It is not clear, for example, what mix of perceived attributes—knowledge, consensus, impartiality, or others—affects public perceptions of the appropriate influence of sci-

Table 7-10
Perceived impartiality of various groups in making policy recommendations about public issues: 2006
(Percent)

	Extent to which group would support (on scale of 1 to 5)					
	What is best for country				Own narrow interests	
Public issue/group	5	4	3	2	1	Don't know
Global warming						
Environmental scientists	40	27	17	6	6	5
Business leaders	6	4	22	27	36	5
Elected officials	9	10	25	24	28	5
Stem cell research						
Medical researchers	32	27	21	9	7	4
Religious leaders	13	12	22	20	26	6
Elected officials	8	7	32	23	25	5
Federal income taxes						
Economists	22	30	25	9	8	6
Business leaders	3	8	24	30	30	4
Elected officials	8	14	26	24	24	4
Genetically modified foods						
Medical researchers	34	29	19	7	6	5
Business leaders	2	4	25	32	32	5
Elected officials	6	10	32	25	21	5

NOTES: Responses to: *When making policy decisions about [public issue], to what extent do you think [group] would support doing what is best for the country as a whole or what serves their own narrow interests?* Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-23.

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Table 7-11
Perceived scientific consensus on public issues: 2006
(Percent)

	Degree of consensus (on scale of 1 to 5)					
	Near complete agreement				No agreement at all	
Group/public issue	5	4	3	2	1	Don't know
Environmental scientists on existence and causes of global warming	14	28	35	9	6	9
Medical researchers on importance of stem cells for research	19	33	29	4	5	9
Economists on effects of reducing federal income taxes	5	15	40	14	13	13
Medical researchers on risks and benefits of genetically modified foods	9	19	41	11	7	13

NOTES: Responses to: *To what extent do [people in group] agree on [public issue]?* Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-24.

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entists and scientific knowledge on public affairs. Likewise, it is not clear why public perceptions vary concerning different leadership groups or whether the interplay of attributes is the same in all segments of the public. In addition, the choice of factual examples raised in the questions may substantially affect responses. For example, it is possible that economists would be perceived very differently when the issue is foreign trade or environmental scientists when the issue is energy conservation. An alternative set of factual examples might also highlight the role of additional considerations that affect public views of who should influence public decisions.[27]

What Makes an Activity Scientific

The label "scientific" is usually considered a favorable one, and many claim it for their research or occupation. When research studies claim to be scientific, they claim to produce valid knowledge; when occupations claim to be scientific, they claim their practitioners have systematic expertise. Because not all claims to science are equally warranted, it is important for the public to scrutinize these claims critically and use reasonable criteria to judge them.

The 2006 GSS asked two batteries of questions that probed what characteristics Americans associate with scientific studies and what disciplines and practices Americans consider scientific. These indicators provide insight into how Americans discriminate between more and less scientific endeavors.

Attributes That Make Something Scientific

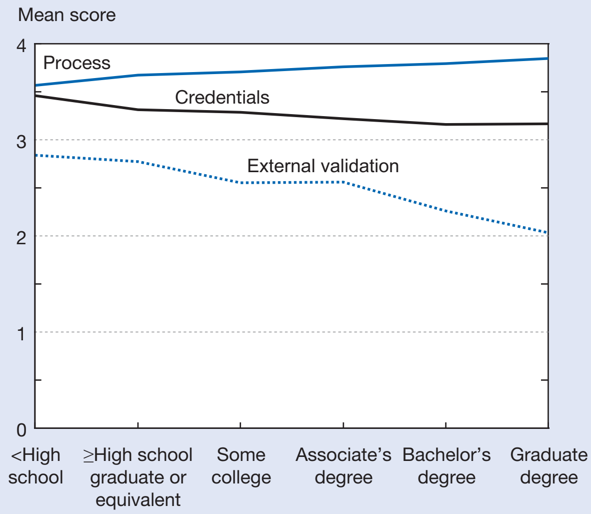
One group of questions asks how important each of eight characteristics is in "making something scientific." These characteristics can be divided into three groups—features of the research process, aspects of the credentials and institutional settings that lend credibility to the research, and external validation by other belief systems (i.e., religious and common sense beliefs). Americans were most likely to consider features of the research process to be very important (appendix table 7-25). Over two-thirds said that "conclusions based on solid evidence" (80%), "carefully examin[ing] different interpretations of the results" (73%), and replication of results by other scientists (67%) were very important in making something scientific.

Americans thought that researcher qualifications were almost as important, with 62% classifying "the people who do it have advanced degrees in their field" as very important. Institutional settings often associated with research, such as laboratories (41%) and universities (33%), ranked lower. For making research scientific, these settings were viewed as similar in importance to having results that were "consistent with common sense," a belief system that is not a part of science. Most Americans viewed consistency with religion, another belief system outside of science, as either not too important (31%) or not at all important (39%) to making something scientific.

Response patterns for this group of questions are related to education (figure 7-12; appendix table 7-26). Although Americans at all levels of education rated research process characteristics as most important, more highly educated Americans gave these the highest ratings. In contrast, individual credentials, institutional auspices, and consistency with other beliefs were less important among more highly educated respondents than among others. As a result of these divergent patterns, the gap in importance between process characteristics and other attributes is very wide at higher levels of education but relatively narrow for people with less schooling.

It is reasonable to interpret the relationship between education and a more dominant emphasis on process criteria for judging whether something is scientific as indicating that more education fosters a more critical, evidence-oriented approach to studies and conclusions that claim to be scientific. This interpretation would likewise suggest that less-educated people more often give weight to more questionable criteria that are either correlated with or unrelated to being scientific. However, other interpretations cannot be entirely ruled out. For example, people who internalize process-oriented understandings of science early in their schooling may be more successful academically and more likely to pursue advanced education. Another possibility is that additional schooling

Figure 7-12
Importance of process, credentials, and external validation to belief that something is scientific, by education level: 2006



NOTES: Responses to how important each of eight statements is to making something scientific—very important, pretty important, not too important, not important at all (where 4 = very important and 1 = not important at all). Mean importance scores for process, credentials, and external validation are computed averages of responses to all statements in category. Process statements: (1) *The conclusions are based on solid evidence;* (2) *The researchers carefully examine different interpretations of the results, even ones they disagree with;* (3) *Other scientists repeat the experiment, and find similar results.* Credentials statements: (1) *The people who do it have advanced degrees in their field;* (2) *It is done by scientists employed in a university setting;* (3) *The research takes place in a laboratory.* External validation statements: (1) *The results of the research are consistent with common sense;* (2) *The results of the research are consistent with religious beliefs.*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix tables 7-25 and 7-26.

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may lead individuals to adopt a conventional account of science in general without having a strong or consistent impact on how they actually evaluate knowledge claims.

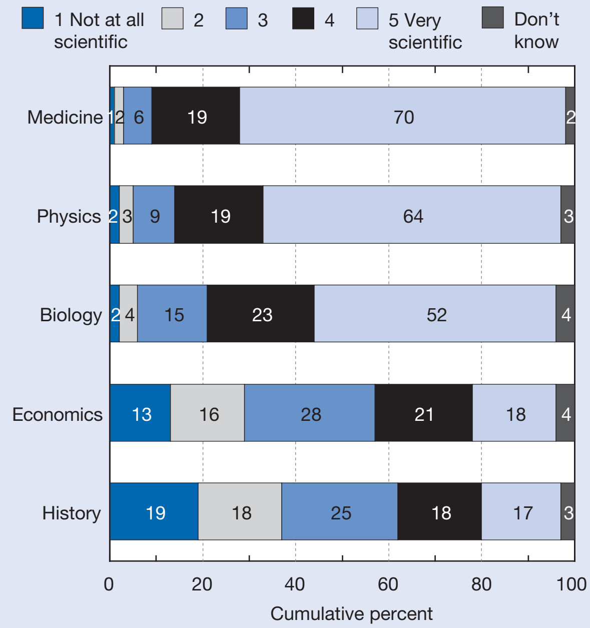
Which Fields Are Scientific

The 2006 GSS asked Americans about eight fields of research or practice and whether they were "very scientific, pretty scientific, not too scientific, or not scientific at all." A similar question on the 2005 Eurobarometer about an overlapping set of fields allows some comparison between U.S. and European perspectives.

Practically all Americans perceived medicine as very or pretty scientific (table 7-12). Americans identified medicine most strongly with science even though it is focused more on practical service delivery and less on research than other fields on the list, including biology and physics. Nonetheless, both of these disciplines were also overwhelmingly seen as either very or pretty scientific. Americans with more years of education and more classroom exposure to science and mathematics more often believed that these two fields were relatively scientific (appendix table 7-27). This was especially true for physics. Engineering, which, like medicine, involves the application of scientific knowledge to practical problems, nonetheless ranked well below the other three fields on this measure. About 50% of Americans said that the two social science disciplines on the list (economics and sociology) were very or pretty scientific. Accounting and history were least often placed at the scientific end of the scale. About 30% of Americans consider each of these fields "not at all scientific," a percentage that far exceeds that for any of the other fields. Survey respondents with less education were more likely than others to classify history as relatively scientific.

The 2005 Eurobarometer asked about five fields that were included in the 2006 GSS (figure 7-13). For these fields, Europeans and Americans had similar views: medicine was seen as the most scientific, with physics and biology following closely behind and, after a large gap, economics leading history. There were two minor differences. Europeans rated physics as somewhat more scientific than biology, whereas

Figure 7-13
European perceptions of scientific nature of various fields: 2005



NOTES: Responses to: *People have different opinions about what is scientific and what is not. I am going to read out a list of subjects. For each one tell me how scientific you think it is, on a scale from 1 to 5, where 5 means that you think it is "very scientific" and 1 that it is "not at all scientific." The intermediate scores allow you to qualify your answer.* See table 7-12 for U.S. responses to similar question.

SOURCE: European Commission, Research Directorate-General, Eurobarometer 224/Wave 63.1 (3 January–15 February 2005): Europeans, Science and Technology (2005).

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Table 7-12
Perceptions of scientific nature of various fields: 2006
(Percent)

Field	Very scientific	Pretty scientific	Not too scientific	Not at all scientific	Haven't heard of field	Don't know
Medicine	81	16	1	—	—	1
Biology	70	24	2	1	—	2
Physics	69	21	3	1	2	4
Engineering	45	32	11	7	—	4
Economics	16	35	31	13	1	3
Sociology	8	41	29	9	8	6
Accounting	13	21	31	32	—	3
History	10	21	37	29	—	3

— = ≤0.5% responded

NOTES: Responses to: *How scientific is [field]?* Detail may not add to total because of rounding.

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2006). See appendix table 7-27.

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Americans rated the two fields as about equal. Europeans saw history as more scientific than Americans did, and the gap between history and economics was wider in the United States than in Europe.

Views of S&E Occupations

Data on public esteem for S&E occupations may be an indicator of the attractiveness of these occupations and their ability to recruit talented people into their ranks. Such data may also have a bearing on the public's sense that S&E affect the nation's well being in the future.

For nearly 30 years, the Harris Poll (Harris Interactive 2006b) has asked about the prestige of a large number of occupations, including scientists and engineers (table 7-13). In 2006, over 50% of Americans said that scientists had "very great prestige," and about one-third expressed this view about engineers. Most occupations in the surveys rank below engineers.

The percentage of survey respondents attributing "very great prestige" to scientists has fluctuated between 51% and 59% in 11 surveys conducted since 1982 and for which results are available in its most recent Harris Poll summary of trends. During the same period, the percentage for engineers has also fluctuated in a relatively narrow range, moving between 28% and 37%. In neither case has there been a clear trend. In contrast, long-term trends are evident for other occupations, including teachers (up), military officers (up), and lawyers (down).

Scientists ranked higher in prestige than almost all occupations in the Harris surveys. In recent years, their ranking was comparable with that of nurses, doctors, and firefighters and slightly ahead of teachers and military officers. Although engineers are not in this top group, very few respondents say that engineers have "hardly any prestige at all." In 2006, only 4% of the public gave this response, which was about the same as for scientists and four other occupations; only medical doctors ranked noticeably better on the "hardly any prestige at all" measure, and 14 occupations ranked significantly lower.

Prestige appears to reflect perceived service orientation and public benefit more than high income or celebrity (Harris Interactive 2004). Americans are more likely to trust people in prestigious occupations (including scientists) to tell the truth (Harris Interactive 2006a).

Some evidence suggests that Americans rate scientific careers more positively than is the case in at least some other countries. In 2004, a little over 50% of South Koreans said they would feel happy if their son or daughter wanted to become a scientist, but 80% of Americans surveyed in 2001 expressed this feeling. Among Chinese, however, science ranked second to medicine as an occupation that survey respondents would like for their children (NSB 2006).

Table 7-13
Prestige of various occupations: Selected years, 1977–2006
(Percent)

Occupation	1977	1982	1992	1997	1998	2000	2001	2002	2003	2004	2005	2006
Doctor	61	55	50	52	61	61	61	50	52	52	54	58
Scientist	66	59	57	51	55	56	53	51	57	52	56	54
Teacher	29	28	41	49	53	53	54	47	49	48	47	52
Military officer	NA	22	32	29	34	42	40	47	46	47	49	51
Police officer	NA	NA	34	36	41	38	37	40	42	40	40	43
Priest/minister/clergyman	41	42	38	45	46	45	43	36	38	32	36	40
Engineer	34	30	37	32	34	32	36	34	28	29	34	34
Member of Congress	NA	NA	24	23	25	33	24	27	30	31	26	28
Architect	NA	NA	NA	NA	26	26	28	27	24	20	27	27
Athlete	26	20	18	21	20	21	22	21	17	21	23	23
Lawyer	36	30	25	19	23	21	18	15	17	17	18	21
Entertainer	18	16	17	18	19	21	20	19	17	16	18	18
Accountant	NA	13	14	18	17	14	15	13	15	10	13	17
Banker	17	17	17	15	18	15	16	15	14	15	15	17
Journalist	17	16	15	15	15	16	18	19	15	14	14	16
Union leader	NA	NA	12	14	16	16	17	14	15	16	15	12
Business executive	18	16	19	16	18	15	12	18	18	19	15	11

NA = not available, question not asked

NOTES: Based on "very great prestige" responses to: *I am going to read off a number of different occupations. For each, would you tell me if you feel it is an occupation of very great prestige, considerable prestige, some prestige, or hardly any prestige at all?*

SOURCE: Firefighters, doctors and nurses top list as "most prestigious occupations," according to latest Harris Poll, The Harris Poll #58, Harris Interactive (26 July 2006), http://www.harrisinteractive.com/harris_poll/index.asp?PID=685, accessed 7 August 2006.

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Public Attitudes About Specific S&T-Related Issues

Public attitudes can affect the speed and direction of S&T development. When science plays a substantial role in a national policy controversy, more than the specific policies under debate may be at stake. The policy debate may also shape public opinion and government decisions about investments in general categories of research. Less directly, a highly visible debate involving science may shape overall public impressions of either the credibility of science or the proper role of science in other, less visible public decisions. Likewise, public attitudes about emerging areas of research and new technologies can have an impact on innovation. The climate of opinion concerning new research areas can influence levels of public and private investment in related technological innovations and, eventually, the adoption of new technologies and the growth of industries based on these technologies.

For these reasons, survey responses about policy controversies involving science, specific research areas, and emerging technologies are worthy of attention. In addition, responses about relatively specific matters provide a window into the practical decisions through which citizens translate more general attitudes into actions, although, like all survey responses, how these responses relate to actual behavior remains uncertain. More generally, even in democratic societies, public opinion about new scientific and technological developments does not translate directly into actions or policy. Instead, it filters through institutions that selectively measure what the public believes and either magnify or minimize the effects of divisions in public opinion on public discourse and government policy (see sidebar, "Designs on Nature").

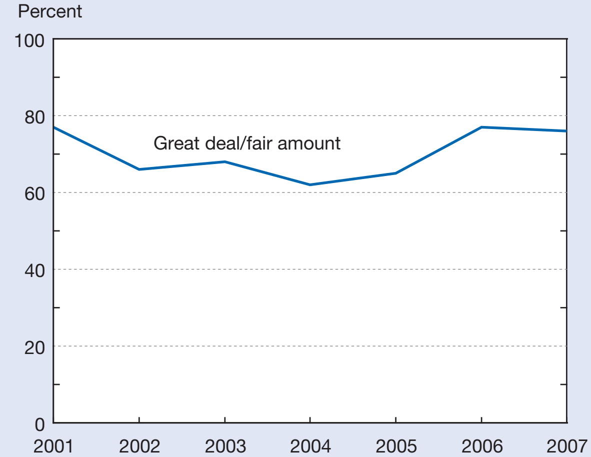
Policy attitudes always involve a multitude of factors and not just knowledge or understanding of relevant science. Values, morals, judgments of prudence, and numerous other factors can come strongly into play, and judgments about scientific fact are often secondary. In assessing the same issue, different people may find different considerations relevant.

This section begins with data on environmental issues, especially global climate change. It then covers attitudes toward recent and novel technologies, including medical biotechnology, agricultural biotechnology (i.e., genetically modified food), and nanotechnology. Data on cloning and stem cell research follow, and the section concludes with some recent data on attitudes toward science and mathematics education.

Environment and Climate Change

The Gallup Organization's annual survey on environmental issues indicates that Americans have recently become somewhat more concerned about environmental quality (figure 7-14). Between 2005 and 2007, the percentage of Americans expressing "a great deal" of worry about the "quality of the environment" rose from 35% to 43%, returning to approximately its 2001 level after 4 years (2002–05) at about 35% (Saad 2006a, 2007).

Figure 7-14
Worry about quality of environment: 2001–07



NOTE: Poll conducted annually in March.

SOURCES: Saad L, Americans See Environment as Getting Worse, The Gallup Poll (20 April 2006), http://www.galluppoll.com/content?ci=22471, accessed 4 March 2007; and special tabulation (2007).

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Despite this rise in concern, however, worry about the environment ranked somewhere in the middle among the 12 issues about which Gallup asked in 2007. Between 70% and 80% of Americans expressed either a great deal or a fair amount of worry about environment and most other issues (Social Security, drug use, crime and violence, future terrorist attacks, the economy, hunger and homelessness, and availability and affordability of energy); only availability and affordability of healthcare (83%) ranked above this range, and only illegal immigration (68%), unemployment (59%), and race relations (51%) ranked below it. In 2006 Gallup surveys, most Americans (62%) believed that the government spent too little to protect the environment and only a handful thought it spent too much (4%) (Gallup Organization 2007a). These numbers are in keeping with 2006 GSS responses to a similar question. Support for additional government spending, after dropping between 1992 to 2003, has rebounded in recent years, rising 11 percentage points between 2003 and 2006. Nonetheless, the trend in support for environmental protection is less evident when Americans are asked about tradeoffs between environmental protection and economic growth (figure 7-15). Indeed, as gasoline prices increased, public support for oil exploration in the Alaskan Arctic National Wildlife Refuge and expanded use of nuclear energy rose substantially between 2003 and 2006. However, support dropped significantly in Gallup's 2007 survey (Gallup Organization 2007a).

Global warming has recently become more prominent among environmental issues for the American public. In 2004, 2006, and 2007, Gallup asked Americans how much they worry about 10 environmental issues. The percentage of Americans who said they worried "a great deal" about

Designs on Nature

In *Designs on Nature* (2005), Sheila Jasanoff analyzed how the United States, Great Britain, and Germany have grappled with recent developments in biotechnology. Her study sought to explain numerous differences among these three leading S&T powers in the kind of political dynamics spawned by biotechnology:

- Agricultural biotechnology generated much more concern in British public life than in either Germany or the United States.
- Embryo research was relatively uncontested in Britain, publicly divisive in the United States, and debated in institutionalized governmental forums in Germany without becoming a salient political issue for a wider public.
- Patenting life forms was seen as an ethical issue in Europe but not in the United States.
- All three nations considered bioethics important, but each understood it very differently.

For Jasanoff, differences in public opinion do not, for the most part, account for these political differences. Rather, differences in political culture and institutions shape when, whether, and how public opinion is mobilized in the political arena and becomes a significant force affecting biotechnology issues. Often, elite deliberations are relatively insulated from public attitudes, and elite politics plays a large role in how the public defines and responds to new scientific issues.

Jasanoff points to differences in how knowledge becomes publicly validated in the three countries, differences that affect "national discourses of risk and safety, naturalness and artificiality, innovation and ownership, constitutional rights, and bioethics" (Jasanoff 2005, pp. 20–1). Differences in public discourse, combined with differences in regulatory approaches, legal institutions, and styles of managing conflict, affect how these countries respond to the new ethical and policy challenges posed by biotechnology. Although countries tend to respond in accordance with long-standing cultural and institutional patterns, Jasanoff observed that countries also alter and adapt these patterns to deal with the novel issues that biotechnology raises.

For each country she studied, Jasanoff identified a dominant cultural and institutional paradigm that characterizes its general approach to issues at the intersection of science and politics:

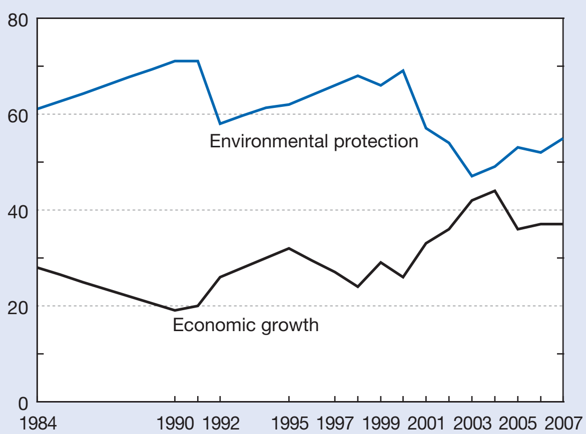
- **United States.** In a predominantly "contentious," adversary process, groups with competing interests vie to define relevant knowledge. Courts loom unusually large as arbiters of disputes, and federal administrators are relatively passive. Public optimism about technology creates an environment that is open to experimentation unless there are demonstrated risks or pre-existing regulatory barriers. New technologies often validate themselves only after they are introduced, by not causing unacceptable harms. Skepticism about expertise makes it difficult to resist demands for quantified measures, formal credentials, and transparent decision processes. Science is viewed as a sphere of objective knowledge separate from "the contaminating touch of politics" (Jasanoff 2005, p. 288).
- **Great Britain.** Biotechnology policy is developed in an atmosphere in which the credibility of state-regulated science has been damaged by the nation's experience with mad cow disease. Public trust in experts imbued with an ethic of public service and a reputation for character and judgment, although damaged, remains a key resource for validating scientific knowledge. Scientific experts associated with the government are trusted to be able to consult with affected parties, gather relevant information, and reach objective decisions that "discern the public's needs" (Jasanoff 2005, p. 268). Transparency is more an option than a requirement.
- **Germany.** Decisionmaking is consensus oriented, with interested parties participating in institutionalized deliberative processes organized by the federal government. Public debate is largely restricted to matters of values, and technical and factual issues are reserved for expert committees whose work is largely removed from public view. Committee members derive their stature from public trust in the institutions they represent. The public assumes that the state can assemble competent expert bodies composed of reasonable individuals who, although they reflect diverse interests and perspectives, can negotiate a shared view of the public interest.

Jasanoff emphasized that these patterns, though resilient, are not rigid, and that actual political processes are more fluid than the central tendencies she described.

global warming rose by 15 points during this period, more than for any of the other issues (Carroll 2006, 2007). Even with this increase, however, global warming still ranked eighth among these issues. At 36%, the percentage of Americans worrying a great deal about this issue was 10 or more points below the comparable figure for "pollution of drinking water" (58%), "pollution of rivers, lakes, and reservoirs" (53%), "contamination of soil and water by toxic waste" (52%), and "maintenance of the nation's fresh water supply for household needs" (51%).

Recent data show other signs that awareness concerning global warming is increasing. After 5 consecutive years

Figure 7-15
Public priorities for environmental protection versus economic growth: 1984–2007



NOTES: Responses to: *With which one of these statements about the environment and the economy do you most agree—protection of the environment should be given priority, even at the risk of curbing economic growth (or) economic growth should be given priority, even if the environment suffers to some extent?* Poll conducted in 1984, 1990–92, 1995, 1997–2006; other years interpolated.

SOURCE: Gallup's Pulse of Democracy: Environment, Gallup Brain, http://brain.gallup.com/content?ci=1615, accessed 24 May 2007.

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without any significant change, 2006 and 2007 Gallup surveys registered a small increase in the percentage of Americans who say they understand the global warming issue very well (Gallup Organization 2007a; Saad 2006b). In addition, the number of Americans who say that the effects of global warming have already begun to occur was higher in 2006 and 2007 than it had been in a decade of surveys (Gallup Organization 2007a; Saad 2006b). The percentage of Americans who believe that most scientists think global warming is occurring has also been rising for over a decade (Nisbet and Myers 2007). However, although most Americans think that global warming is mostly the result of human activities rather than natural changes, public opinion on this question has been stable since 2001 (Gallup Organization 2007a).

Biotechnology and Its Medical Applications

Recent advances in recombinant DNA technology enable the manipulation of genetic material to produce plants and animals with more desirable characteristics. Americans, Canadians, and Europeans have similarly favorable attitudes toward biotechnology in general and medical applications in particular.

In 2005, over two-thirds of Americans said that they either strongly supported (19%) or supported (52%) "the use of products and processes that involve biotechnology." Less than one-fourth expressed opposition. In Canada, support for biotechnology had been lower than in the United States in 2003, but climbed to 67% in 2005, closely resembling the U.S. figure (Canadian Biotechnology Secretariat 2005).[28] Similarly, in 2005 almost two-thirds of Europeans, when asked about either biotechnology or genetic engineering,[29] said that this technology would have a positive effect on their way of life in the next 20 years (European Commission 2005b).

Americans and Canadians also held similar views of biotechnology's potential in the field of medicine. In 2005, more than 8 of 10 respondents in each country agreed that biotechnology would be one of the most important sources of health treatments and cures in the 21st century (Canadian Biotechnology Secretariat 2005).

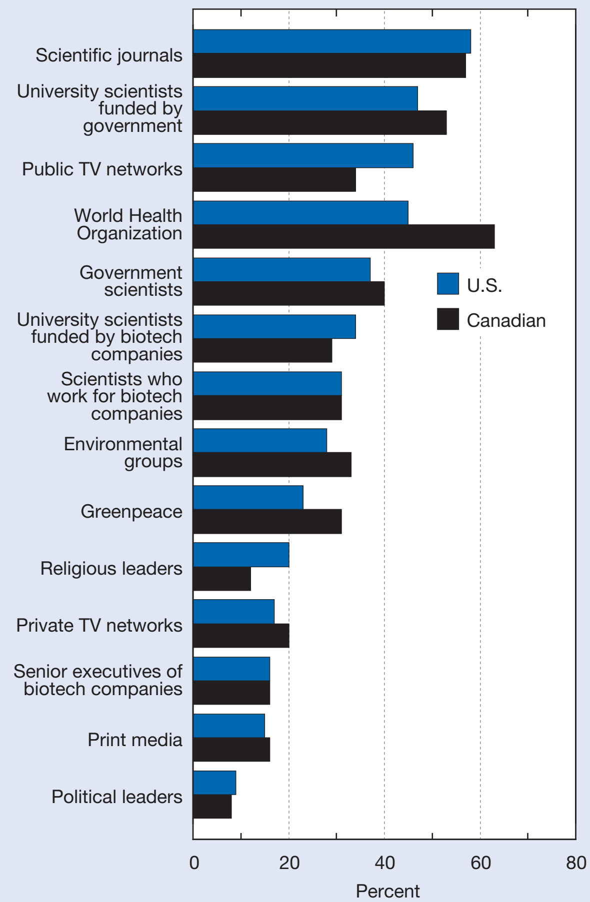
Few Americans (about 1 in 10) consider themselves "very familiar" with biotechnology. Overall, Canadians report even less familiarity, although this difference is small. Without a strong knowledge base to use in evaluating information, their assessment of the credibility of information sources is an important element in forming their judgments about information on this topic. The Canada-U.S. Survey on Biotechnology asked respondents in both countries to rate their trust in various institutions that could provide information about biotechnology. It found similar results for both Canada and the United States. In both countries, scientific journals and government-funded scientists placed at or near the top of the list. Conversely, privately owned mass media, biotechnology company executives, and religious and political leaders ranked near the bottom in both countries (figure 7-16).

Genetically Modified Food

Although the introduction of genetically modified (GM) crops has provoked much less controversy in the United States than in Europe, U.S. popular support for this application of biotechnology is limited and does not explain the difference (see sidebar, "Designs on Nature"). In a series of five surveys conducted between 2001 and 2006, the Pew Initiative on Food and Biotechnology (Mellman Group, Inc. 2006) has consistently found that only about one-fourth of Americans favor "the introduction of genetically modified foods into the U.S. food supply." Although opposition to GM food declined to 46% in the most recent survey, opposition remains much more common than support. The Canada-U.S. Survey on Biotechnology (Canadian Biotechnology Secretariat 2005) reported a similar finding. The proportion of U.S. survey respondents reporting a negative reaction to the phrase "genetically modified food" (44%) was more than twice the 20% that reported a positive reaction. Nonetheless, an analysis of public opinion on GM food concluded that Americans express more favorable views than Europeans, with Canadians falling somewhere in between (Gaskell et al. 2006).

Pew Initiative on Food and Biotechnology data (Mellman Group, Inc. 2006) suggest that misconceptions about GM food are widespread in the United States. Most Americans (60%) believe they have not eaten GM foods, even though processed foods in the United States commonly contain GM ingredients. This number has not shown a clear trend in the 5 years since Pew began asking this question. People who claim to have heard more about GM foods are more likely to say that they have eaten them. Although this survey found

Figure 7-16
U.S. and Canadian views on credibility of sources of information on biotechnology: 2005



NOTES: Responses to: *For each of the following, if you were to hear information from them regarding biotechnology, how much would you trust that information to be credible, using a scale of 1–5, where 1 is not at all credible and 5 is extremely credible?* Data reflect responses of 4 or 5.

SOURCE: Canadian Biotechnology Secretariat, Canada-U.S. Survey on Biotechnology (2005).

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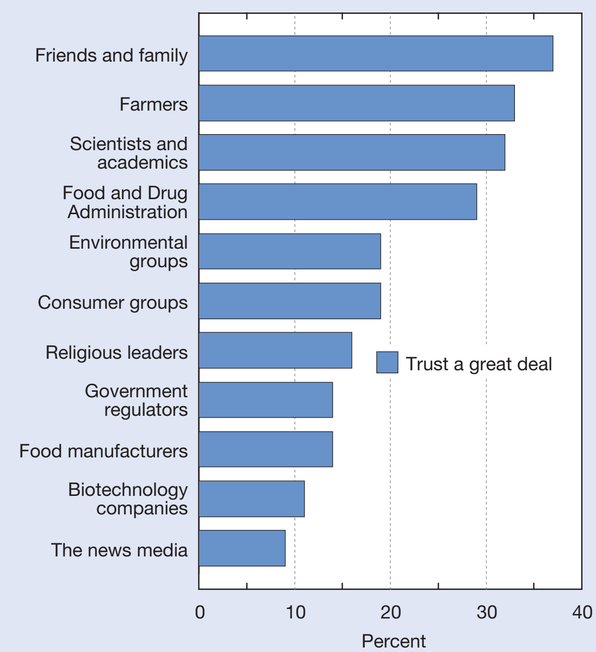
Americans were fairly evenly divided about the safety of GM foods—34% believed they are basically safe, 29% believed they are basically unsafe, and 37% said they had no opinion—opinions change when people have more information. Thus, when Americans are told that GM food is already widely used in commonly purchased groceries, the percentage judging them to be safe rises by about 10 points.[30]

As with biotechnology in general, Americans are apt to rely on trusted sources of information concerning GM food, about which their knowledge is also limited. Among sources listed in both the Pew survey on GM food and the Canadian Biotechnology Secretariat survey on biotechnology, American attitudes are generally consistent: scientists and government rank relatively high and biotechnology companies and the news media rank relatively low. In the Pew survey, more Americans (37%) expressed a great deal of trust in friends and family than in any other group. Although Americans' level of trust in farmers as sources of information on GM food was comparable with that for scientists and academics, others involved in commercial food production, including food manufacturers and biotechnology companies, were near the bottom of the list (figure 7-17).

Surveys have generally found that Americans are even more wary of genetic modification of animals than they are of genetic modification of plants (Mellman Group, Inc. 2005). Stronger ethical and safety concerns appear to play a role in people's concern, and concern is greater among women than among men, although this gender gap has been declining. Many Americans express support for regulatory responses, including labeling foods with GM ingredients, but this support appears to be quite sensitive to the way issues are framed. Thus, whereas 29% of Americans expressed a great deal of confidence in "the Food and Drug Administration or FDA," only about half as many expressed the same confidence when the question was posed about "government regulators." In addition, the proportion that expressed great confidence in the FDA dropped by 12 percentage points between 2001 and 2006 (Mellman Group, Inc. 2006).

Additional findings from earlier U.S. surveys can be found in *Science and Engineering Indicators 2006* (NSB 2006).

Figure 7-17
Trust in information sources about genetically modified foods: 2006



NOTES: Responses to: *Please tell me how much you trust what each group or organization says about genetically modified foods. Do you trust what they have to say about genetically modified foods a great deal, some, not too much, or not at all?* Data reflect responses of "a great deal."

SOURCE: The Mellman Group, memorandum to the Pew Initiative on Food and Biotechnology (16 November 2006) on results of poll conducted for Pew in October 2006.

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Nanotechnology

Nanotechnology involves manipulating matter at unprecedentedly small scales to create new or improved products that can be used in a wide variety of ways. Nanotechnology has been the focus of relatively large public and private investments for almost a decade, and innovations based on nanotechnology are increasingly common. Even relative to other new technologies, nanotechnology is still in an early stage of development.

The general public remains relatively unfamiliar with nanotechnology. Among 2006 GSS respondents, over half (54%) had heard "nothing at all" about it. An additional 25% had heard "just a little," and smaller proportions had heard either "some" (15%) or "a lot" (5%) (appendix table 7-28). These numbers are similar to those that Cobb and Macoubrie (2004) reported in a survey done 2 years earlier. Familiarity with nanotechnology was at about the same level in Europe in 2005, where 44% of survey respondents said they had heard of it (Gaskell et al. 2005).

Even among the minority of GSS respondents who had heard of nanotechnology, knowledge levels do not appear to be high (appendix table 7-7). Over half (57%) correctly responded true when asked whether "nanotechnology involves manipulating extremely small units of matter, such as individual atoms, in order to produce better materials," but many (36%) said they did not know, and a few (7%) thought this statement was false. About half (51%) did not know whether or not "the properties of nanoscale materials often differ fundamentally and unexpectedly from the properties of the same materials at larger scales." For this question, 39% correctly answered true and the remaining 9% answered false.

When nanotechnology is defined in surveys, Americans express favorable expectations for it. After receiving a brief explanation of nanotechnology, GSS respondents were asked about the likely balance between the benefits and harms of nanotechnology. About 40% said the "benefits will outweigh the harmful results," 19% expected the two to be about equal, and only 9% expected the harms to predominate (appendix table 7-29). The fact that about half of respondents either gave a neutral response (19%) or said they didn't know (32%) suggests that opinion may be open to change as Americans become more familiar with this technology. In a 2005 survey that asked Americans and Canadians about risks and benefits in two separate questions, about half of Americans foresaw substantial benefit or some benefit from nanotechnology, compared with 14% who saw substantial risk or some risk; Canadian responses were almost as optimistic (Canadian Biotechnology Secretariat 2005). Eurobarometer data, though not precisely comparable, indicate that European opinion is generally consistent with that of Americans (European Commission 2005b). In the 2005 Eurobarometer, 48% of Europeans expected nanotechnology to have "a positive effect on our way of life in the next 20 years," whereas only 8% expected a negative effect. Although familiarity with nanotechnology is similar in Europe and the United States, more Europeans than Americans said they did not know whether or not this new technology would have a positive effect.

Among Americans, favorable expectations for nanotechnology are associated with more education, greater science knowledge, and greater familiarity with nanotechnology. Men are also somewhat more likely to have favorable expectations than women (appendix table 7-29). Patterns are similar to those for responses concerning S&T generally. Unlike in Canada, where younger people's views of nanotechnology are significantly more positive than the views of older people, Americans of all ages have similar opinions (Canadian Biotechnology Secretariat 2005).

Stem Cell Research and Human Cloning

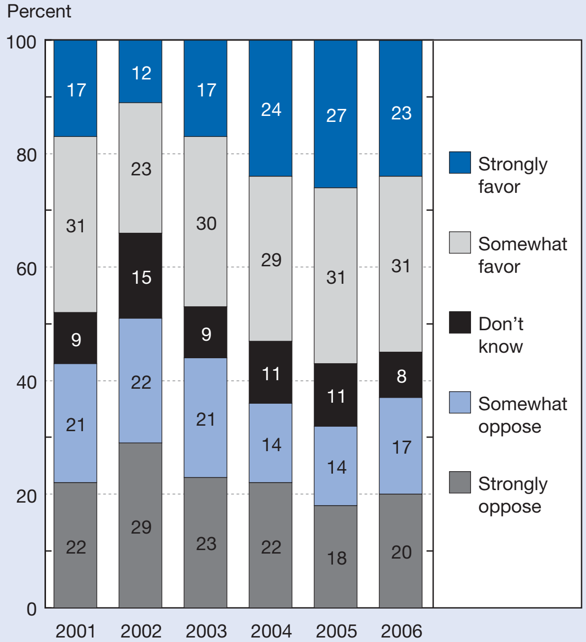
Unlike most issues involving scientific research, studies using embryonic stem cells have generated considerable public controversy. In the case of stem cell research, strongly held views about moral fundamentals determine many people's attitudes. There is little reason to believe that this is the case for certain other S&T issues, such as nanotechnology.

Although a majority of the public supports such research, a significant minority is opposed. When surveys ask about medical technologies to be derived from stem cell research in the context of expected health benefits, public response is relatively positive. But technologies that involve cloning human embryos evoke consistently strong and negative responses.

Since 2004, the majority of the American public has favored "medical research that uses stem cells from human embryos" (VCU Center for Public Policy 2006). Support grew continuously from 2002 (35% in favor) to 2005 (58% in favor), before returning to about the 2004 level in 2006 (figure 7-18). In five annual Gallup surveys between 2002 and 2006, the percentage of Americans who found such research "morally acceptable" in general climbed from 52% to 61%, while the percentage saying it was "morally wrong" in general correspondingly dropped from 39% to 30% (Gallup Organization 2007b). Likewise, a consistent majority in three Pew surveys conducted between December 2004 and July 2006 agreed that it was "more important to continue stem cell research that might produce new medical cures than to avoid destroying the human embryos used in the research"; about one-third of Americans said not destroying embryos was more important (Pew Research Center for the People and the Press 2006b).

In some circumstances, support for medical technologies derived from stem cell research can be even stronger than support for the research itself. When the question is framed as an emotionally compelling personal issue ("If you or a member of your family had a condition such as Parkinson's Disease, or a spinal cord injury, would you support the use of embryonic stem cells in order to pursue a treatment for that condition?"), 70% of Americans support treatments that use stem cells, and only 21% do not (VCU Center for Public Policy 2006). Responses become more mixed when questions mention "cloning technology" and decidedly negative when the technology is characterized as "used to create human embryos" (table 7-14).

Figure 7-18
Public attitudes toward stem cell research: 2001–06



NOTE: Responses to: *On the whole, how much do you favor or oppose medical research that uses stem cells from human embryos?* Question most recently asked 7-21 November 2006.

SOURCE: Virginia Commonwealth University (VCU), VCU Center for Public Policy, Survey and Evaluation Research Laboratory, Opinions Shifting on Stem Cell Research; Opposition to Cloning Continues, VCU Life Sciences Survey (2006), http://www.vcu.edu/lifesci/centers/cen_lse_surveys.html.

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Americans are overwhelmingly opposed to reproductive cloning. In a Research!America survey, the idea of using "cloning technology to produce a child" is rejected by about 4 of 5 people, and VCU Center for Public Policy and other surveys produce very similar results (Center for Genetics and Society 2006; Research!America 2006). In six annual VCU surveys, at least 60% of Americans said they were "strongly opposed" to "cloning or genetically altering" humans (VCU Center for Public Policy 2006).

The specter of reproductive cloning can generate apprehension about therapeutic cloning. Asked how concerned they were that "the use of human cloning technology to create stem cells for human therapeutic purposes will lead to a greater chance of human reproductive cloning," over two-thirds of Americans say they are either very (31%) or somewhat (38%) concerned (VCU Center for Public Policy 2006).

Public attitudes toward stem cell research and cloning are not grounded in a strong grasp of the difference between reproductive and therapeutic cloning, however. Most Americans say they are "not very clear" (35%) or "not clear at all" (35%) about this distinction, with 22% saying they are "somewhat clear" and only 7% characterizing themselves as "very clear" about it. Since VCU began asking this question in 2002, the number of Americans who profess greater comprehension has declined, despite, or perhaps because of, the increased visibility of stem cell research as a public issue.

Support for stem cell research is strongest among people with more years of formal education. Americans who are more religious, more conservative, and older are more likely to oppose such research (Gallup Organization 2007b; Pew Research Center for the People and the Press 2006b; VCU Center for Public Policy 2006).

Table 7-14
Public opinion on medical technologies derived from stem cell research: Most recent year
(Percent)

Question	Favor	Oppose
1. *If you or a member of your family had a condition such as Parkinson's Disease, or a spinal cord injury, would you support the use of embryonic stem cells in order to pursue a treatment for that condition? (yes or no)*	70	21
2. *Therapeutic cloning is the use of cloning technology to help in the search for possible cures and treatments for diseases and disabilities. Do you think that research into therapeutic cloning should be allowed? (yes or no)*	59	35
3. *Do you favor or oppose using human cloning technology IF it is used ONLY to help medical research develop new treatments for disease? (strongly favor, somewhat favor, somewhat oppose, or strongly oppose)*	45	51
4. *Do you favor or oppose using human cloning technology IF it is used to create human embryos that will provide stem cells for human therapeutic purposes? (strongly favor, somewhat favor, somewhat oppose, or strongly oppose)*	35	57

NOTES: Questions 1, 3, and 4 asked 7–21 November 2006. Question 2 asked in 2005. Detail does not add to total because "don't know" responses not shown.

SOURCES: Questions 1, 3, and 4, Virginia Commonwealth University (VCU), Center for Public Policy, Survey and Evaluation Research Laboratory, VCU Life Sciences Survey (2006), http://www.vcu.edu/lifesci/centers/cen_lse_surveys.html; and Question 2, Research!America, America Speaks! Poll Data Summary, vol. 7, p. 20 (March 2006), *PARADE*/Research!America Health Poll (2005), www.researchamerica.org.

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Canadian attitudes toward stem cell research are very similar (Canadian Biotechnology Secretariat 2005). Although European survey questions about stem cell research, medical applications, and cloning are sufficiently different from U.S. and Canadian data to make direct comparisons impossible, overall patterns and levels of support appear similar to those in North America (European Commission 2005b; Gaskell et al. 2006).

S&T Education

In much public discourse about how Americans will fare in an increasingly S&T-driven world, education in science, mathematics, engineering, and technology is seen as crucial preparation for adult life. Perhaps because education is more a local issue than a national one, however, national public opinion data about education in science and related subjects are lacking. A recent national survey of parents with school-age children indicates that most believe that "greatly increasing the number and quality of math and science courses students take in high schools" would do "a lot" or "quite a bit" to improve high school education in America (67%) and that it is "crucial" for most students to "learn higher level math skills like advanced algebra and calculus" (62%) (Public Agenda 2006). Nevertheless, when questions are personalized to their own children, a majority of these parents are satisfied with the amount of science their children are being taught in the schools. The percentage of Americans who believe that "kids are not taught enough math and science" is either a very or somewhat serious problem in their local public schools (32%) is 20 points lower than it was when this question was asked in 1994.

Conclusion

In assessing public knowledge and attitudes concerning S&T, two kinds of standards for judgment are possible. One standard is some conception of what a technologically advanced society requires, either currently or in the future, to be well prepared to compete in the world economy and enable its citizens to live satisfying lives. The other standard involves comparison with the past or with other countries.

By the first standard, individual judgments will inevitably vary, but it is safe to say that most proponents of S&T will find at least some of the data disquieting. They might view as causes for concern the significant minorities of Americans who cannot answer relatively simple knowledge questions about S&T, the proportion of Americans who express basic misconceptions about emerging technologies such as biotechnology and nanotechnology, or the proportion who believe relatively great scientific uncertainty surrounds global climate change. For many, some attitudes might appear problematic, too, such as the sizable parts of the population who express serious reservations about the place of morality in science or the speed of technological change, or who favor coverage of nonscientific material about human origins in public school science classes.

Trend analyses that use past U.S. data as a basis for comparison paint a different picture. Relative to Americans in the recent past, today's Americans score as well on factual knowledge and somewhat better on understanding the process of scientific inquiry, are more skeptical about scientific claims for astrology, and are at least as optimistic about new technology and favorably disposed to increased government investment in science. When Americans compare science with other institutions, science's relative ranking appears to be as or more favorable than in the past. The survey data provide little or no evidence of declining knowledge or increasingly negative attitudes.

When the data are examined using other countries as a benchmark, the United States compares favorably. Compared with adult residents of other developed countries, Americans appear to know as much or more about science, and they express as much or more optimism about technology. The only circumstance in which the United States scores below other countries on science knowledge comparisons is when, as with beliefs about human evolution, many Americans experience a conflict between accepted scientific knowledge and their religious beliefs.

Regardless of the standard used in assessing public knowledge and attitudes, one strong and persistent pattern in the data stands out: more highly educated Americans tend to know more about S&T, express more favorable attitudes about S&T, and make discriminations that are more consistent with those likely to be made by scientists and engineers themselves. Thus, for example, they focus more heavily on process criteria for evaluating whether something is scientific, and their classification of fields as more and less scientific more closely resembles a classification that would be found in a university catalog. Along with their formal schooling, they appear to have acquired perspectives, attitudes, and knowledge akin to those found among the proponents of S&T. Whether or in what sense this association is causal is uncertain: although greater knowledge may affect attitudes and perspectives, pre-existing attitudes and perspectives may affect whether or not people acquire the kinds of knowledge available to them in school. What is clear, across a variety of indicators, is that Americans with relatively more years of education and more science knowledge also have perspectives and attitudes that more closely mirror those articulated by the leaders of the American S&E community.

Notes

1. The patterns in the use of data sources do not necessarily mean that people are getting information from less-detailed sources. Newspapers and the Internet include long articles, and the Internet contains links to additional sources of information. In addition, declining reliance on magazines may result from short-term causes, such as a few S&T magazines going out of business without new ones immediately filling the market niche, rather than from a long-term change in information-seeking patterns.

2. Like most survey data, General Social Survey (GSS) data, used in figure 7-3 and elsewhere in this chapter, are weighted to make them correspond more closely to known parameters in the general population, such as sex and race distributions. In tables and figures that compare different survey years, the data are presented using a weighting formula that can be applied to all years. In tables that present only 2006 survey results, numbers are calculated using a new weighting formula that is designed to produce more accurate figures for that year. As a result, there may be minor discrepancies between the 2006 GSS results that appear in different tables and figures.

3. A survey that called attention to particular sources of information on the Internet, such as Weblogs, might well produce different results.

4. Although health news and science and technology news may appear to be closely related categories, the profile of people who follow each type of news closely is different: 63% of Americans who follow health closely are women, whereas 69% of Americans who follow S&T news closely are men (Pew Research Center for the People and the Press 2006a). Many researchers stress that both interest in and knowledge about S&T are often specific to individually defined domains within this broad category and do not generalize to the category as a whole (see sidebar, "Asset-Based Models of Knowledge").

5. Science, space and technology includes manned and unmanned space flight, astronomy, scientific research, computers, the Internet, and telecommunications media. It excludes forensic science, S&E education, and telecommunications media content. Biotechnology and basic medical research includes stem cells, genetic research, cloning, and agribusiness bioengineering. It excludes clinical research and medical technology. Stories often do not fall neatly into a single category.

6. People can become involved with S&T through many other non-classroom activities. Participating in government policy processes, going to movies that feature S&T, bird watching, and building computers are a few examples. Data on this sort of involvement with S&T are unavailable.

7. It is possible that the substantial difference between Pew and IMLS estimates for "zoos or aquariums" is the result of differences in the categories the two surveys offered to respondents. Both surveys asked about zoos and aquariums, but IMLS also asked about nature centers and children's or youth museums, whereas Pew did not. Pew respondents who visited these kinds of museums may have reasoned that "zoo or aquariums" was the most closely comparable category in the survey and classified their visits accordingly.

8. The NSF surveys asked respondents the number of times in the past year that they have visited an art museum, a natural history museum, a science or technology museum, a zoo or aquarium, or a public library. The Pew survey asks them whether or not they have visited one of the institutions, and includes planetarium in the list. For the S&T-related institutions in the list, the historic NSF numbers are about 4 percentage points higher than the Pew numbers, but the difference may have to do with how the questions were asked. Some research suggests that when surveys ask for the number of times respondents have engaged in an activity, the percentage saying they have engaged in the activity at least once is larger than the percentage who would answer "yes" if asked whether they had engaged in the activity at all, probably because some respondents experience the first type of question as implying that the activity is common or acceptable (Knauper 1998; Sterngold, Warland, and Herrmann 1994). The IMLS survey's institution categories are sufficiently different from the NSF categories to make focused comparisons over time problematic.

9. The IMLS survey only asked about children's museum visits in households where adults had visited a museum in 2006, either in-person or remotely via the Internet. Because IMLS assumed that children in other households did not visit museums, there is reason to believe that the actual percentages are somewhat higher than the IMLS estimates.

10. One possible explanation for differences between Europe and the United States in attendance at informal science institutions is that adult leisure patterns reflect patterns that developed in childhood, when, especially for older Europeans, informal science institutions were less readily available than in the United States. The available national data do not permit a test of this explanation.

11. Survey items that test factual knowledge sometimes use readily comprehensible language even at the cost of some scientific imprecision. This may prompt some highly knowledgeable respondents to feel 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 even 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, often subtle, modifications in how they understand existing data in light of new evidence.

12. Early NSF surveys used additional factual knowledge indicators, which were combined to form an aggregate indicator. Bann and Schwerin (2004) performed statistical analyses on this and other groups of indicators to produce shorter scales that involved fewer questions and required less time to administer, but were functionally equivalent to the scales that used additional items (e.g., had similar measurement properties and yielded performance patterns that correlated with similar demographic characteristics). For factual knowledge, Bann and Schwerin produced two alternative scales that, except for one item, used identical questions. One of these scales was administered in 2004, and the other was substituted in 2006. Appendix table 7-4 presents trend data using each scale. To enable aggregated comparisons of 2004 and 2006 results, it includes the average numbers of correct answers to the group of overlapping items from those 2 years.

13. The two nanotechnology questions were asked only of respondents who said they had some familiarity with nanotechnology, and a sizable majority of the respondents who ventured a substantive answer (i.e., not "don't know") answered the questions correctly. To measure nanotechnology knowledge more reliably, researchers would prefer a scale with more than two questions.

14. Even small, apparently nonsubstantive differences in question wording can affect survey responses. U.S. surveys, for example, have asked respondents whether or not it is true that "it is the father's gene that decides whether the baby is a boy or a girl." In contrast, the 2005 Eurobarometer asked whether or not it is true that "it is the mother's genes that decide whether the baby is a boy or a girl." To a scientifically knowledgeable respondent, these questions are equivalent. To other respondents, however, they may not be. Research has shown that some survey respondents have an "acquiescence bias"—when given the opportunity to do so, they tend to provide positive responses to questions and are therefore more likely to answer true than false (Schaeffer and Presser 2003). Thus, the U.S. question is probably easier to answer correctly than the Eurobarometer question; in other words, in two equally knowledgeable populations, more people would get the U.S. question right. Although Americans score better on this topic than Europeans, it is possible that this has as much or more to do with acquiescence bias as it does with scientific knowledge.

15. In its own international comparison of scientific literacy, Japan ranked itself 10th among the 14 countries it evaluated (National Institute of Science and Technology Policy 2002).

16. Early NSF surveys used additional questions to measure understanding of probability. Through a process similar to that described in endnote 12, Bann and Schwerin (2004) identified a smaller number of questions that could be administered to develop a comparable indicator. These questions were administered in 2004 and 2006, and appendix tables 7-9 and 7-10 record combined probability responses using these questions; appendix table 7-9 also shows responses to individual probability questions in each year.

17. Methodological issues make fine-grained comparisons of data from different survey years suspect. Although the question content and interviewer instructions were identical in 2004 and 2006, for example, the percentage of respondents who volunteered "about equal" was substantially different. This difference may have been produced by the change from telephone interviews in 2004 to in-person interviews in 2006 (though 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.

18. The English version of the European question reads, "The benefits of science are greater than any harmful effects it may have." Respondents can strongly agree, tend to agree, neither agree nor disagree, tend to disagree, strongly disagree, or say that they do not know. The U.S. question is prefaced by the statement that "People have frequently noted that scientific research has produced benefits and harmful results" and asks the respondent, "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 the benefits." Respondents who say that the benefits are greater are then asked whether "the balance has been strongly in favor of the benefits, or only slightly." Respondents who say the harmful results are greater are asked a parallel question to distinguish strongly from slightly. Some respondents are recorded as saying that the benefits and harmful results are "about equal" when they volunteer this response.

Although these questions differ in their references to "science" and "scientific research," "effects" and "results," and in the exact wording of the response categories, they are similar in their overall thrust and in the availability of a middle category ("neither agree nor disagree," "about equal"). For other questions that are worded similarly in the 2005 Eurobarometer and either the 2004 or 2006 NSF surveys, the presence of a middle category in Europe and the absence of one in the United States makes direct comparison problematic. This lengthy, though incomplete, comparison regarding a single question pair should provide some indication of why international attitude comparisons should be treated with caution.

19. Unlike the U.S. question, the European question joins two logically independent ideas—more spending on science and less spending on other priorities. In addition, because nations begin from different levels of spending, survey responses cannot be read as indicating different views about the proper level of spending in this area, nor do they indicate the strength of sentiment in different countries. Differences in the connotations of questions posed in different languages add further complexities. Perhaps for some or all of these reasons, variations among European countries in responses to this question are large, with about two-thirds of respondents agreeing in Italy, Spain, and France, but less than one-third in Finland and the Netherlands.

20. Some Americans may think that science can resolve differences over what to value or settle policy questions without requiring value judgments. This view accords science a kind of influence that goes beyond what the scientific community thinks it can properly exercise. There are no survey data that indicate how many Americans accord science too much influence in this regard.

21. Although these questions treat economists as scientists and compare them to other categories of scientists, data reported later in this chapter indicate that many Americans do not consider economics to be very scientific. To understand public perceptions of the role of science and scientists in dealing with contested public issues, it helps to have indicators both for disciplines that the public almost universally

sees as scientific and for disciplines whose scientific status is less secure in the public's eyes. Many social scientists (e.g., Gieryn 1999) believe that much can be learned from research on how institutional boundaries are defined and maintained. Universities overwhelmingly categorize economics as a social science.

22. These question batteries were designed as indicators of public views regarding the appropriate influence of science on public issues generally. Questions were posed concerning specific issues both because (1) this is likely to increase the degree to which respondents think of similar situations when they make judgments and (2) because views about the appropriate role of science are likely to depend heavily on context. A study of any one of the specific issues would likely make somewhat different distinctions and ask more and different questions about the topic.

Three other issues are worthy of mention: (1) Because survey respondents are variably familiar with the issues posed in these questions, certain categories are characterized with significant imprecision. For example, "medical researchers" is not an optimal characterization of the kind of researchers who are experts on the health effects of genetically modified foods. (2) Judgments that affect trust in leaders may be difficult to capture in survey questions. A concept such as disinterestedness, for example, (in the sense of a judgment made and expressed in light of appropriate collective interests and independent of personal interests that are not supposed to be given any weight) likely cannot be stated in language that can be used in a survey. (3) Comparable data on other issues is lacking, which makes generalizing observed patterns to other issues hazardous. Just as it is uncertain how attitudes that are highly general shape concrete judgments, it is uncertain how more specific judgments generalize beyond the terms in which they are posed. Because different attitude indicators have different limitations, it can be valuable to have indicators with complementary strengths and flaws. In all cases, it is worth keeping the actual question wording in mind when interpreting the significance of patterns in the data.

23. The questions were worded as follows:

- "How much influence should each of the following groups have in deciding what to do about global warming? a. Environmental scientists. Would you say a great deal of influence, a fair amount, a little influence, or none at all?" This wording was then repeated in the next two questions, except that "elected officials" and "business leaders" were substituted for environmental scientists.
- "How much influence should each of the following groups have in deciding about government funding for stem cell research? a. Medical researchers. Would you say a great deal of influence, a fair amount, a little influence, or none at all?" This wording was then repeated in the next two questions, except that "religious leaders" and "elected officials" were substituted for medical researchers.
- "How much influence should each of the following groups have in deciding whether to reduce federal income taxes? a. Economists. Would you say a great deal of influence, a fair amount, a little influence, or none at all?" This wording was then repeated in the next two questions, except that "business leaders" and "elected officials" were substituted for economists.
- "Some say that the government should restrict the sale of genetically modified foods. Others say there is no need for such restrictions. How much influence should each of the following groups have in deciding whether to restrict the sale of genetically modified foods? a. Medical researchers. Would you say a great deal of influence, a fair amount, a little influence, or none at all?" This wording was then repeated in the next two questions, except that "elected officials" and "business leaders" were substituted for medical researchers.

24. The questions were worded as follows: "On a scale of 1 to 5, where 1 means "very well" and 5 means "not at all," how well do the following groups understand" each of four public issues: "the causes of global warming," "stem cell research," "the likely effects of reducing federal taxes," and "the risks posed by genetically modified foods." For global warming, respondents were asked about environmental scientists, elected officials, and business leaders. For stem cell research, respondents were asked about medical researchers, religious leaders, and elected officials. For federal taxes, respondents were asked about economists, business leaders, and elected officials. For genetically modified foods, respondents were asked about medical researchers, elected officials, and business leaders.

25. The questions were worded as follows: "When making policy recommendations about" each of four public issues "on a scale of 1 to 5, to what extent do you think the following groups would support what is best for the country as a whole versus what serves their own narrow interests?" The issues were "global warming," "stem cell research," "federal income taxes," and "genetically modified foods." If asked about what narrow interests meant, interviewers were instructed to respond "Well, someone might gain financially if a certain policy were adopted or it might advance his or her career."

26. Three of the four questions were worded as follows: "On a scale of 1 to 5, where 1 means "near complete agreement" and 5 means "no agreement at all," to what extent do" groups of scientists "agree on" an issue. The groups and issues were "environmental scientists/the existence and causes of global warming," "medical researchers/the importance of stem cells for research," "economists/the effects of reducing federal income taxes" and "medical researchers/the risks and benefits of genetically modified foods." The global warming question read "agree among themselves about" instead of "agree on."

27. Among the considerations that might be considered relevant are the role of ordinary citizens whose interests are specially affected by a decision and the institutional context for a decision (e.g., public versus private, different branches or levels of government). There is an extensive literature, analyz-

ing mostly qualitative and nonnational data, that explores the complexities in when and why the public treats scientists and others as having the authority to influence or make decisions. Although attempts to synthesize that literature and clarify its relationship to what can be learned from national surveys would be welcome, this kind of multivariate analysis and interpretation goes well beyond the scope of this document.

28. A 2006 Canadian survey showed little or no change from 2005 (Decima Research 2006).

29. Although experts generally consider these two terms to be synonymous, survey results for "biotechnology" are generally more favorable than for "genetic engineering" (Gaskell et al. 2006).

30. Food safety concerns are not the only reason that people oppose use of genetically modified foods. Other concerns include the environmental effects of genetically modified crops and the power that large corporations that manufacture genetically modified seed gain over the food supply.

Glossary

Biotechnology: The use of living things to make products.

EU-25: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

Genetically modified food: A food product containing some quantity of any genetically modified organism as an ingredient.

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

Therapeutic cloning: Refers to the use of cloning technology in medical research to develop new treatments for diseases; differentiated from human reproductive cloning.

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