Chapter 7
Science and Technology: Public Attitudes and Public Understanding

Highlights

- **In National Science Foundation (NSF) surveys conducted since 1979, about 90 percent of U.S. adults report being very or moderately interested in new scientific discoveries and the use of new inventions and technologies.** Those with more years of formal education and those who have taken more courses in science and mathematics are more likely than others to express a high level of interest in science and technology (S&T).
- **News about S&T, however, does not attract much public interest.** According to Pew Research Center surveys, only about 2 percent of the most closely followed news stories of the past 15 years were about scientific breakthroughs, research, and exploration. The leading science-related news event of 2000 was the announcement that scientists had completed mapping the human genome. However, only 16 percent of the public claimed to be following that story very closely. Twenty-eight percent said they were closely following news about the Microsoft antitrust court case, an event that may more of a business than a technology story, although the outcome could have a major impact on innovation in the software industry.
- **The number of people who feel either well informed or moderately well informed about S&T is relatively low.** In 2001, less than 15 percent of NSF survey respondents described themselves as well informed about new scientific discoveries and the use of new inventions and technologies; a substantial minority, approximately 30 to 35 percent, thought that they were poorly informed. People are feeling less informed than they used to. A recent downward trend is particularly noticeable for the five S&T-related issues included in the NSF survey.
- **Most Americans do not know a lot about S&T.** The general public's ability to answer basic questions about science has hardly changed. For instance, in 2001, only about 50 percent of NSF survey respondents knew that the earliest humans did not live at the same time as dinosaurs, that it takes Earth one year to go around the Sun, that electrons are smaller than atoms, and that antibiotics do not kill viruses. However, the number answering the last item correctly rose from 40 percent in 1995 to 51 percent in 2001, an increase that may be attributable to widespread media coverage of an important public health issue, antibiotic-resistant bacteria.
- **For the first time, a majority (53 percent) of NSF survey respondents answered "true" to the statement "human beings, as we know them today, developed from earlier species of animals," bringing the United States more in line with other industrialized countries in response to this question.** Although a majority (60 percent) of people surveyed in a Gallup poll were opposed to the Kansas State Board of Education's decision to delete evolution from the state's science standards (a decision that was later reversed), more than two-thirds favored teaching both evolution and creationism in U.S. public school classrooms.
- **A majority of Americans (about 70 percent) lack a clear understanding of the scientific process.** Although more than 50 percent of NSF survey respondents in 2001 had some understanding of probability, and more than 40 percent were familiar with how an experiment is conducted, only one-third could adequately explain what it means to study something scientifically. Understanding how ideas are investigated and analyzed is a sure sign of scientific literacy. Such critical thinking skills can also prove advantageous in making well-informed choices at the ballot box and in other daily living activities.
- **All indicators point to widespread support for government funding of basic research.** In 2001, 81 percent of NSF survey respondents agreed with the statement: "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."
- **Data from the NSF survey show a gradual decline in public support for genetic engineering over the past 15 years.** The shift can be seen most clearly among the college educated and those classified as attentive to S&T. In no year has a majority of Americans agreed that the benefits of genetic engineering outweighed the harmful results. In 2001, 40 percent of those surveyed thought that the benefits outweighed the harmful results, down from 49 percent in 1985. However, the number of people who think the harms outweigh the benefits has also declined in most years, from 39 percent in 1985 to 33 percent in 2001. Concurrently, the percentage saying that the benefits are equal to the harms increased from 12 percent in 1985 to 28 percent in 2001.
- **In the 2001 NSF survey, 61 percent of respondents reported that they supported genetically modified food production;** 36 percent said that they were opposed. In addition, 89 percent said that they supported genetic testing to detect inherited diseases (9 percent were opposed), and 47 percent said that they supported cloning animals, about the same as the percentage opposing the technology.
- **Anti-biotechnology sentiments are much more common in Europe than in the United States.** In addition, the number of people harboring negative perceptions of biotechnology has increased in both Europe and Canada during the past few years, especially when compared with attitudes in the United States. These latest findings are from an international study conducted in late 1999 and early 2000 in the United States, Europe, and Canada.

- **On a 10-question "pop quiz" on biotechnology, most Americans, Europeans, and Canadians gave the incorrect answer (true) to the statement "ordinary tomatoes do not contain genes, while genetically modified tomatoes do," and fewer than half the respondents in each region knew that animal genes can be transferred into plants.** On the same quiz, Americans and Canadians seemed to know more than Europeans about the science of biotechnology; they averaged 6.2 and 6.1 correctly answered questions, respectively, compared with Europeans, who averaged 5.4 correctly answered questions. In responding to another question in this quiz, about half of Americans, Europeans, and Canadians knew that more than half of human genetic makeup is identical to that of chimpanzees.
- **In response to surveys conducted in late 1999 and early 2000, about half of the Americans thought that genetic engineering would "improve our way of life in the next 20 years."** The corresponding statistics for Europe and Canada were 38 and 50 percent, respectively. However, a sizable minority of Americans (29 percent) said the opposite, that genetic engineering "will make things worse" during the next 20 years, compared with 31 percent of Europeans and 40 percent of Canadians. In all three surveys, biotechnology ranked sixth among the seven technologies that respondents were asked about (only nuclear energy ranked lower). In contrast, more than 80 percent of Americans and Canadians said that solar energy, computers, and telecommunications would improve our way of life in the next 20 years. The corresponding European percentages were somewhat lower but still greater than 70 percent. In addition, approximately 70 percent of Americans, Canadians, and Europeans each thought that the Internet would improve their lives during the next 20 years.
- **Data from the 2001 NSF survey show that Americans have been listening to what scientists and others have been saying about global climate change.** Nearly 80 percent believe in the existence of global warming, and 53 percent of those surveyed said that the possibility of global warming should be treated as a very serious problem.
- **Most adults learn about the latest developments in S&T primarily from watching television.** Although the Internet is affecting what Americans know about these subjects, only 9 percent identified it as their main source of information about S&T, compared with those who identified television (44 percent) or newspapers and magazines (16 percent). However, according to a 2000 Pew Research Center survey, the Internet is displacing network news shows in certain types of households. Also, according to the 2001 NSF survey, the Internet is the preferred resource when seeking information about specific scientific issues, indicating that encyclopedias—and every other information resource—have lost a substantial number of customers to the Internet.
- **Access to the Internet at home is an indicator of both attitudes toward and knowledge of S&T.** Those who have home computers hooked up to the World Wide Web seem to harbor fewer reservations about S&T and have more knowledge of science and the scientific process than their non-access counterparts.
- **Few characters on prime time entertainment shows are scientists.** According to a recent study, the percentage of prime time television characters who are scientists was less than 2 percent in each year during the mid-1990s. Even though scientists seldom show up on the small screen, the appearance of women and minorities as scientists is even more rare. The reverse was true for foreign nationals, however, because they are more likely to portray scientists than other types of characters on television.
- **Most people believe that scientists and engineers lead rewarding professional and personal lives, although a stereotypical image of these professions, deeply rooted in popular culture, exists and has been difficult to dislodge.** For example, 25 percent of those surveyed thought that scientists were apt to be odd and peculiar people, and 29 percent thought that scientists have few other interests but their work. In addition, a majority (53 percent) of those surveyed agreed with the statement "scientific work is dangerous."
- **Belief in pseudoscience, including astrology, extrasensory perception (ESP), and alien abductions, is relatively widespread and growing.** For example, in response to the 2001 NSF survey, a sizable minority (41 percent) of the public said that astrology was at least somewhat scientific, and a solid majority (60 percent) agreed with the statement "some people possess psychic powers or ESP." Gallup polls show substantial gains in almost every category of pseudoscience during the past decade. Such beliefs may sometimes be fueled by the media's miscommunication of science and the scientific process.
- **Alternative medicine, defined here as any treatment that has not been proven effective using scientific methods, has been gaining in popularity.** One study documented a 50 percent increase in expenditures for alternative therapies and a 25 percent increase in the use of alternative therapies between 1990 and 1997. Also, more than two thirds of those responding to the NSF survey said that magnetic therapy was at least somewhat scientific, although no scientific evidence exists to support claims about its effectiveness in treating pain or any other ailment.

Introduction

Chapter Overview

Americans are highly supportive of science and technology (S&T), but lack knowledge of them. That is the major finding of the National Science Foundation's (NSF's) biennial surveys of Public Attitudes Toward and Understanding of Science and Technology. The most recent survey in this series was conducted in early 2001.[1]

Statistics on Americans' lack of knowledge of such subjects as history, geography, mathematics, and science receive a considerable amount of media attention and are regularly cited in speeches given by various educators and policymakers. Even late night talk show hosts make fun of Americans' inability to answer simple questions. Although it is true that many Americans do not do well when quizzed on their knowledge of science and other subjects, it is not always clear how important this deficiency is. For instance, it has been noted that Americans are hardly unique; citizens in other countries perform just as poorly in tests of their basic knowledge of the world around them (Gup 2000). Also, a case can be made that most people do not need to know the answers to be able to function in their daily lives and serve as productive members of society. However, strong critical thinking and problem-solving skills—the ability to evaluate information and make sound decisions—do play an important role in people's lives.[2]

Chapter Organization

The chapter begins with a discussion of the public's interest in and knowledge of S&T. The level of interest in S&T is an indicator of both the visibility of the science and engineering (S&E) community's work and the relative importance accorded S&T by society. The first section also contains data on the level of public understanding of both basic science concepts and the scientific process.

In the second section, public attitudes toward S&T are examined. Data on public attitudes toward Federal funding of scientific research and public confidence in the science community are included. In addition, this section contains information on public perceptions of the benefits and harms (or costs) of scientific research, genetic engineering, space exploration, the use of animals in scientific research, global warming, and attitudes toward math and science education.

The next sections feature discussions on the public image of the science community, including public perceptions of scientists and science occupations, and where Americans get information about S&T. Finally, interest in science fiction and the relationship between science and pseudoscience, including concerns about belief in paranormal phenomena, are examined in the last section of the chapter.

In addition, results of surveys sponsored by organizations other than NSF are discussed throughout each section.[3]

Public Interest in and Knowledge of S&T

Most people say they are interested in S&T. When asked in a survey about their level of interest, few people will admit to having no interest. This is the usual pattern that shows up in NSF surveys in which approximately 9 out of every 10 adults interviewed by telephone report they are either very or moderately interested in new scientific discoveries and the use of new inventions and technologies. (See appendix table 7-1.)

Despite the expression of interest in S&T, few people (less than 15 percent in 2001) feel very well informed about these subjects. And, available evidence suggests that their lack of confidence in their knowledge is justified, because a substantial number of people appear to be unable to answer simple science-related questions.

In this section, four topics will be covered:

- public interest in S&T and other issues,
- the public's sense of feeling well informed about S&T and other issues,
- the "attentive" public for S&T policy, and
- public understanding of S&T.

[1]Of the 15 *Indicators* volumes published since 1972, 14 have included a chapter on public attitudes toward and understanding of S&T. The surveys for the 1972, 1974, and 1976 *Indicators* contained a block of 20 items inserted into an omnibus national personal interview survey conducted by Opinion Research Corporation of Princeton, New Jersey. The 1979 survey was designed by Miller and Prewitt (1979) and analyzed by Miller, Prewitt, and Pearson (1980); the personal interviews were conducted by the Institute for Survey Research at Temple University. Additional national surveys were undertaken for the 1982, 1985, 1987, 1991, and 1993 *Indicators* reports, with telephone interviews conducted by the Public Opinion Laboratory of Northern Illinois University. The chapter for *Science Indicators—1985* was based on a national telephone survey conducted by the Public Opinion Laboratory for Professor George Gerbner of the Annenberg School of Communication at the University of Pennsylvania. In 1995, 1997, and 1999, the Chicago Academy of Sciences conducted surveys that continued the core of attitude and knowledge items from previous *Indicators* studies and included telephone interviews with a random-digit sample of 2,006 adults in 1995, 2,000 in 1997, and 1,882 in 1999. Interviews for the 1995 survey were conducted by the Public Affairs Division of Market Facts Incorporated. The interviews for the 1997 and 1999 surveys were conducted by the National Opinion Research Center. The 2001 survey was conducted by ORC Macro and included telephone interviews with a random-digit sample of adults. The results can be found in past volumes of *Indicators*.

In general, the response rate for previous NSF surveys has been 70 percent or higher. However, for the 1999 and 2001 surveys, the response rates were 66 and 39 percent, respectively. Moreover, the highly educated were overrepresented in the 2001 survey, and those with little education, underrepresented. For more information on the 1999 survey methodology, see Miller, Kimmel, and Hess (2000), and for more information on the 2001 survey, see Duffy, Muzzy, and Robb (2001).

[2]In a recent survey, workers rated critical thinking skills as more important than job-specific skills such as computer skills (Hebel 2000).

[3]Every effort was made to include relevant data from sources other than NSF. However, it should be noted that not many survey organizations regularly or even occasionally collect information on public attitudes toward or understanding of S&T.

Public Interest in S&T and Other Issues

Surveys conducted by NSF and other organizations consistently show that Americans are interested in S&T issues. Among those who participated in the 2001 NSF survey, 47 percent said that they were *very interested* in new scientific discoveries, and 43 percent reported that they were *very interested* in the use of new inventions and technologies. About 45 percent said that they were *moderately interested* in these issues, and about 10 percent reported *no interest*. (See appendix table 7-1 and figure 7-1.)

Nearly everyone is interested in new medical discoveries. Year after year, more people express interest in this subject than in any other. In 2001, about two-thirds of the NSF survey respondents reported they were *very interested* in new medical discoveries.[4] None of the other survey items, except local school issues, received such a high percentage of *very interested* responses. Local school issues ranked second, with 59 percent of the respondents saying they were *very interested* in this topic. (See appendix table 7-1.)

In 2001, the level of interest in S&T came close to an all-time high. On a scale ranging from 0 to 100,[5] the average level of public interest in new scientific discoveries was 69. Between 1985 and 1995, the index scores for this item ranged from 61 in 1992 to 67 in 1995. (See figure 7-2 and appendix table 7-2.)

The interest index for new inventions and technologies tracks quite closely with that for new scientific discoveries. It has been no lower than 64 since 1983. In 2001, the index level for this item was 66. The highest score ever recorded for this item was 69 in 1997. (See figure 7-2 and appendix table 7-2.)

New medical discoveries is the only issue that has consistently produced interest index scores in the 80s. Scores for environmental pollution and local school issues have been in the 70s for the past 10 years. Interest in environmental pollution seems to have gradually subsided, dropping from 80 in 1990 to 70 only 11 years later. During the same period, interest in local school issues increased from 67 in 1990 to 74 in 2001. Despite all the newsworthy events taking place in space during the past few years, interest in space exploration declined, dropping from 55 in 1997 to 50 in 2001. (See "Public Attitudes Toward Space Exploration.")

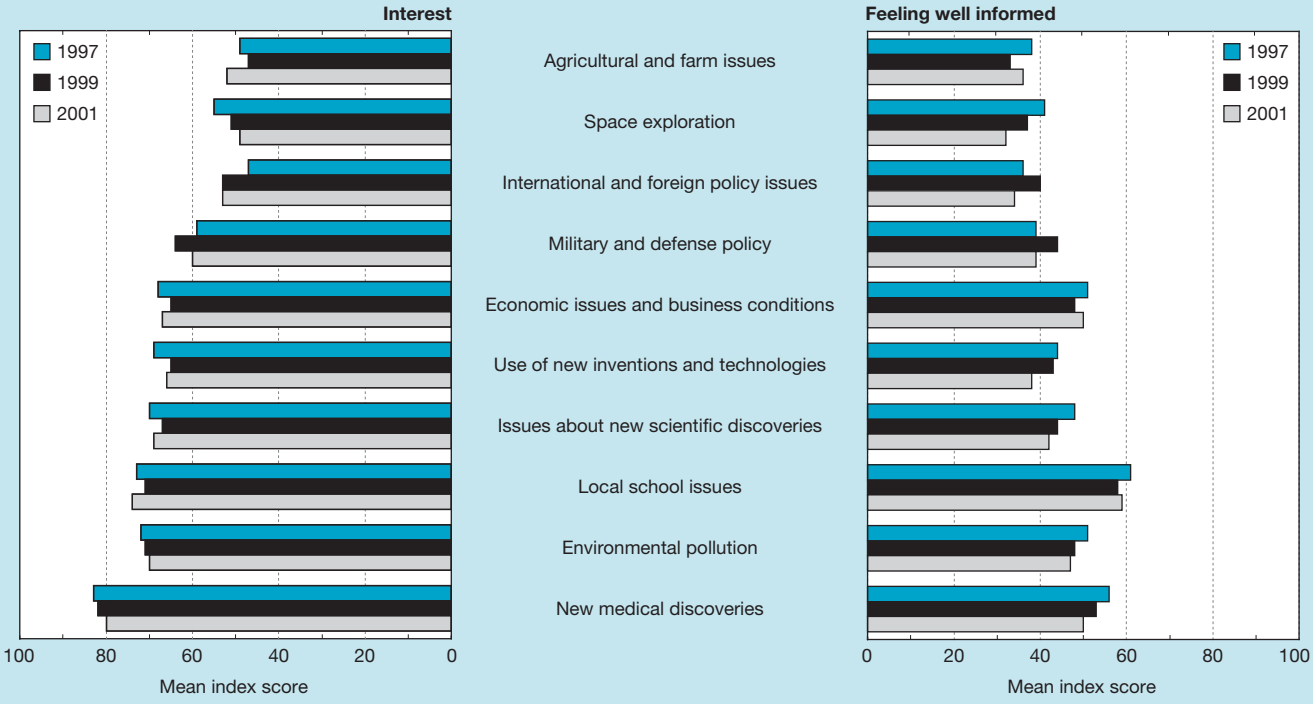
Are People as Interested in S&T Issues as They Assert?

When asked about their interest in S&T issues, few survey respondents admit being uninterested. However, there is reason to believe that their level of interest may not be as high as the data indicate. Surveys conducted by the Pew Research Center show crime, health, sports, and community affairs as the four types of news followed most closely by the

[4]Americans not only are interested in new medical discoveries, but also strongly support government-sponsored medical research. In a Research!America (2000) poll, 65 percent of those surveyed said they supported doubling spending on such research during the next five years.

[5]Responses were converted to index scores ranging from 0 to 100 by assigning a value of 100 for a "very interested" response, a value of 50 for a "moderately interested" response, and a value of 0 for a "not at all interested" response. The values for each issue were then averaged to produce an index score reflecting the average level of interest for the given issue.

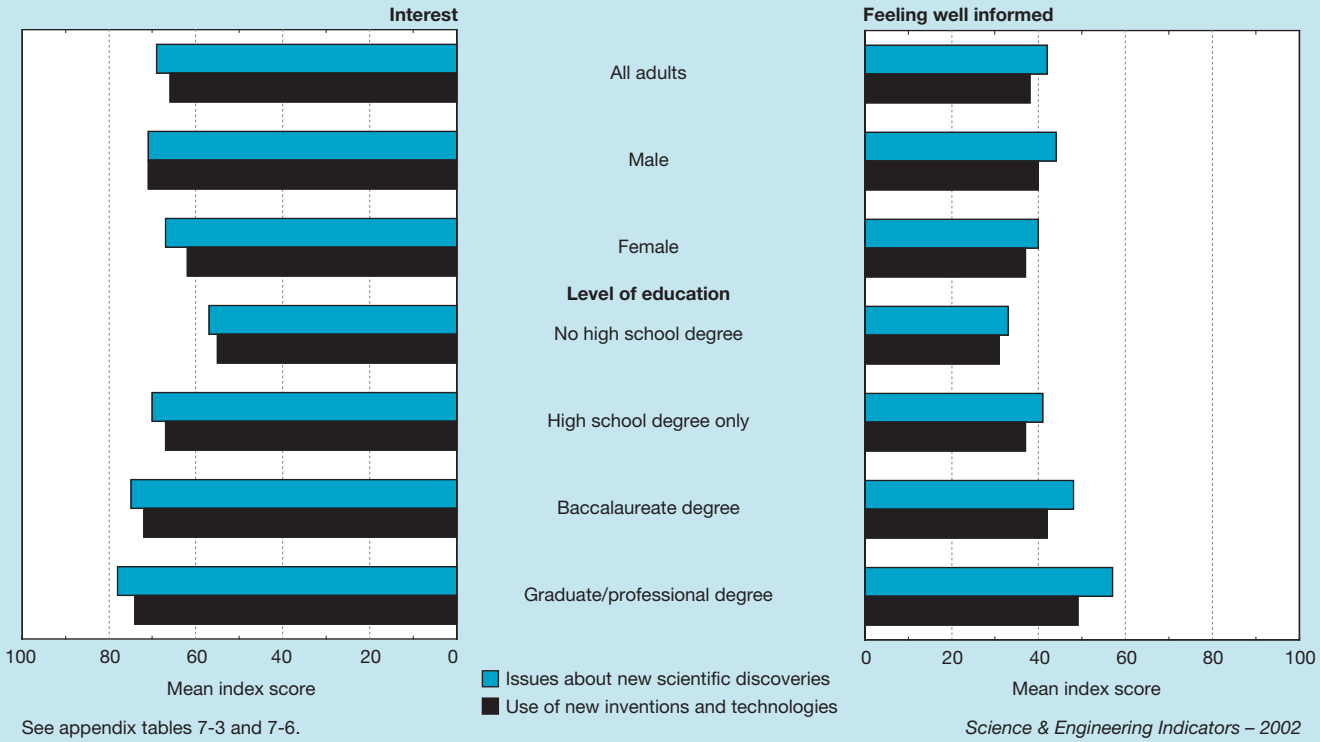
Figure 7-1.
Indices of public interest in and feeling well informed about public policy issues: 1997, 1999, and 2001



See appendix tables 7-2 and 7-5.

Science & Engineering Indicators – 2002

Figure 7-2.
Indices of public interest in and feeling well informed about scientific and technological issues, by sex and level of education: 2001



See appendix tables 7-3 and 7-6.

Science & Engineering Indicators – 2002

American public; S&T ranks only seventh. (See text table 7-1 and sidebar "Leading News Stories of 2000.") Still, interest in news about S&T is only part of the story. The millions of people who visit science museums every year are also demonstrating interest in science without necessarily being interested in science news. (See "Where Americans Get Information About Science and Technology.") In addition, the number of science-related books on best seller lists seems to be increasing (Lewenstein 2001).[6]

In addition, S&T issues are rarely selected in most national polls designed to determine the top public priorities in the United States. For example, according to one recent poll from 2000, the leading public priorities are (1) improving the educational system, (2) keeping the economy strong, (3) securing Social Security, (4) reducing crime, and (5) securing Medicare (Pew Research Center for the People and the Press 2000a). In the same poll, protecting the environment ranked ninth, just ahead of national defense. Science did not rank among the top 14. However, when survey participants are specifically given the opportunity to rank S&T in the context of other issues, their priorities can change. In such a poll, 50 percent of those surveyed said that "more money for science

[6]The first science-related books on the *Publishers Weekly* best seller list to sell more than a half million copies were Carl Sagan's *Cosmos* in 1980 and Stephen Hawking's *Brief History of Time* in 1988. The success of *Cosmos* led to Sagan receiving a $2 million advance for his science fiction novel *Contact*, the largest advance up until that time for a work of fiction that had yet to be written (Lewenstein 2001).

Text table 7-1.
News followed by American public: 2000

Type of news	Percentage following very closely		
	All	Internet users	Non-Internet users
Crime	30	25	35
Health	29	26	31
Sports	27	28	25
Community	26	22	30
Religion	21	17	27
Local government	20	19	22
Science and technology	18	22	14
Washington news	17	17	17
Entertainment	14	14	17
International affairs	14	15	14
Business and finance	14	17	10
Consumer news	12	13	11
Culture and arts	10	11	8

NOTE: Responses are to the following question: Please tell me how closely you follow this type of news either in the newspaper, on television, or on radio: very closely, somewhat closely, not very closely, or not at all closely?

SOURCE: Pew Research Center for the People and the Press, "Internet Sapping Broadcast News Audience: Investors Now Go Online for Quotes, Advice," Biennial Media Consumption survey (Washington, DC, June 11, 2000). Available at <http://www.people-press.org/media00rpt.htm>.

Science & Engineering Indicators – 2002

research and engineering" was *very important*, and 44 percent said *somewhat important,* ranking this issue ahead of tax cuts (50 and 35 percent, respectively) and campaign finance reform (29 and 36 percent, respectively) (Research! America 2001). As in many other polls, however, education and Social Security/Medicare were ranked ahead of every other issue in terms of importance, with 85 and 72 percent, respectively, of those surveyed saying those two public agenda items were *very important*.

Most polls, especially those conducted during the 2000 presidential campaign, show education to be one of the public's top priorities (Gallup Poll Editors 2001). Thus, it is not surprising to see the NSF interest index score for local school issues jumping three points between 1999 and 2001 from 71 to 74, displacing environmental pollution as the public's second highest priority (after new medical discoveries).

Sex as an Indicator of Interest in S&T Issues

Men express more interest than women in new scientific discoveries and the use of new inventions and technologies. (See figure 7-2.) The 9-point gap is particularly large for the latter but smaller than the 14-point gap for space exploration. Men also express more interest than women in economic and business conditions, military and defense policy, and international and foreign policy. Women are more interested than men in new medical discoveries and local school issues; the differences are 11 and 10 points, respectively. (See appendix table 7-3.)

Level of Education as an Indicator of Interest in S&T Issues

Level of formal education and number of mathematics and science courses completed are associated with interest in new scientific discoveries and the use of new inventions and technologies. (See figure 7-2 and appendix table 7-3.) A relationship also exists between education and level of interest in international and foreign policy, space exploration, and economic issues and business conditions. There does not seem to be a relationship between education and level of interest in new medical discoveries, military and defense policy, or environmental pollution. (See appendix table 7-3.)

In addition, people who have college degrees follow S&T stories more closely than those who do not. For example, in the July 2000 Pew Research Center survey, 25 percent of those who had college degrees said they were closely following the human genome announcement. Among those who did not have college degrees, fewer than 12 percent were closely following the story. In contrast, during the same month, 23 percent of the latter group said they were closely following the story about the Philadelphia police beating a carjacking suspect. Only 16 percent of those who had college degrees claimed to be following that story very closely (Pew Research Center for the People and the Press 2000c).

Data for the United Kingdom

Although comparable data for the European Union, Japan, and Canada have not been collected since the late 1980s or early 1990s (these data were included in previous editions of *Indicators*), several items used in the U.S. survey were replicated in a 2000 survey of U.K. residents (Office of Science and Technology and The Wellcome Trust 2000). The data show that British residents express less interest than their counter-

Leading News Stories of 2000

Few science or technology stories attract much public interest. According to the Pew Research Center's surveys, which track public interest in specific domestic and international news stories, the leading science-related news story of 2000 was the announcement that scientists had completed mapping the human genome (Pew Research Center for the People and the Press 2000c). However, only 16 percent of those interviewed reported that they were following this story very closely. In contrast, 61 percent said they were closely following the recent increase in gas prices, putting that issue at the top of the list of leading news stories of 2000, followed by the terrorist attack on the USS Cole, at 44 percent.* Rounding out the top 10, at number 10, was the Super Bowl; 31 percent of those surveyed reported they were closely following that story, nearly twice as many as the number who said they were closely following the human genome story.

The Federal court ruling ordering the breakup of Microsoft (since overturned) attracted almost as much interest as the Super Bowl story; 28 percent said they were closely following the Microsoft story.† However, this news may have been more of a business story than a technology story, although a case can be made that the court decision will have a major effect on innovation in the software industry. The Microsoft case spotlights an issue that has long been a fertile subject for study and debate among economists, which is the effect of antitrust policy on innovation.

Death and/or destruction usually lead Pew's list of the top 10 stories each year (although 2000 was somewhat of an exception). In fact, most of the science-related stories on the list of the most closely followed stories of the past 15 years are about natural disasters, e.g., earthquakes, floods, and other weather-related stories. Only about 2 percent of the 776 stories on the list are about scientific breakthroughs, research, and exploration (Pew Research Center for the People and the Press 2000d).

*Although the increase in gas prices received less press coverage than the election, this story hits closer to home for most people. This is the highest recorded interest in gas prices since the Persian Gulf War in 1990.

†According to a Gallup poll, although about half the public believes Microsoft is a monopoly, most people do not think the company should be broken up (Moore 2001).

parts in the United States in new medical discoveries, environmental issues, new inventions and technologies, and new scientific discoveries. (See text table 7-2.)

In addition, U.K. survey participants were asked to rate (on a 5-point scale) their interest in, and to assess the benefits of, 11 disciplines or technologies. Rankings by level of interest and perceived benefits were similar. For example: Two health-related items, new medicines and heart and other transplants, were at the top of both lists: 35 and 28 percent, respectively, of the respondents said they were *very interested* in these topics. Respondents were also most likely to judge these items as beneficial; 61 and 56 percent, respectively, categorized them as *very beneficial*.

Ranking next in terms of both interest and perceived benefits were research into climate change as well as computing and the Internet (both with 20 percent *very interested* and 29 percent *very beneficial* responses). Respondents also saw telecommunications as being highly beneficial. In addition to the 28 percent who judged these technologies as being very beneficial, another 52 percent gave this item a "4" on the 5-point scale, placing it just behind new medicines and heart and other transplants in terms of the total percentage scoring this category beneficial. However, only 16 percent of the respondents said they were very interested in telecommunications. New and faster methods of transportation rounded out the top six categories.

Five items received the lowest scores under both criteria. In order of perceived benefits were human fertility testing, new methods of food production and manufacture, space research and astronomy, genetic testing, and cloning. Respondents expressed more interest, however, in space and food than in the other biology-related categories.

The Public's Sense of Being Well Informed about S&T Issues

In general, most Americans feel that they are not well informed about S&T issues. In fact, for all issues included in the 2001 NSF survey, the level of feeling well informed was considerably lower than the level of expressed interest. For example, in the 2001 NSF survey, nearly half of the respondents said they were *very interested* in new developments in science and technology. Yet fewer than 15 percent of respondents described themselves as *very well informed* about new scientific discoveries and the use of new inventions and technologies; approximately 30 percent considered themselves *poorly informed*. (See appendix table 7-4.) Consequently, the corresponding index scores[7] were lower than the interest index scores for those same issues. (See figure 7-1.)

In 2001, three issues exhibited index scores in the 50s (local school issues, economic issues and business conditions, and new medical discoveries); two exhibited scores in the 40s (environmental pollution and issues about new scientific discoveries); and the other five exhibited scores in the 30s. (See appendix table 7-5.)

The NSF survey shows that people are feeling less informed than they used to. This downward trend is particularly noticeable for the five S&T-related issues included in the survey: between 1997 and 2001, index scores fell 5 or more points for four issues (new medical discoveries, new scientific discoveries, the use of new inventions and technologies, and space exploration) and 4 points for environmental pollution.

Sex as an Indicator of Feeling Well Informed About S&T Issues

Men were more likely than women to feel well informed about 6 of the 10 issues included in the 2001 NSF survey. By far the widest gap, 13 points, was in space exploration. Military and defense policy and economic issues and business conditions had gender gaps of 10 and 9 points, respectively. Other items (for example, issues about new scientific discoveries and international and foreign policy issues) had gender gaps of 7 or fewer points. (See appendix table 7-6.)

[7]Responses were converted to index scores ranging from 0 to 100 by assigning a value of 100 for a "very well informed" response, a value of 50 for a "moderately well informed" response, and a value of 0 for a "poorly informed" response. The values for each issue were then averaged to produce an index score reflecting the average level of feeling informed for the given issue.

Text table 7-2.
Interest in science-related topical issues, United States and United Kingdom: 2000/2001
(Percent)

	Very interested		Moderately interested		Not interested	
Issue	U.S.	U.K.	U.S.	U.K.	U.S.	U.K.
New medical discoveries	66	46	31	41	3	13
Environmental issues	50	35	43	47	7	17
New inventions and technologies	46	24	46	50	8	26
New scientific discoveries	50	22	45	49	6	28

NOTES: Data for United States collected in 2001; data for United Kingdom collected in 2000.

SOURCES: National Science Foundation, 2001 Survey of Public Attitudes Toward and Understanding of Science and Technology (Arlington, VA, 2001); Office of Science and Technology and The Wellcome Trust, "Science and the Public: A Review of Science Communication in the United Kingdom" (London, UK, March 2000).

In contrast, women were more likely than men to feel well informed about two issues in the survey: local school issues and new medical discoveries. For these issues, the disparity in index scores between the two sexes was 10 and 7 points, respectively.

Level of Education as an Indicator of Feeling Well Informed About S&T Issues

As expected, in general, the more education an individual has, and the more mathematics and science courses the individual has completed, the better informed that person believes he or she is. The relationship between education and feeling well informed is evident for new scientific discoveries, the use of new inventions and technologies, space exploration, economic issues and business conditions, and international and foreign policy issues, but not for the other issues in the survey. (See appendix table 7-6.)

The "Attentive Public" for S&T Issues

It may not be easy to pinpoint exactly the audience for issues pertaining to S&T policy. It is probably safe to say that members of the S&E workforce, especially those in the academic community, are interested in and well informed about various S&T policy issues. However, the number of members in this community is relatively small. (See chapter 3, "Science and Engineering Workforce," and chapter 5, "Academic Research and Development.")

In addition to scientists and engineers and those who work in science policy, other members of the public are interested in S&T and probably pay attention to news reports about new scientific discoveries and new inventions and technologies. Also, some people are attentive because a particular S&T-related issue or event is affecting their daily lives. This type of situation was portrayed in the popular movie *Erin Brockovich,* in which the main character, who was not a scientist or even well educated, embarked on a mission to learn everything she could about a scientific issue that was at the center of a court case. Although the science community took umbrage at the way scientific evidence was portrayed in the film (Kolata 2000), the movie illustrates how people become informed and attentive when their health and well-being are at stake.

Classifying the Public as Attentive, Interested, or Residual

It is important to identify the audience for S&T issues so that the attitudes of this group can be compared with those of everyone else. Therefore, it is useful to classify the public into three groups:

- The *attentive public* consists of those who (1) express a high level of interest in a particular issue; (2) feel very well informed about the issue; and (3) read a newspaper on a daily basis, read a weekly or monthly news magazine, or read a magazine relevant to the issue.[8]
- The *interested public* consists of those who claim to have a high level of interest in a particular issue but do not feel very well informed about it.
- The *residual public* consists of those who are neither interested in nor feel very well informed about a particular issue.

Given these criteria, there is an attentive public for every policy issue. The corresponding groups differ in size and composition. For example, data for 2001 showed that, for most issues covered by the NSF survey, fewer than 10 percent of the public could be considered attentive. Local school issues had, by far, the largest audience, followed by new medical discoveries, economic and business conditions, and environmental pollution. In 2001, 31, 14, 12, and 10 percent, respectively, of all survey respondents were classified as attentive to those subjects. (See appendix table 7-7.)

Identifying the Attentive Public for S&T Issues

People likely to be attentive to S&T issues are identified by combining the attentive public for new scientific discoveries with the attentive public for new inventions and technologies. In 2001, 10 percent of the population met the criteria, down from 14 percent in 1997. In 2001, 48 percent of the population could be classified as the interested public for S&T issues; the residual public constituted 42 percent of the total. (See appendix table 7-7.)

Sex and Level of Education as Identifiers of the Attentive Public for S&T Issues

Men were more likely than women to be attentive to S&T issues. (See figure 7-3 and appendix table 7-8.) In addition, a direct correlation exists between attentiveness to S&T issues, years of formal education, and the number of science and mathematics courses completed during high school and college. In 2001, only 3 percent of people lacking high school diplomas were classified as attentive to S&T issues, compared with 23 percent of those who had graduate and/or professional degrees. Similarly, 7 percent of those having limited coursework in science and mathematics were attentive to S&T issues compared with 18 percent of those who had completed nine or more high school and college courses in science or mathematics.

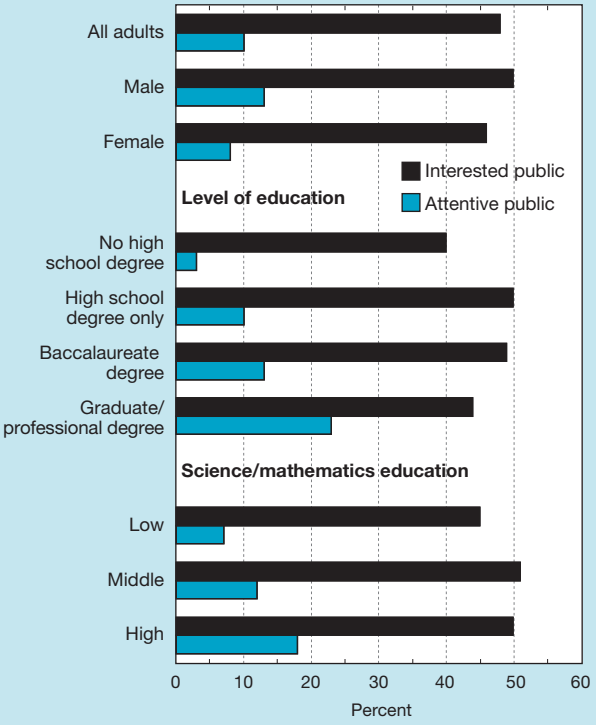
Public Understanding of S&T

Science literacy in the United States is fairly low.[9] The majority of the general public knows a little, but not a lot, about S&T. For example, most Americans know that Earth travels around the Sun and that light travels faster than sound. However, few can successfully define *molecule*. In addition, most Americans are unfamiliar with the scientific process.

[8]For a general discussion of the concept of issue attentiveness, see Miller, Pardo, and Niwa (1997).

[9]It is useful to draw a distinction between *science literacy* and *scientific literacy*. Science literacy refers to the possession of technical knowledge. In contrast, scientific literacy involves not simply knowing the facts but also thinking logically, drawing conclusions, and making decisions based on careful scrutiny and analysis of the facts (Maienschein 1999).

Figure 7-3.
Public attentiveness to science and technology issues, by sex and level of education: 2001



NOTES: "Attentive" public are people who (1) express high level of interest in a particular issue; (2) feel well informed about that issue, and (3) read a newspaper on a daily basis, read a weekly or monthly news magazine, or frequently read a magazine highly relevant to the issue. "Interested" public are people who express high level of interest in a particular issue but do not feel well informed about it. The attentive public for science and technology is a combination of the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Anyone who is not attentive to either of these issues, but who is a member of the interested public for at least one of these issues, is classified as a member of the interested public for science and technology. Survey respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college math/science courses. They were classified as "middle" if they took six to eight such courses, and "low" if they took five or fewer.

See appendix table 7-8. *Science & Engineering Indicators – 2002*

People who have knowledge of basic science facts, concepts, and vocabulary may have an easier time following news reports and participating in public discourse on various issues pertaining to S&T. Even more important than having basic knowledge may be an appreciation for the nature of scientific inquiry. Understanding how ideas are investigated and analyzed can be valuable for staying abreast of important issues, participating in the political process, and assessing the validity of other types of information. (See "Science Fiction and Pseudoscience.") According to a science journalist:

> Without a grasp of scientific ways of thinking, the average person cannot tell the difference between science based on real data and something that resembles science—at least in their eyes—but is based on uncontrolled experiments, anecdotal evidence, and passionate assertions…[W]hat makes science special is that evidence has to meet certain standards (Rensberger 2000, p. 61).

The NSF survey contains a series of questions designed to assess public knowledge and understanding of basic science concepts and terms. The survey includes 18 such questions: 13 true or false, 3 multiple choice, and 2 open-ended questions that asked respondents to define in their own words *DNA* and *molecule*. In addition, the survey includes questions designed to test public understanding of the scientific process, including knowledge of what it means to study something scientifically, how experiments are conducted, and probability.

Understanding Science Facts, Concepts, and Vocabulary

The percentage of correct responses to most of the NSF survey questions pertaining to basic science facts, concepts, and vocabulary has remained nearly constant. (See appendix table 7-9.) For example, more than 70 percent of those surveyed knew that:

- Plants produce oxygen.
- The continents have been moving for millions of years and will continue to move.
- Light travels faster than sound.
- Earth goes around the Sun (and not vice versa).
- Not all radioactivity is manmade.

In contrast, about half the respondents knew that:

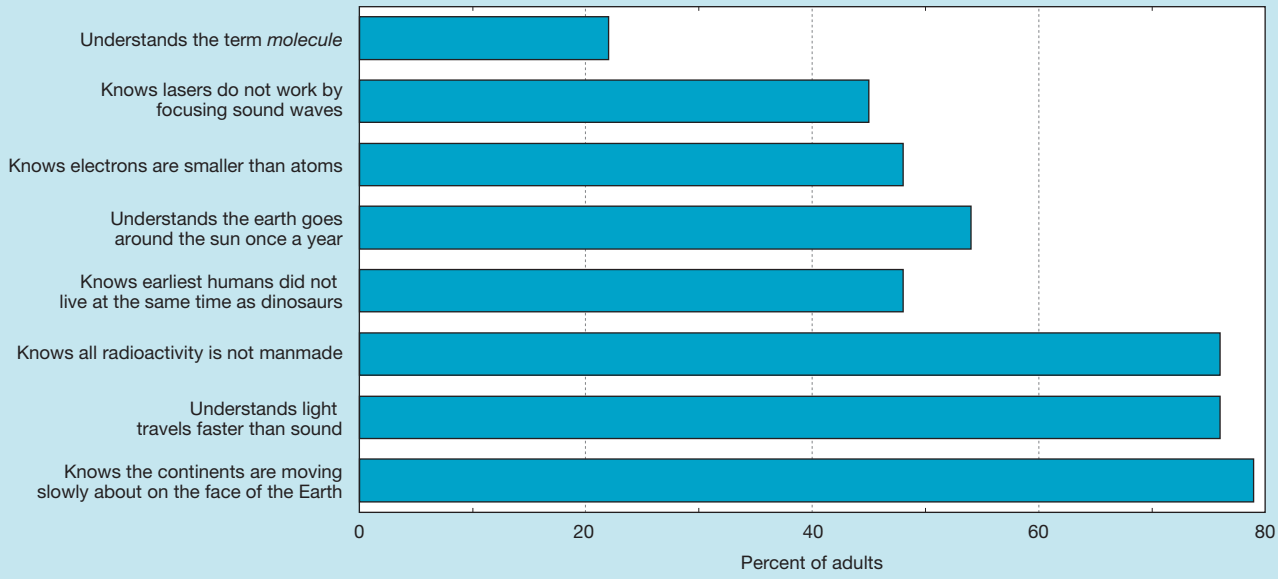
- The earliest humans did not live at the same time as dinosaurs.
- It takes Earth one year to go around the Sun.
- Electrons are smaller than atoms.
- Antibiotics do not kill viruses.
- Lasers do not work by focusing sound waves. (See figure 7-4 and appendix table 7-10.)

A strong, positive relationship exists between number of correctly answered questions and level of formal education, number of science and mathematics courses completed, and attentiveness to S&T. For example, those who did not complete high school answered an average of 50 percent of the questions correctly compared with scores of 63 percent for high school graduates, 77 percent for college graduates, and 80 percent for those who earned graduate or professional degrees. (See appendix table 7-9.)

In addition, only 22 percent of respondents were able to define *molecule*, and 45 percent gave an acceptable definition for *DNA*.[10] Although the percentage of correct responses

[10]These percentages are higher than those recorded in past NSF surveys. The increase may be attributable to a different technology being used to record responses to open-ended questions. For the first time, in 2001, respondents' answers were recorded on audiotape instead of being manually typed into a computer by the interviewer. Thus, the coders worked from sound files of actual responses rather than hand-typed text. Probably as a result of having more complete information from each respondent, more respondents were classified as having provided an acceptable definition of these terms. See Miller and Kimmel (2001) and Duffy, Muzzy, and Robb (2001).

Figure 7-4.
Public understanding of scientific terms and concepts: 2001



See appendix table 7-10.

Science & Engineering Indicators – 2002

to these questions was considerably lower than that for most of the short-answer questions, it is noteworthy that the percentage of correct responses increased in the late 1990s.

A higher percentage of men than women answered every question but three correctly. The gender gap was 20 or more points for four questions:

- Lasers work by focusing sound waves (61 percent of men compared with 30 percent of women).
- Light travels faster than sound (89 percent of men compared with 65 percent of women).
- Earth takes one year to go around the Sun (66 percent of men compared with 42 percent of women).
- Earth goes around the Sun and not vice versa (86 percent of men compared with 66 percent of women).

More women than men answered the following questions correctly:

- The father's gene decides whether the baby is a boy or a girl (72 percent of women compared with 58 percent of men).
- Antibiotics do not kill viruses (55 percent of women compared with 46 percent of men).

For the first time, a majority of all survey respondents answered the antibiotic question correctly (although a majority of men missed it). The growing resistance of bacteria to antibiotics has received widespread media coverage during the past few years. In identifying the main cause of the problem, the overprescribing of antibiotics, it is almost always mentioned that antibiotics are ineffective in killing viruses. In addition, parents of young children, especially those prone to ear infections, have been warned by their pediatricians about this problem. Although the message still has not reached a large segment of the population, the percentage of those answering correctly has been rising, from 40 percent in 1995 to 51 percent in 2001.

During most of the 20th century, probably the most contentious issue in science teaching has been whether evolution is taught or not taught in U.S. public school classrooms. The latest major dispute in this long-running battle was the Kansas State Board of Education's 1999 decision to delete evolution from the state's science standards. This event received widespread coverage in the press and sparked an outcry in the science community.[11] In addition, most of the public was not happy with the decision; 60 percent of Americans were opposed to the school board's action.[12] Moreover, most Kansans also felt the same way.[13] Thus, it was not too surprising when two board members who had voted for the change were defeated in the next election by candidates who supported the teaching of evolution. Subsequently, the reconstituted Kansas School Board reversed the decision.

The attention received by the Kansas controversy may be responsible for a change in response to the "evolution" question. For the first time, a majority of survey respondents an-

[11]The National Science Board issued a statement in August 1999 on the Kansas action (NSB 1999).

[12]According to the results of this survey (People for the American Way Foundation 2000), opponents of the school board action were more likely to be better educated, younger, and residents of the Northeast.

[13]In an October 1999 poll, sponsored by the *Kansas City Star* and the *Wichita Eagle* (1999), 52 percent of the participants disagreed with the Kansas State Board of Education's decision; 57 percent agreed with the statement: "Students in science classes in public schools should study and be tested on the idea of evolution, the theory that living creatures have common ancestors and have changed over time."

swered *true* to the statement "human beings, as we know them today, developed from earlier species of animals," representing a major change in response to this question[14] and bringing the United States more in line with other industrialized countries in response to this question (Gendall, Smith, and Russell 1995).

Gallup polls taken during the past 20 years consistently show a plurality (45 percent in February 2001) of Americans agreeing with the statement: "God created human beings pretty much in their present form at one time within the last 10,000 years or so" (Brooks 2001).

In addition, two-thirds of those surveyed (68 percent) favor teaching this belief (known as creationism) along with evolution in public schools, although 29 percent are opposed. However, 55 percent are opposed to teaching creationism *instead* of evolution (*Gallup News Service* 2000).

A study conducted for the People for the American Way Foundation took a closer look at the question of teaching evolution and found an overwhelming majority of Americans (83 percent) agreeing that it should be taught in the classroom. However, there is also strong support for teaching creationism. A detailed breakdown of the survey findings shows a wide range of opinion on the issue:

- 20 percent favor teaching only evolution and nothing else in public schools;
- 17 percent want only evolution taught in science classes but say that religious explanations can be discussed in other classes;
- 29 percent do not have a problem with creationism being discussed in science classes but believe it should be discussed as a "belief," not a scientific theory;
- 13 percent believe that both evolution and creationism should be taught as scientific theories in science class;
- 16 percent want no mention of evolution at all;
- 4 percent are in favor of teaching both evolution and creationism but are unsure about how to do it; and
- 1 percent have no opinion (People for American Way Foundation 2000).

Understanding the Scientific Process

The NSF survey also includes questions intended to determine how well the public understands the scientific process. Respondents are asked to explain what it means to study something scientifically.[15] In addition, respondents are asked questions pertaining to the experimental evaluation of a drug and about probability.[16]

In 2001, 33 percent of respondents provided good explanations of what it means to study something scientifically.[17] A large minority (43 percent) answered the experiment questions correctly, including the question(s) that focused on the use of control groups. A majority (57 percent) answered the four probability questions correctly. (See appendix table 7-11.)

A combination of each survey participant's responses to the three items is used to estimate his or her overall level of understanding of the scientific process. To be classified as "understanding the scientific process," a respondent must answer all the probability questions correctly and either provide a "theory testing" response to the question about what it means to study something scientifically or provide a correct response to the open-ended question by explaining why it is better to test a drug using a control group. In 2001, 30 percent of respondents met these criteria. (See footnote 10, figure 7-5, and appendix table 7-11.)

Public Attitudes Toward S&T, Scientific Research, Federal Funding of Scientific Research, and Specific Science-Related Issues

In general, Americans express highly favorable attitudes toward S&T. In 2001, overwhelming majorities of NSF survey respondents agreed with the following statements:

- "Science and technology are making our lives healthier, easier, and more comfortable." (86 percent agreed and 11 percent disagreed)
- "Most scientists want to work on things that will make life better for the average person." (89 percent agreed and 9 percent disagreed)
- "With the application of science and technology, work will become more interesting." (72 percent agreed and 23 percent disagreed)
- "Because of science and technology, there will be more opportunities for the next generation." (85 percent agreed and 14 percent disagreed) (See appendix table 7-12.)

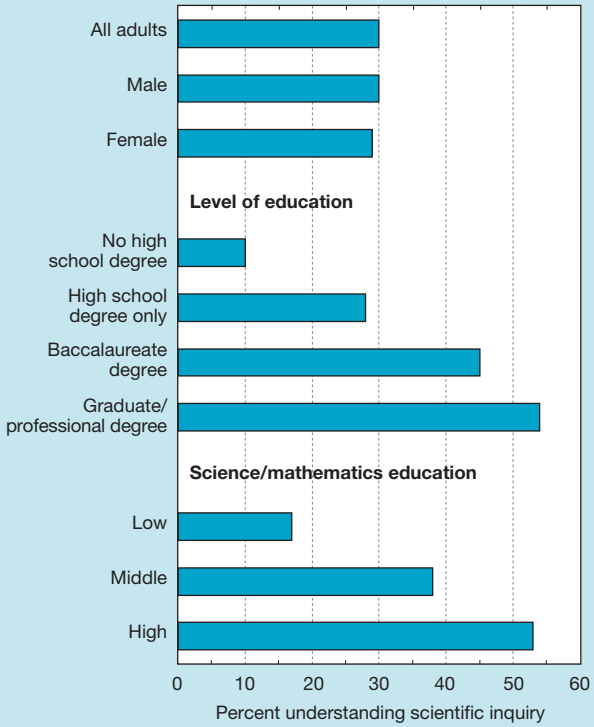
[14]For example, the comparable percentages for 1985, 1990, 1995, and 1999 were 45, 45, 44, and 45 percent, respectively.

[15] The question was: "When you read news stories, you see certain sets of words and terms. We are interested in how many people recognize certain kinds of terms, and I would like to ask you a few brief questions in that regard. First, some articles refer to the results of a scientific study. When you read or hear the term scientific study, do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?" If the response is "clear understanding" or "general sense": "In your own words, could you tell me what it means to study something scientifically?"

[16]The question pertaining to experimental evaluation was: "Now, please think of this situation. Two scientists want to know if a certain drug is effective in treating high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many 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 text of the probability question was: "Now think about this situation. 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 three children are healthy, the fourth will have the illness? Does this mean that if their first child has the illness, the next three will not? Does this mean that each of the couple's children will have the same risk of suffering from the illness? Does this mean that if they have only three children, none will have the illness?"

[17]Correct explanations of scientific study include responses describing scientific study as theory testing, experimentation, or rigorous, systematic comparison.

Figure 7-5.
Public understanding of nature of scientific inquiry: 2001



NOTE: Survey respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college math/science courses. They were classified as "middle" if they took six to eight such courses, and "low" if they took five or fewer.

See appendix tables 7-11. *Science & Engineering Indicators – 2002*

In addition, Americans seem to have more positive attitudes toward S&T than their counterparts in the United Kingdom and Japan.[18] (See text table 7-3.)

Despite these positive indicators, a sizable segment, although not a majority, of the public has some reservations concerning science and especially technology. For example, in 2001, approximately 50 percent of NSF survey respondents agreed with the following statement: "We depend too much on science and not enough on faith" (46 percent disagreed). In addition, 38 percent agreed with the statement: "Science makes our way of life change too fast" (59 percent disagreed). (See appendix table 7-12.)

Over time these percentages have remained nearly constant, with only slight variation from survey to survey. For example, since 1983, at least 80 percent of survey respondents have agreed that "science and technology are making our lives healthier, easier, and more comfortable." The percentages have ranged from 84 percent in 1983 and 1990 to 90 percent in 1999. Similarly, the percentage disagreeing that "we depend too much on science and not enough on faith" has ranged from 39 percent in 1985 to 48 percent in 1997. (See appendix table 7-13.)

In addition, an increasing number of people believe that the benefits of scientific research outweigh any harmful results. (See "Public Attitudes Toward Scientific Research.") The concerns that do exist are related to the effect of technology on society. For example, in 2001, a sizable minority, 44 percent, agreed with the statement that "people would do better by living a simpler life without so much technology." (See appendix table 7-14.) Also, about 30 percent of respondents agreed that "technological discoveries will eventually destroy the Earth" and that "technological development creates an artificial and inhumane way of living." (See appendix tables 7-15 and 7-16.)

The existence of public concern about the effect of technology on society does not negate the fact that the vast majority of Americans have highly favorable opinions of technology and are highly appreciative of the role of S&T in the history and economic success of the United States. Results from various surveys show the following:

- More than 90 percent think science and technology have been important "in establishing the United States' influence in the world" and "to America's economic success in the 20th century"; 60 percent think they have been very important. Also, 90 percent believe that science and technology have changed life during the past 100 years for the better, and more than 70 percent say they were more likely to vote for a candidate "who places a high priority on strengthening science and technology" (Bayer/NSF 2000).
- Eighty-nine percent think science and technology will play a major role "if life is going to be better in this country in the future (Pew Research Center for the People and the Press 1999a)." More people gave this response for science and technology than for any other item in the survey, including medical advances, which got the second highest vote of confidence. Also, the 89 percent statistic represents a substantial increase over the corresponding 77 percent recorded in the 1996 version of the survey.[19]
- Americans also believe that advancements in science and technology were the nation's and the government's greatest achievements during the 20th century. The space program tops the list of those achievements, followed by technology in general, and computers. More than 70 percent of those surveyed said that the invention of airline travel and television were a change for the better; more than 80 percent gave the same response for the highway system and computers; and more 90 percent put the automobile and radio in the "change-for-the-better" category.

[18]In a 1998 study conducted in Japan, 81 percent of those surveyed agreed that "advancements in science and technology are too rapid to keep up with," and 84 percent agreed that "science and technology can be abused or misused." The comparable percentages in 1995 were 54 and 78 percent, respectively. In addition, in 1998, only 58 percent agreed that there are more positive than negative aspects to science and technology (up from 52 percent in 1995) (Prime Minister's Office 1995; "Public Opinion Survey on Future Science and Technology" 2001).

[19]However, it should be noted that the percentage of people identifying "the pace of technological change" as a major threat to "our country's future well-being" rose from 29 percent in 1996 to 35 percent in 1999.

Text table 7-3.
International comparison of attitudes toward science and technology (S&T)

Attitude	Agree (percent) U.S. (2001)	U.K. (2000)	Japan (1995)
S&T are making our lives healthier, easier, and more comfortable.	86	67	51
In general, scientists want to make life better for the average person.	89[a]	67	45[b]
Because of S&T, there will be more opportunities for the next generation.	85	77	NA
We depend too much on science and not enough on faith	51	38	53
It is important to know about science in my daily life.	84[c]	59	71[c]
Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the Government.	82[d]	72	80
Science makes our lives change too fast.	38	44	NA
The benefits of science are greater than the harmful effects.	72	43	64[e]

[a]Phrased as, "Most scientists want to work on things that will make life better for the average person."

[b]Those disagreeing that "there are a lot of scientists who have no interest in either human beings or society."

[c]Only "disagree" data available.

[d]The U.S. question refers to support by the Federal Government.

[e]Those disagreeing with the statement, "I cannot find any value in the activities of scientists and engineers."

SOURCES: This table is reproduced from The Office of Science and Technology and The Wellcome Trust report, "Science and the Public: A Review of Science Communication in the United Kingdom" (London, UK, March 2000). U.S. data have been updated from the National Science Foundation, 2001 Survey of Public Attitudes Toward and Understanding of Science and Technology (Arlington, VA, 2001).

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The only technologies not receiving strong public endorsement were nuclear energy and nuclear weapons. Among technologies introduced in the past decade, Americans are the most enthusiastic about communication technologies, such as email, the Internet, cellular phones, and cable TV, and the least enthusiastic about fertility drugs, Prozac, Viagra, and the cloning of sheep (Pew Research Center for the People and the Press 1999b).

♦ Eighty-seven percent agree that "technology in general makes a positive contribution to society"; only 3 percent think that it makes a negative contribution (American Association of Engineering Societies 1998).

Trends in Attitudes Toward S&T

To track trends in public attitudes toward S&T, an Index of Scientific Promise and an Index of Scientific Reservations were developed.[20] In addition, the ratio of the Promise Index to the Reservations Index is a useful indicator of current and changing attitudes toward S&T. The ratio fell from 1.46 in 1999 to 1.30 in 2001 largely because of a decline in the Index of Scientific Promise. Thus, although people still have highly positive attitudes toward S&T, their attitudes may have been somewhat less positive in 2001 than they were two years earlier. The change occurred across all education groups and among both sexes. (See appendix table 7-17.)

Public Attitudes Toward Scientific Research

An overwhelming majority of Americans consistently believe that the benefits of scientific research outweigh any harmful results. In 2001, 47 percent of NSF survey respondents said that the benefits *strongly* outweighed the harms, and 25 percent said that the benefits *slightly* outweighed the harms. These percentages have remained nearly constant during the past two

[20]The Index of Scientific Promise and the Index of Scientific Reservation are factor scores converted to a 0–100 scale. The Index of Scientific Promise includes agreement/disagreement responses to the following survey items: "science and technology are making our lives healthier, easier, and more comfortable"; "most scientists want to work on things that will make life better for the average person"; "with the application of science and new technology, work will become more interesting"; and "because of science and technology, there will be more opportunities for the next generation." The Index of Scientific Reservation includes agreement/disagreement responses to the following survey items: "we depend too much on science and not enough on faith"; "it is not important for me to know about science in my daily life"; and "science makes our way of life change too fast." A factor analysis verified the existence of a two-factor structure. The lowest possible factor score (strong disagreement with all of the items) was set to 0, and the highest possible factor score (strong agreement with all of the items) was set to 100. All factor scores between the highest and the lowest were placed on the 0–100 scale accordingly.

decades, as has the percentage of respondents taking the opposite view that the harms outweigh the benefits. However, the most recent data show the latter (which had been in the teens for most of the past two decades) declining from 15 percent in 1999 to 10 percent in 2001. Concurrently, the percentage of respondents saying the benefits were *equal* to the harmful results increased from 11 percent in 1999 to 19 percent in 2001. (See figure 7-6 and appendix table 7-18.)

Men express greater confidence than women that the benefits of scientific research outweigh the harmful results. About three-fourths of the men, compared with approximately two-thirds of the women, agreed that the benefits outweighed the harms. Level of education is also strongly associated with a positive response to this question. Those who did not complete high school were less likely than those with more formal education to believe that the benefits outweighed the harms, although it should be noted that even 55 percent of this group said the benefits outweighed the harms. The corresponding percentages for high school graduates and for those having at least a bachelor's degree were 70 and 87 percent, respectively. (See appendix table 7-18.)

Public Attitudes Toward Federal Funding of Scientific Research

All indicators point to widespread support for government funding of basic research. In 2001, 81 percent of NSF survey respondents agreed with the following statement: "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."[21] (See appendix table 7-19.) The level of agreement with this statement has consistently been in the 80-percent range. In 2000, 72 percent of U. K. residents agreed with the statement, as did 80 percent of Japanese residents (in 1995). (See text table 7-3.)

If the stability and lack of variation of this measure of public support for basic research are noteworthy, so is the consistently small number of people who have the opposite viewpoint. In 2001, 16 percent disagreed with the statement; the same level of disagreement had been recorded two years earlier. (See appendix table 7-20.)

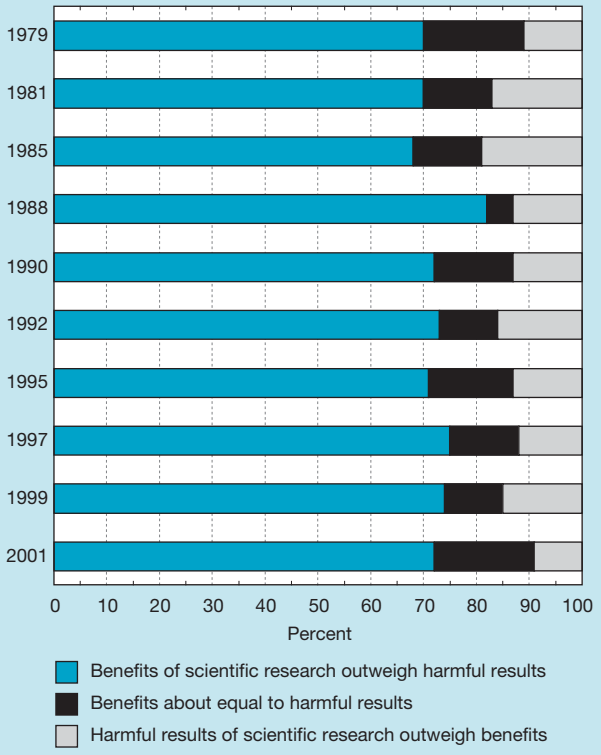
Although there is strong evidence that the public supports the government's investment in basic research, few Americans are able to name the two agencies that provide most of the Federal funds for this type of research. In a recent survey, only 5 percent identified the National Institutes of Health (NIH) as the agency that "funds most of the taxpayer-supported medical research performed in the United States," and only 3 percent named NSF as "the government agency that funds most of the basic research and educational programming in the sciences, mathematics and engineering." (Research!America 2001).[22]

In addition, those with more positive attitudes toward S&T were more likely to express support for government funding of basic research. In 2001, 93 percent of those who scored 75 or higher on the Index of Scientific Promise agreed that the Federal Government should fund basic scientific research compared with only 68 percent of those with relatively low index scores. (See figure 7-7 and appendix table 7-20.)

In 2001, only 14 percent of NSF survey respondents thought the government was spending too much on scientific research; 36 percent thought the government was not spending enough, a percentage that has grown steadily since 1990, when 30 percent chose that answer.[23] (See appendix table 7-21.) Men are more than likely than women to say the government is spending too little in support of scientific research (40 versus 33 percent in 2001). (See appendix table 7-22.)

To put the response to this item in perspective, at least 65 percent of those surveyed thought the government was not spending enough on other programs, including programs to improve health care, help senior citizens, improve education, and reduce pollution. Only the issues *space exploration* and *national defense* received less support for increased spending than scientific research.

Figure 7-6.
Public assessment of scientific research: 1979–2001



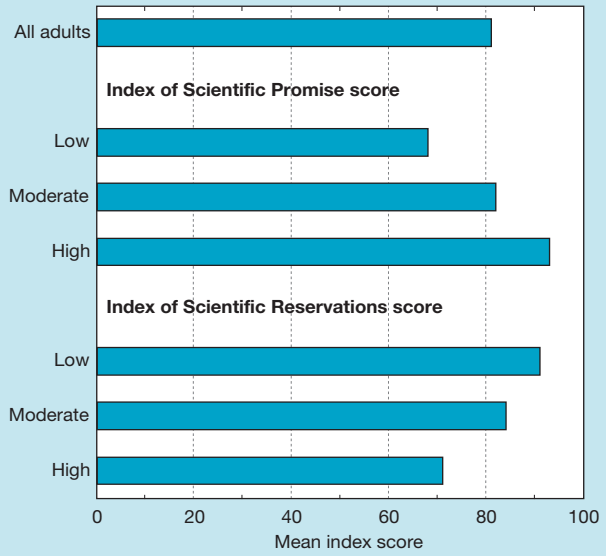
See appendix table 7-18. *Science & Engineering Indicators – 2002*

[21]Another recent poll used almost identical wording and produced a similar result: 78 percent of those surveyed agreed with the statement, 19 percent disagreed, and 3 percent were not sure. In the same poll, 86 percent felt that it was very important that the United States maintain its leadership in scientific research (Research!America 2001).

[22]In the same survey, 64 percent could name the FDA (Food and Drug Administration) and 22 percent knew the name of the CDC (Centers for Disease Control and Prevention) (Research!America 2001).

[23]In a another survey, 41 percent of respondents said they would increase spending on scientific research if they were making up the budget for the federal government; 10 percent said they would decrease spending; and 46 percent said they would keep it the same (Pew Research Center for the People and the Press 2001).

Figure 7-7.
Support for Federal governmental funding of basic scientific research, by level of general support for or reservations about science and technology: 2001



See appendix table 7-20. *Science & Engineering Indicators – 2002*

In 2001, 48 percent of those surveyed thought spending on space exploration was excessive, the highest percentage for any item in the survey—and nearly double the number of those who felt that the government was spending too much on national defense.[24] In contrast, the latter has been falling steadily, from 40 percent in 1990 to 25 percent in 2001. (See appendix table 7-21 and "Public Attitudes Toward Space Exploration.")

Sex as an Indicator of Support for Federal Funding of Scientific Research

Men express more support for Federal funding of scientific research than women. The most recent data show that 86 percent of men and 77 percent of women who responded to the survey agreed that the Federal Government should support basic research. (See appendix table 7-19.)

Level of Education as an Indicator of Support for Federal Funding of Scientific Research

Support for federally funded basic research is tied to education level. In 2001, about 80 percent of those surveyed who had not completed college agreed that the Federal Government should support scientific research compared with about 90 percent of those who had completed college. (See appendix table 7-19.)

[24]CNN/USA Today/Gallup polls show Americans having generally positive views of NASA but little interest in increasing the agency's budget. In December 1999, 16 percent of those surveyed thought NASA's funding should be increased, 49 percent thought it should remain at the current level, and 24 percent thought it should be reduced. In addition, 10 percent thought that funding for the space program should be eliminated entirely. Since Gallup began surveying the public about this subject (in 1984), no more than a quarter of those surveyed have favored an increase in NASA's budget (Carlson 2001).

Public Attitudes Toward Specific Science-Related Issues

Public Attitudes Toward Genetic Engineering

There is no question that genetic engineering has become a hot issue. From the nationwide recall of taco shells containing an unapproved form of genetically modified corn to scientists promising to clone humans in the not-too-distant future, genetic engineering has been the source of a growing number of concerns in recent years. Americans, like their counterparts in other countries, have been trying to understand and weigh the risks and benefits of this issue. In the case of agricultural products, the benefits of expanded yields, reduced perishability, and decreased need for chemical pesticides have been counterbalanced by perceived health and environmental risks and a threat to consumers' ability to make choices about what they eat (Hopkin 2001).

The conventional wisdom that biotechnology[25] is not a contentious issue, including the assumption that opposition is limited to an extremist "fringe," may no longer be true (Priest 2000). The battle for the hearts and minds of the American public is certainly under way:

- Media coverage of agricultural biotechnology increased more than eightfold between 1997 and 2000 (Shanahan, Scheufele, and Lee 2001).
- The PBS documentary series *Frontline* produced "Harvest of Fear," a two-hour special on the subject that aired in April 2001. (See <http://www.pbs.org/wgbh/harvest>.)
- The Biotechnology Association of America spent $7.5 million on political advertising in 2000, more than any other special interest group except one (Goldstein 2001).

Despite the exposure of this issue in the media, the most recent data show that 70 percent of the public consider themselves "not very well informed" or "not informed at all" about modern biotechnology; the corresponding statistic for Europeans is 80 percent (Priest 2000, Gaskell et al. 2000). Available data, however, indicate that awareness is increasing (Shanahan, Scheufele, and Lee 2001).

Even though most people do not consider themselves well informed about biotechnology, there is no shortage of researchers studying public opinion, including an international effort to compare attitudes in the United States, Europe, and Canada (Gaskell and Bauer 2001).[26] In the 2000 U.S. survey, participants were asked to assess six biotechnology applications, which are listed here in rank order from the one receiving the least opposition to the one receiving the most: genetic testing for inherited disease, engineering of bacteria to pro-

[25]Throughout this chapter, the terms *genetic engineering* and *biotechnology* are used interchangeably. A distinction is maintained only to reflect the specific term used in a particular survey and/or by a particular author.

[26]The 1997 U.S. survey was conducted by Jon D. Miller, Chicago Academy of Sciences, and the 2000 U.S. survey was conducted by Susanna Priest, Texas A&M University. The 1996 and 1999 Canadian surveys were conducted by Edna Einsiedel, University of Calgary. The 1997 and 1999 European studies were undertaken by George Gaskell, Martin Bauer, and Nick Alum for the European Commission.

duce pharmaceuticals, genetic engineering of pest-resistant crops, food biotechnology, organ transplants, and animal cloning. In the European survey, genetically modified (GM) food received more negative responses than any other application. (See sidebar "Public Attitudes Toward Biotechnology.")

The 2001 and earlier NSF surveys suggest that the American public is somewhat ambivalent about genetic engineering. Although the evidence is not entirely conclusive, the NSF surveys show the following:

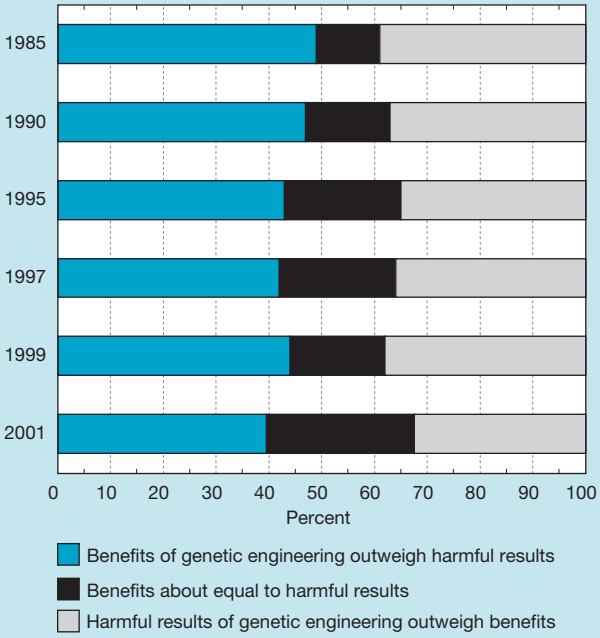
- Support for genetic engineering has never been very high. That is, in no year has a majority of respondents agreed that the benefits outweigh the harmful results.
- Support for genetic engineering has gradually declined during the past 15 years. In 2001, 40 percent of those surveyed thought the benefits outweighed the harms, down from 49 percent in 1985.

The ambiguity in the survey results becomes apparent when one looks at the data on the number of people who think the harms outweigh the benefits. This statistic has also declined in most years, from 39 percent in 1985 to 33 percent in 2001. Consequently, the declining numbers in both the benefits-greater-than-harms and harms-greater-than-benefits categories was offset by a growing number of respondents who think the benefits are equal to the harms. The percentage in this group grew from 12 percent in 1985 to 28 percent in 2001.[27] (See figure 7-8 and appendix table 7-23.)

Men have always had more favorable attitudes than women toward genetic engineering. The gender gap has usually been at least 10 points. In 2001, 45 percent of men and 34 percent of women responding to the survey said that the benefits of genetic engineering outweighed the harmful results. (See appendix table 7-23.)

College graduates are more likely than high school graduates to tout the benefits of genetic engineering. That is, they are both more likely than others to believe that the benefits are greater than the harms and less likely to say that the harms outweigh the benefits.[28] In 2001, 48 percent of survey respondents who had earned college degrees agreed that the benefits outweighed the harms compared with 37 percent of those who had earned only high school degrees and 39 percent of those who had not graduated from high school. Also, 25 percent of the college graduates thought the harms outweighed the benefits compared with 36 percent of high school graduates. The drop in support for genetic engineering during the past 15 years occurred among both high school and college graduates.

Figure 7-8.
Public assessment of genetic engineering: 1985–2001



See appendix table 7-23. *Science & Engineering Indicators – 2002*

Until 2001, the majority (at least 60 percent) of people classified as attentive to science and technology (who may or may not be college graduates) agreed that the benefits of genetic engineering outweighed the harmful results. This statistic dropped from 64 percent in 1999 to 49 percent in 2001. In addition, there was a substantial increase in those saying the harmful results outweighed the benefits, from 20 percent in 1995 to 30 percent in 2001.

Public Attitudes Toward Space Exploration

Public support for space exploration rose during the 1990s, then slipped in 2001. The most recent data show 45 percent of the public agreeing that the benefits of space exploration outweigh the costs, down from 49 percent in 1999. Not since 1985 (before the *Challenger* accident), have more than 50 percent of respondents to NSF's public attitudes survey stated that the benefits of the space program exceeded the costs. The drop in support during the mid-1980s, from 54 percent in 1985 to 47 percent three years later, was particularly dramatic. NSF survey data suggest that most of the public is having difficulty recognizing the benefits of the space pro-

[27]Other researchers have noted that survey participants "have seen more and more risks in agricultural biotechnology as time goes by" and that "the use of biotechnology or genetic modification in food production seems much more acceptable to the public when it is used to enhance food safety than when it is used to improve food quality" (Shanahan, Scheufele, and Lee 2001). In response to one survey, the percentage of people who said that biotechnology would provide benefits for themselves and their families within the next five years fell from 78 percent in March 1997 to 63 percent in October 1999, and 59 percent in May 2000. However, this statistic rose to 64 percent in January 2001 (International Food Information Council 2000). In response to yet another survey, conducted in July 2001, 30 percent of those surveyed thought that foods that have been produced using biotechnology pose a serious health hazard to consumers. The same survey showed that 52 percent of respondents supported the use of biotechnology in agriculture and food production; surveys conducted in 2000 and 1999 produced similar statistics—48 and 51 percent, respectively (Saad 2001).

[28]Another survey produced similar findings (for food biotechnology)—those who did not complete college were less likely than those with college and postgraduate degrees to support biotechnology in food production. For example, 65 percent of those with graduate degrees reported that they supported the technology compared with 59 percent of those with just college degrees, 54 percent of those with some college, and 44 percent of those who had never attended college (Saad 2001).

Public Attitudes Toward Biotechnology

Anti-biotechnology sentiments are much more common in Europe than in the United States.* In addition, the number of people harboring negative attitudes toward biotechnology has increased in both Europe and Canada during the past few years, especially when compared with attitudes in the United States. These are the latest findings from a recent international study conducted in the United States, Europe, and Canada (Gaskell and Bauer 2001; Miller et al. 1999).**

Assessment of Selected Biotechnology Applications

The 1999 and 2000 surveys, which replicate earlier ones conducted in 1996 and 1997, asked respondents to assess the usefulness, risk, and moral acceptability of several applications of biotechnology and to indicate whether they would encourage the use of each application.

Two sets of questions pertained to agricultural applications of biotechnology, including genetic engineering of:

- foods, for example, to make them higher in protein, increase their shelf-life, or improve their taste, and
- crops, for example, to make them more resistant to insect pests.

The three surveys show that Europeans have the least favorable attitudes toward these applications and Americans have the most favorable attitudes, with Canadians placing somewhere in between. For example, in 2001:

- 46 percent of Europeans agreed that genetically modified (GM) food was useful, compared with 57 percent of Canadians and 69 percent of Americans;
- 60 percent of the Europeans agreed that GM food was risky; the corresponding percentages for Canadians and Americans were 58 and 49 percent, respectively;
- only 40 percent of Europeans said that GM food was morally acceptable compared with 55 percent of Canadians and 60 percent of Americans; and
- only 34 percent of Europeans would encourage the production of GM food compared with 48 percent of Canadians and 58 percent of Americans.†

The pattern of responses was similar for attitudes toward GM crops and other plants, although the results reflected somewhat more support for this application of biotechnology. (See figure 7-9.)

What is particularly noteworthy about these data is that they indicate a dramatic drop in support in both Europe and Canada since the surveys were conducted in 1996. In contrast, attitudes in the United States toward GM foods are almost identical to those in 1997, with one slight exception: the proportion of U.S. survey respondents agreeing that GM foods are morally acceptable dropped from 65 percent to 60 percent between 1997 and 2000.‡ Consequently:

- the gap in attitudes between Europeans and Americans, which was not particularly large in the mid-1990s, is now quite wide, and
- Canadians and Americans, who used to harbor similar attitudes, no longer do so; Canadian attitudes now more closely resemble those of Europeans.

The international study included questions pertaining to the following medical applications of biotechnology:

- introducing human genes into bacteria to produce medicines or vaccines (for example, to produce insulin for diabetics), and
- using genetic testing to detect inherited diseases.

Attitudes toward these two medical applications in all three regions were more positive than those for the two agricultural applications. For example, more than 80 percent of Americans and Canadians and 70 percent of Europeans agreed that introducing human genes into bacteria to produce medicines or vaccines was useful. Similarly, at least 75 percent of Americans and Canadians and almost 60 percent of Europeans thought this application was morally acceptable and should be encouraged. However, a pattern similar to that for the agricultural applications should be noted. Between 1997 and 2000, U.S. support for introducing human genes into bacteria to produce medicines and vaccines remained strong while Eu-

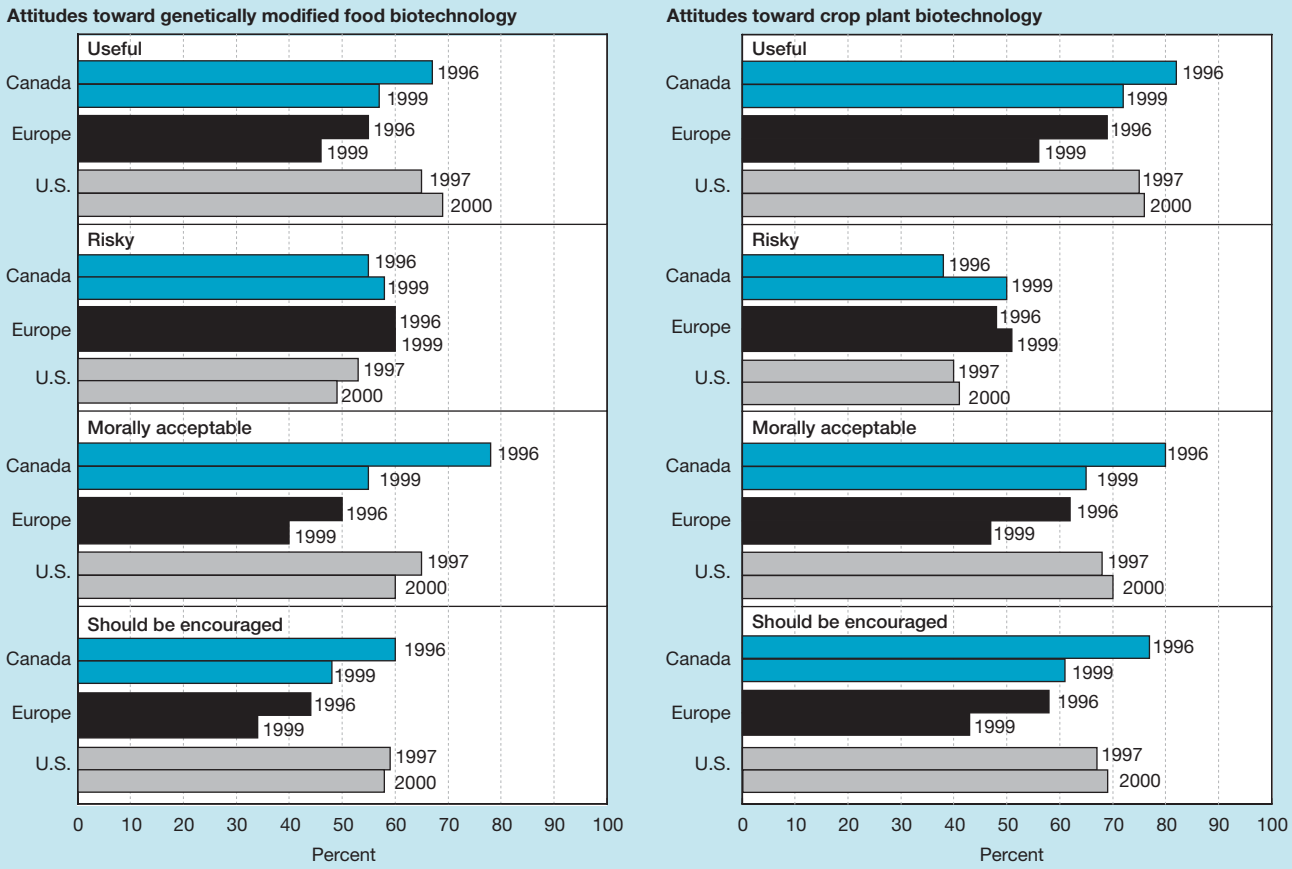
*In the view of a longtime observer of European culture and politics, Europeans seem to be more fearful than Americans of perceived health risks associated with new technologies. Concerns that seem to cause much more consternation in Europe than in the United States—in addition to those about genetically modified organisms (GMOs)—are pork and beef raised with growth hormones; phthalates in plastic toys; measles, mumps, and rubella vaccine; cellular phones; and "economy-class syndrome." The recent experience with bovine spongiform encephalopathy (BSE) or "mad cow" disease, a real health risk, seems to have affected trust in the rest of the food supply, especially anything resulting from new technologies such as GMOs. In addition, there is also an anti-American aspect to the situation. Because American companies are the source of many of the new technologies: "[T]he negative response may tie in with the aversion to globalization among the working class and the anti-Americanism that is never far from the surface among Europe's intelligentsia. People think GMO crops…all come from the U.S." (Reid 2001).

**Seventeen countries were included in the European study, and it should be noted that negative attitudes were more prevalent in some countries than others. (See Gaskell and Bauer 2001.)

†In response to the 2001 NSF survey, 61 percent said that they supported GM food production; 36 percent said that they were opposed. Men (70 percent), college graduates (68 percent), and those classified as attentive to science and technology were more likely than others to favor this application of biotechnology. (See appendix table 7-24.)

‡The 2000 U.S. survey showed that genetically engineered food was of less concern to those surveyed than all other areas of food-related concern, such as bacterial contamination, the use of artificial preservatives, poor nutritional quality, the use of chemical pesticides, diseases from animals that pass to humans, and general food safety (Priest 2000).

Figure 7-9.
Attitudes toward genetically modified food and crop biotechnologies in Canada, Europe, and the United States



SOURCES: Gaskell, G., and Bauer, M.W. (editors) *Biotechnology 1996–2000,* National Museum of Science and Industry (U.K.) and Michigan State University Press. The 1999 and 2000 surveys were conducted by George Gaskell, Martin Bauer, and Nick Alum for the European Commission; Susanna Priest, Texas A&M University; and Edna Einsiedel, University of Calgary. The 1997 U.S. survey was conducted by Jon D. Miller, Chicago Academy of Sciences.

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ropean and Canadian support declined. (See figure 7-10.)

Using genetic testing to detect inherited diseases has the most support across all three regions. For example, at least 80 percent of those surveyed in Canada and the United States agreed that this application was useful and its use should be encouraged.* Moreover, support increased in recent years in both countries. In contrast, it fell in Europe during the same period. In other words, although the residents of all three regions shared similar (highly supportive) sentiments in 1996 and 1997, that is no longer the case. In 1999, 74 percent of Europeans agreed that genetic testing was useful, down from 83 percent in 1996. In addition, 65 percent of Europeans said its use should be encouraged, down from 76 percent in 1996. (See figure 7-10.)

The 1999/2000 surveys also asked respondents in all three regions to assess the usefulness, risk, and moral acceptability of "cloning animals such as sheep whose milk can be used to make drugs and vaccines." Nearly half (47 percent) of European respondents agreed this that application was useful compared with 57 percent of Canadians and 61 percent of Americans. Similarly, only 36 percent of Europeans thought that this application was morally acceptable and would encourage its use, compared with just less than 50 percent of Americans and Canadians.† However, more Americans and Canadians (58 and 61 percent, respectively) than Europeans (54 percent) assigned risk to the use of this application.

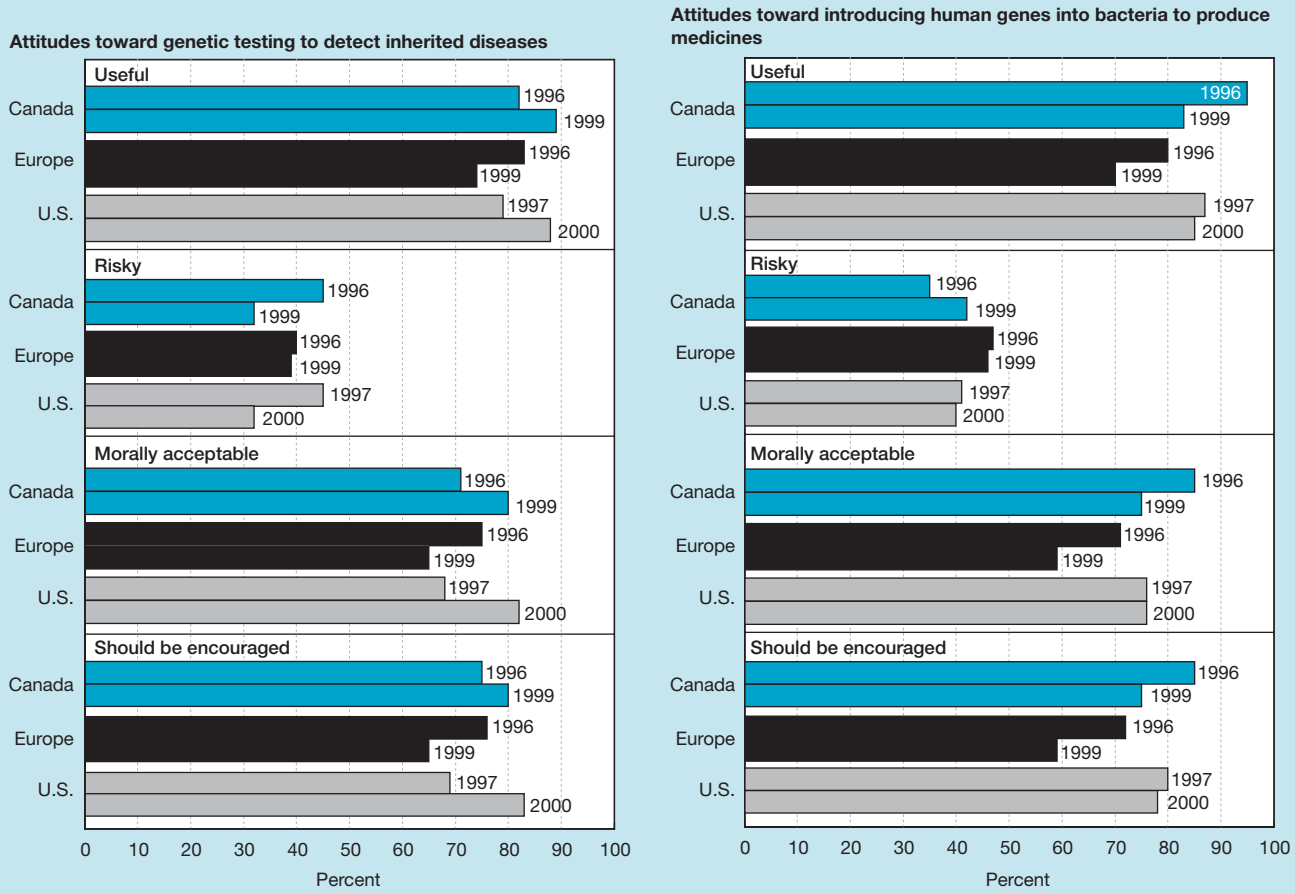
In response to a Gallup poll, 90 percent of those surveyed opposed human cloning and 64 percent opposed animal cloning (Carroll 2001). Support for animal cloning varied by education, income, sex, age, and religion. For example:

- A majority (56 percent) of those having postgraduate education and 52 percent of those having annual in-

*In response to the 2001 NSF survey, 89 percent said that they supported genetic testing to detect inherited diseases; 9 percent were opposed. (See appendix table 7-24.)

†In response to the 2001 NSF survey, 47 percent said that they supported cloning animals; 48 percent were opposed. (See appendix table 7-24.)

Figure 7-10.
Attitudes toward genetic testing and medicine production in Canada, Europe, and the United States



SOURCES: Gaskell, G., and Bauer, M.W. (editors) *Biotechnology 1996–2000,* National Museum of Science and Industry (U.K.) and Michigan State University Press. The 1999 and 2000 surveys were conducted by George Gaskell, Martin Bauer, and Nick Alum for the European Commission; Susanna Priest, Texas A&M University; and Edna Einsiedel, University of Calgary. The 1997 U.S. survey was conducted by Jon D. Miller, Chicago Academy of Sciences.

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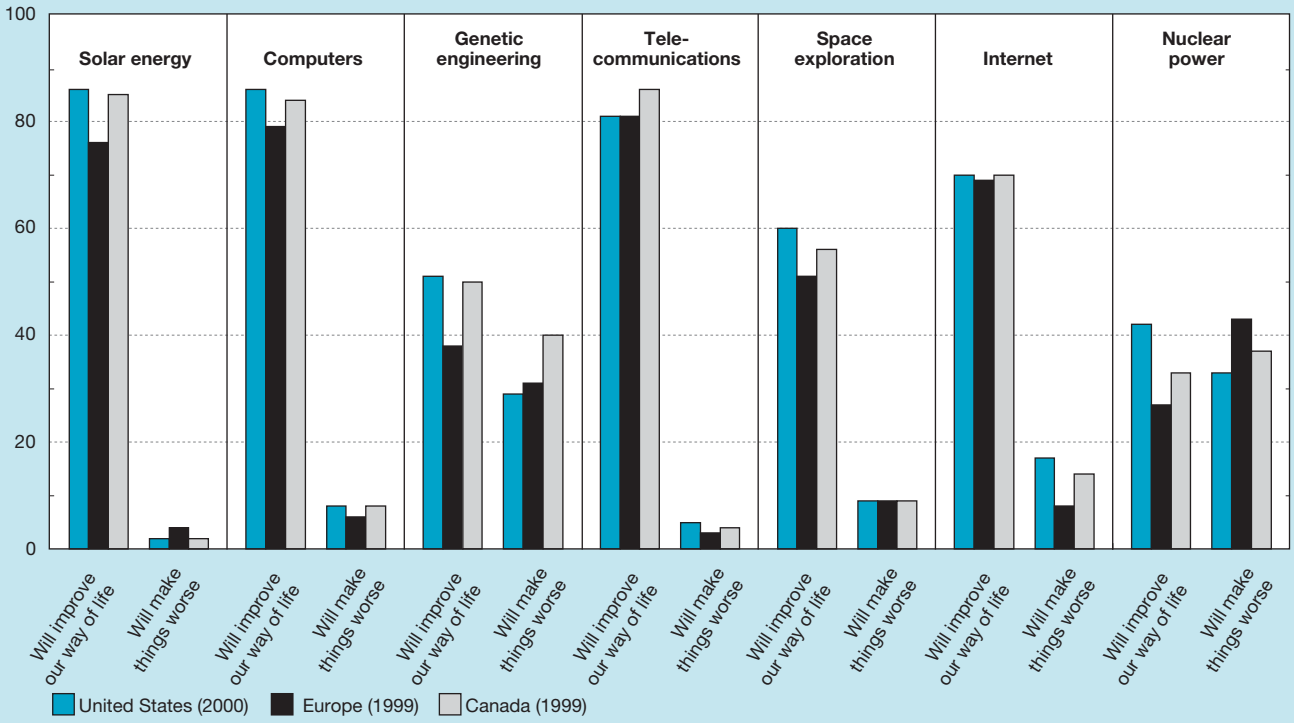
comes above $75,000 said that cloning animals should be allowed. Only 19 percent of those having a high school education or less and 14 percent of those earning less than $20,000 annually shared the same view.

- Seventy-four percent of women but only 53 percent of men opposed animal cloning.
- Seventy-eight percent of those over age 65 opposed animal cloning.
- Only 22 percent of those who said that religion was very important in their lives favored animal cloning compared to 40 percent of those who said that religion was "fairly" important. A majority of those who said that religion was not very important in their lives favored animal cloning.

In response to another poll conducted in early 2001, 90 percent of those surveyed said that it was a bad idea to clone human beings (the corresponding statistic for 1997 was 93 percent) (Time/CNN 2001). Survey respondents cited the following reasons for their opposition to cloning humans: cloning violates their religious beliefs (34 percent), cloning interferes with human distinctiveness and individuality (22 percent), cloning could be used for questionable purposes like breeding a superior race or cloning armies, and cloning is dangerous (14 percent).

The public is somewhat more accepting of human cloning to help infertile couples. In response to one poll, 71 percent said that cloning a human was unethical, but 40 percent thought it would be okay to use cloning to help infertile couples (*Popular Science* 2000). In response to another poll, 20 percent said that cloning would be okay to help infertile couples to have children without having to adopt (76 percent were opposed) (Time/CNN 2001).

Figure 7-11.
Public attitudes toward selected technologies in the United States, Europe, and Canada



SOURCES: Gaskell, G., and Bauer, M.W. (editors) *Biotechnology 1996–2000,* National Museum of Science and Industry (U.K.) and Michigan State University Press. The 1999 and 2000 surveys were conducted by George Gaskell, Martin Bauer, and Nick Alum for the European Commission; Susanna Priest, Texas A&M University; and Edna Einsiedel, University of Calgary.

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Public Perceptions of Selected Technologies, Including Biotechnology

In response to the 1999/2000 surveys, 51 percent of Americans thought that genetic engineering would "improve our way of life in the next 20 years." The corresponding statistics for Europe and Canada were 38 and 50 percent, respectively. However, a sizable minority of Americans (29 percent) said the opposite, that genetic engineering would "make things worse" over the next 20 years compared with 31 percent of Europeans and 40 percent of Canadians. (See figure 7-11.)

How do these statistics compare with those for attitudes toward other technologies? In all three surveys, biotechnology ranked sixth among the technologies respondents were asked about. Only nuclear energy had a lower score, with less than half (42 percent of Americans, 33 percent of Canadians, and 27 percent of Europeans) saying that nuclear energy would improve our way of life in during the next two decades.

In other words, with respect to technologies that will "improve our way of life in the next 20 years," computers and information technology, solar energy, telecommunications, the Internet, and even space exploration received substantially higher numbers of positive responses than biotechnology did. More than 80 percent of Americans and Canadians said that solar energy, computers, and telecommunications would improve our way of life in the next 20 years. The corresponding European percentages were somewhat lower, but still greater than 70 percent. In addition, approximately 70 percent of Americans, Canadians, and Europeans each thought that the Internet would improve their lives during the next 20 years. The corresponding percentages for space exploration ranged from 51 percent (Europeans) to 60 percent (Americans).

Americans, Canadians, and Europeans Take a Pop Quiz on Biotechnology

Americans and Canadians may know more about the science of biotechnology than their European counterparts. On a 10-question quiz, Americans and Canadians averaged 6.2 and 6.1 correct responses, respectively, compared with the European average of 5.4.

One question on this quiz is mentioned just about every time this subject is discussed. Respondents were asked whether the following statement is true or false: "Ordinary tomatoes do not contain genes, while genetically modified tomatoes do."

Less than 50 percent of respondents in all three groups answered this question correctly. That is, 44 percent of

Americans and Canadians and 40 percent of Europeans gave the right answer, which is "false."*

In response to another question, 47 percent of Americans knew that more than half of human genetic makeup is identical to that of chimpanzees (actually it is closer to 98 percent).† Canadians and Europeans did somewhat better than Americans in answering this question correctly, with slight majorities, 52 and 51 percent, respectively, providing the correct answer.

The most difficult question on the quiz was: "Animal genes cannot be transferred into plants."

More Canadians (43 percent) answered correctly ("false") than Americans (36 percent) or Europeans (30 percent).

In the United States (and Canada) opposition to biotechnology does not seem to be related to science literacy or level of formal education. The opposite is true in Europe. That is, in Europe, better educated groups were markedly more positive about encouraging the use of biotechnology than less-educated groups (Priest 2000).

However, those in the United States with extensive university-level science training (those who remember having taken six or more courses in science) were more positive about all six biotechnology applications included in the survey. This difference in support between those with a lot of science education and those without can be seen most clearly in data for the two most controversial applications in the United States: cloning and organ transplants (Priest 2000).

Labeling Issue and Trust in Groups With a Stake in Biotechnology

In spring 2000, various environmental organizations such as the Sierra Club, Friends of the Earth, the Natural Resources Defense Council, Public Citizen, and the Humane Society put together a petition demanding that GM foods be taken off the shelf until they are tested for safety and labeled. Along with health and environmental concerns, labeling is another biotechnology issue that has received an increasing amount of attention in recent years. Data collected with the U.S. biotechnology survey revealed a substantial amount of concern about a lack of government regulation. In other words, the public is concerned about whether the regulatory system functions adequately in this new area (Priest 2000).

Although Americans have been eating food containing GM ingredients for many years, they have been unaware of that fact. Most Americans do not know that the government does not require labels on food to identify GM ingredients.‡ However, most think this type of labeling should be required. Around 85 percent of those surveyed in 1999 and 2000 agreed that the Food and Drug Administration (FDA) should require labeling on all fruits, vegetables, or foods that have been genetically altered (Shanahan, Scheufele, and Lee 2001). About the same percentage agreed that:

> Simply labeling products as containing biotech ingredients does not provide enough information for consumers. It would be better for food manufacturers, the government, health professionals, and others to provide more details through toll-free phone numbers, brochures, and websites.

In the United States, scientists are considered more competent and trustworthy than any other group involved in biotechnology. Scientists received more votes of confidence than the Department of Agriculture, farm groups, the FDA, or the U.S. Environmental Protection Agency. Environmental groups ranked next to last and major biotechnology companies ranked lowest in terms of competence and trustworthiness (Jenkins-Smith et al. 2001).

*In a more recent survey conducted in the United States, 58 percent of the participants provided the correct answer (Jenkins-Smith et al. 2001).

†In a more recent survey conducted in the United States, 55 percent of the participants provided the correct answer (Jenkins-Smith et al. 2001).

‡Approximately one-third (34 percent) of those surveyed answered "false" to the statement, "U.S. regulations require labels to identify any food that contains genetically modified ingredients" (Jenkins-Smith et al. 2001).

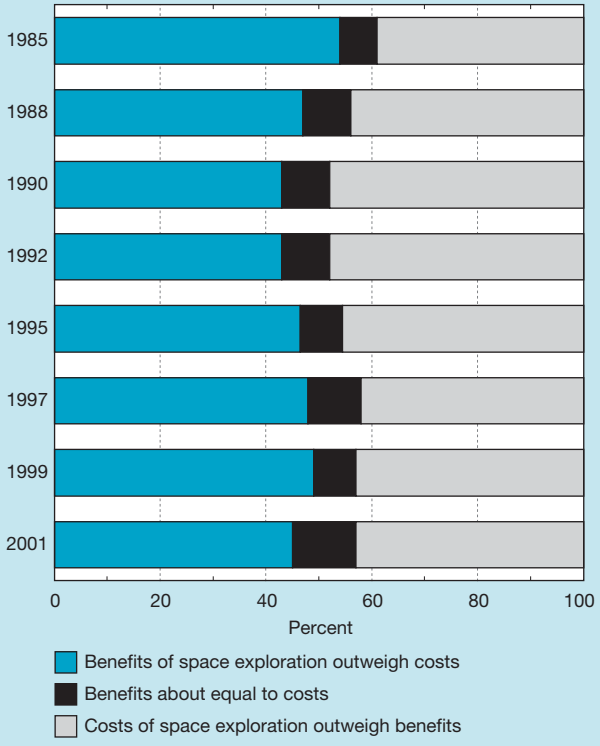
gram. The effects of the Challenger accident (and other mishaps, such as the loss of the billion-dollar Mars *Observer*) are still being felt, and even NASA's recent successes, such as Senator John Glenn's return to space on the space shuttle Discovery in late 1998, have not provided a lasting boost to public opinion. (See figure 7-12 and appendix table 7-25.)

Another survey series (Carlson 2001) has been tracking Americans' views of NASA. In late 1999, 53 percent of those surveyed described NASA's job performance as excellent or good; 43 percent gave the agency a fair or poor rating. In contrast, 76 percent rated NASA's performance as excellent or good following John Glenn's return to space in 1998. The lowest performance rating in this survey series was recorded in September 1993. At that time, only 43 percent thought that NASA's performance was excellent or good.

Like other issues, space exploration receives differing levels of support from men and women. Men are much more likely than women to champion the benefits of space exploration. In every year but two (1990 and 1992), a majority of men responding to the survey agreed that the benefits outweighed the costs, while 40 percent of women held this view. In contrast, during the late 1980s and early 1990s, 50 percent or more of women responding to the survey thought that the costs exceeded the benefits. This is no longer true; in 2001, 45 percent of women thought that the costs outweighed the benefits.

People who have more formal education are more likely than others to say that the benefits of space exploration exceed the costs. In 2001, only 33 percent of respondents lacking a high school education agreed that the benefits outweighed the costs compared with 44 percent of those who had graduated from high school and 55 percent of those who had a bachelor's or higher degree.

Figure 7-12.
Public assessment of space exploration: 1985–2001



See appendix table 7-25. *Science & Engineering Indicators – 2002*

Those identified as attentive to S&T or space exploration are more likely than the public at large to believe that the benefits exceed the costs. In 2001, at least 60 percent of each attentive group put the benefits ahead of the costs compared with less than 50 percent of the public at large.

Public Attitudes Toward Use of Animals in Scientific Research

Few issues in science are as divisive as the use of animals in scientific research. (See appendix tables 7-26 and 7-27.)[29]

Public attitudes toward research using animals are shaped by:

- **The purpose of the research.** Using animals in research to fight diseases such as cancer and AIDS draws less opposition than using animals to test cosmetics.
- **The type of animal.** The public tolerates the use of mice in scientific experiments to a greater degree than the use of dogs and chimpanzees.[30]
- **The existence of alternatives, such as computer simulations.** When researchers can meet their goals without using animals, the public opposes the use of animals (Kimmel 1997).

Data from the NSF surveys and those conducted by other organizations show the following:

- In 2001, 52 percent opposed research using dogs and chimpanzees.
- Compared with the citizens of other industrialized nations, Americans are more supportive of animal research (Kimmel 1997).

In addition, attitudes toward the use of animals in research continue to depend on the sex and age of the respondent. Women are far more likely than men to say they are opposed to the use of dogs and chimpanzees in scientific research. In 2001, 62 percent of women surveyed voiced opposition, but only 40 percent of men held the same view. (See appendix table 7-27.) This gender gap in opinion cannot be attributed to differences between the sexes in science and mathematics education or differences in science literacy (Kimmel 1997). In 2001, the majority of people 54 years of age and younger opposed the use of dogs and chimpanzees in scientific research, whereas a majority of those 65 and older were supportive. (See appendix table 7-27.)

Public Attitudes Toward Global Warming

Americans seem to be listening to what scientists and others have been saying about global climate change.[31] Data from the 2001 NSF survey show that 88 percent of the public had heard of global warming, and of those, 77 percent believed that "increased carbon dioxide and other gases released into the atmosphere will, if unchecked, lead to global warming and an increase in average temperatures." (See appendix table 7-28.) In addition, in assessing the severity of the problem, an overwhelming majority of those surveyed responded that the possibility of global warming should be treated as either a *very serious* (53 percent) or *somewhat serious* (33 percent) problem. (See appendix table 7-29.)

Gallup polls show an increasing number of Americans "worrying" about global warming between 1997 and 2000. In 2000, 40 percent of those polled reported that they worried *a great deal* about the "greenhouse effect," or global warming, up from 24 percent in 1997 and 34 percent in 1999. However, the percentage dropped to 33 percent in 2001. The most recent Gallup data show a decrease in the amount of public concern for all 13 environmental problems included in the survey between 2000 and 2001. (See sidebar "Gallup Polls on Environmental Issues" and text table 7-4.)

[29]In another survey, 71 percent of respondents answered "yes" to the question: "Do you believe the use of animals in medical research is necessary for progress in medicine?" (Research!America 2001).

[30]Fewer people oppose the use of mice in scientific research; 30 percent of those surveyed opposed research on mice compared with 52 percent who opposed research using dogs and chimpanzees. (See appendix tables 7-26 and 7-27.)

[31]The United Nations-sponsored Intergovernmental Panel on Climate Change recently issued a report warning of the catastrophic effects of global warming over the next century. The report represents a consensus of 700 scientists from more than 100 countries (Houghton et al. 2001).

Gallup Polls on Environmental Issues

The Gallup Organization has been tracking public attitudes toward environmental issues for more than a decade. The major findings include the following:

- Americans do not think environmental pollution is one of the most important problems facing the country today. According to a recent Gallup survey, the environment ranked 16th, well below education, the economy, crime, and health care, which top the list of problems identified as the most serious. However, the environment was considered to be the most important problem that will face the United States 25 years from now, more important than Medicare and Social Security and the lack of energy sources, which rank second and third on the list.*
- According to a poll taken in March 2001, 61 percent of respondents believed that global warming is occurring, up from 48 percent who responded the same way in November 1997 (Newport and Saad 2001). The same percentage also believes that human activities are more responsible for increases in the Earth's temperature over the last century than natural causes (one-third of those surveyed said the latter). In addition, 34 percent of those surveyed thought that news reports about the seriousness of global warming are accurate, and another 32 percent thought they were underestimating the problem, leaving only 30 percent who think the press is exaggerating the problem. Although Americans seem to be aware of the issue and believe press reports, they do not appear to be all that concerned. On a list of 13 types of environmental worries, the greenhouse effect, or global warming, ranked 12th. (See text table 7-4.)
- Given a choice of two statements, "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," most respondents agreed with the first. However, the percentage agreeing with the first statement declined from 70 percent in January 2000 to 57 percent in March 2001, the lowest percentage recorded since this question was first asked (in September 1984).
- Most respondents (56 percent) opposed opening up the Alaskan Arctic Wildlife Refuge for oil exploration and 51 percent opposed expanding the use of nuclear energy. In addition, most (62 percent) opposed setting legal limits on the amount of energy an average consumer can use. But nearly 80 percent favored strengthening enforcement of Federal environmental regulations. Also, in March 2001, 52 percent (versus 36 percent) of those surveyed picked the statement "protection of the environment should be given priority, even at the risk of limiting the amount of energy supplies—such as oil, gas, and coal, which the United States produces" over the alternative statement "development of U.S. energy supplies, such as oil, gas and coal, should be given priority, even if the environment suffers to some extent."

*Another survey found scientists to be more concerned than those in other professions about the global environment. That is, they were more likely to agree that "improving the global environment" should be a top priority (they were also more concerned about population growth) (Pew Research Center for People and the Press 1997).

Public Attitudes Toward Science and Mathematics Education

Public discontent with the quality of science and mathematics education in the United States persists. As noted earlier in the chapter, surveys taken shortly before the 2000 presidential election revealed education to be at or near the top of lists of the most important problems facing the country.[32]

In response to the 2001 NSF survey, 68 percent of those queried agreed that "the quality of science and mathematics education in American schools is inadequate."[33] The percentage of survey respondents agreeing with this statement has ranged from 63 percent in 1985 and 1999 to 75 percent in 1992. Unlike other survey items, this question revealed no gender gap with respect to attitudes toward the quality of science and math education. (See appendix table 7-30.)

However, a strong positive correlation does exist between level of education and finding fault with the quality of science and math education. In 2001, 52 percent of respondents who had less than a high school education were dissatisfied with the quality of science and math education. In comparison, 68 percent of high-school-only graduates agreed with the statement, as did 76 percent of college graduates.

In another survey, more than 90 percent of those queried agreed that students in their states needed a stronger education in science and math "to be prepared for the new inventions, discoveries, and technologies that the increased investment in research and development will likely bring," and 85 percent agreed that "improving precollege science education should be one of [their] governor's top education priorities." Finally, 82 percent said they would be more likely

[32]However, according to another survey, 66 percent of the public thinks the public education system will improve in the next 50 years; 30 percent said it will get worse (Pew Research Center for People and the Press 1999a).

[33]According to another survey, conducted in August 2000, 61 percent of the public is either somewhat or completely dissatisfied with the quality of education in the United States, an increase over the percentage recorded the previous year (Gallup News Service 2001b).

Text table 7-4.
Environmental worries

Issue	Worry "a great deal" (percent)			
	1997	1999	2000	2001
Pollution of drinking water	NA	68	72	64
Pollution of rivers, lakes, and reservoirs	NA	61	66	58
Contamination of soil and water by toxic waste	NA	63	64	58
Contamination of soil and water by radioactivity from nuclear facilities	NA	48	52	49
Air pollution	42	52	59	48
Loss of natural habitat for wildlife	NA	51	51	48
Damage to Earth's ozone layer	33	44	49	47
Loss of tropical rain forests	NA	49	51	44
Ocean and beach pollution	NA	50	54	43
Extinction of plant and animal species	NA	NA	45	43
Urban sprawl and loss of open space	NA	NA	42	35
"Greenhouse effect" or global warming	24	34	40	33
Acid rain	NA	29	34	28

NA = not available

SOURCE: Gallup Organization, "Only One in Four Americans Are Anxious About the Environment," Poll Release (Princeton, NJ, 2001).

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to vote for a presidential candidate in the November 2000 election if the candidate supported Federal efforts to strengthen U.S. science and math education (Bayer/NSF 2000).

Two NSF/Bayer surveys conducted in 2000 and 2001 included questions about public attitudes toward the results of the Third International Math and Science Study (TIMSS). One of the key findings of TIMSS, first conducted in 1995 and repeated in 1999 (see chapter 1, "Elementary and Secondary Education"), was that high school seniors in the United States performed poorly in tests of their knowledge of science and math. In fact, they ranked last or nearly last among the students who participated in TIMSS.

According to the 2000 NSF/Bayer survey, most people were unaware of the TIMSS results, although they received a considerable amount of coverage in the press. Only 7 percent of those queried knew that the scores of U.S. seniors were considerably lower than those of students in most other participating countries; nearly 50 percent thought that U.S. students scored average or higher. However, after being informed of the TIMSS results, almost everyone expressed concern, and 52 percent said that they were very concerned.

In 2001, two-thirds of NSB/Bayer survey respondents considered the TIMSS-R results a warning sign that "U.S. students may be inadequately prepared for the workplace when they enter it in several years."

Public Image of the Science Community

It is generally conceded that scientists and engineers have somewhat of an image problem (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development 2000). Although their intelligence and work are highly respected (see "Public Confidence in Leadership of the Science Community"), that admiration does not seem to extend to other aspects of their lives. The charming and charismatic scientist is not an image that populates popular culture.[34] For example, the entertainment industry often portrays certain professions such as medicine, law, and journalism as exciting and glamorous, whereas scientists and engineers are almost always portrayed as unattractive, reclusive, socially inept white men or foreigners working in dull, unglamorous careers. (See sidebar "Few Scientists in Prime Time.")

Why does public image matter? What difference does it make if the public image of scientists and engineers is less than positive? Public image is important for at least two reasons:

- Scientists represent the first line of communication about science to the general public. That is, they are responsible for conveying information, often through the news media, about scientific issues. They can also help the public understand the importance of science and appreciate its benefits. Image has a lot to do with how effective that communication is in capturing the attention of the public. The more appealing the image, the more likely that people will listen to what is being said.

[34]See Goldman (1989). Theater also helps reinforce the stereotype, In the recent, Pulitzer prize and Tony-winning play *Proof*, mathematicians are portrayed as "a bunch of brilliant but crazy nerds who do things that are impossible to understand" (Davis 2001). Others, however, like author, screenwriter, and physician Michael Crichton defend Hollywood's depiction of science and technology. Movies such as *Jurassic Park* provide a needed balance to the "round-the-clock boosterism" science and technology usually receive in our society. According to Crichton (American Association for the Advancement of Science annual meeting in Anaheim California 1999), scientists are not the only professionals negatively portrayed on the big screen. Accountants, police officers, and politicians also frequently receive less than positive treatment.

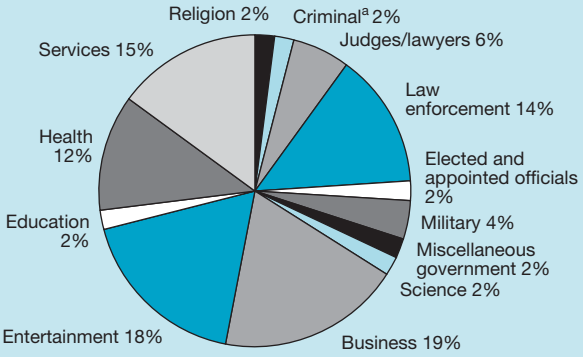
Few Scientists in Prime Time

Few characters on prime time television shows are scientists. According to a recent study, the percentage of scientists was typically less than 2 percent in the mid-1990s (Gerbner and Linson 1999). Figure 7-13 provides the breakdown for the professions of all characters in prime time between 1994 and 1997. In 1994, 2.3 percent of the characters on nighttime TV shows were scientists. Comparable figures for 1995, 1996, 1997, and 1998 were 1.6, 1.9, 1.8, and 1.0 percent, respectively.*

If scientists seldom show up on the small screen, the appearance of women and minorities as scientists is even more rare. During the period of the study, white men constituted 41 percent of the U.S. population, played 53 percent of all TV roles, and played 75 percent of the scientists. The corresponding statistics for white women were 42, 31, and 13 percent, respectively. Minorities were similarly underrepresented in the science profession on TV. However, the reverse was true for foreign nationals—only 3 percent of all characters on prime time shows were foreign nationals, but 9 percent of the scientists were members of this group. (See text table 7-5.)

*It should be noted that the 2 percent statistic for scientists in prime time probably does not differ that much from their total representation in the U.S. workforce. However, this issue can be looked at from the opposite perspective, that is, that members of other professions (e.g., doctors and lawyers) are probably overrepresented in prime time, which is not the case with respect to scientists.

Figure 7-13.
Occupations of characters in prime time dramatic entertainment: 1994–1997



[a]Although 4% (N = 245) of all characters committed crime during sample period, only 2% were identified with "criminal" as their main occupation.

NOTE: Occupations of 3,577 characters whose occupations are identified, from total sample of 6,882 speaking characters appearing in weekly samples of prime time dramatic entertainment programs (1994–97).

SOURCE: G. Gerbner and B. Linson, "Images of Scientists in Prime Time Television: A Report for the U.S. Department of Commerce From the Cultural Indicators Research Project" (Washington, DC: U.S. Department of Commerce, 1998). Unpublished report.

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Text table 7-5.
Who plays scientists on television: 1994–97
(Percentages)

Characteristics	U.S. population	Television characters: Prime time characters	Television characters: Scientists in prime time
White			
Male	41.0	52.7	75.0
Female	42.1	30.7	13.2
Black			
Male	6.0	7.3	8.3
Female	6.6	4.9	1.4
Hispanic[a]	11.0	2.5	0.0
Asian	3.0	1.6	0.7
Foreign national origin	10.0	3.2	9.0
Disabled	19.0	0.7	0.7

[a]Hispanics may be of any race and are included in totals for each racial group as appropriate.

SOURCE: G. Gerbner and B. Linson. "Images of Scientists in Prime Time Television: A Report for the U.S. Department of Commerce From the Cultural Indicators Research Project" (Washington, DC, U.S. Department of Commerce, 1998), unpublished report.

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♦ Children are strongly influenced by the images they see around them at home, at school, and in popular culture. Researchers in this field point out that television has a tremendous influence on children's attitudes and behaviors, and what they see on television can affect the choices they make in life, including the careers they choose.[35] If they harbor negative stereotypes of scientists and engineers as nerdy and weird-looking, then they could reject science and engineering as potential careers.[36]

Public Confidence in Leadership of the Science Community

Public confidence in the leadership of various professional communities has been tracked for more than a quarter of a century (Davis and Smith annual series). Participants in the General Social Survey were asked whether they had a "great deal of confidence, only some confidence, or hardly any confidence at all" in the leadership of various professional communities. In 2000, 41 percent reported that they had a great deal of confidence in the leadership of the science community. Only the medical community received a greater vote of

[35]According to one study of 1,500 television viewers, the more that people watch television, the more they think scientists are odd and peculiar (Gerbner and Linson 1999).

[36]According to one researcher, "ask any teenager, or even any preteen, what she or he thinks that students gifted in mathematics and science look like, and it is likely that the answer will include an image that looks like the 'nerdy' scientist from *Back to the Future*: male, with glasses, a pocket protector, and a very strange hairdo.…It is nearly impossible to encourage students to do well in mathematics and science when they are faced with such ridiculous stereotypes everywhere they turn…We need more shows like *Apollo 13*, where scientists are shown as dedicated, intelligent professionals who lead exciting, fulfilling lives." (Sheffield 1997 pp. 377–78.)

confidence. Science has ranked second since 1978, when it displaced the education community for the first time. The military, Supreme Court, banks and financial institutions, major companies, organized religion, and education occupied the next six spots in 2000. The public had the least confidence in the press and television; in 2000, only 10 percent of respondents reported having a "great deal of confidence" in their leadership. (See figure 7-14 and appendix table 7-31.)

Although the vote of confidence for the science community has fluctuated somewhat since 1973, it has remained about 40 percent. In contrast, the vote of confidence for the medical profession, once as high as 60 percent in 1974, has been gradually declining during most of the past 25 years.

Public Perceptions of Scientists

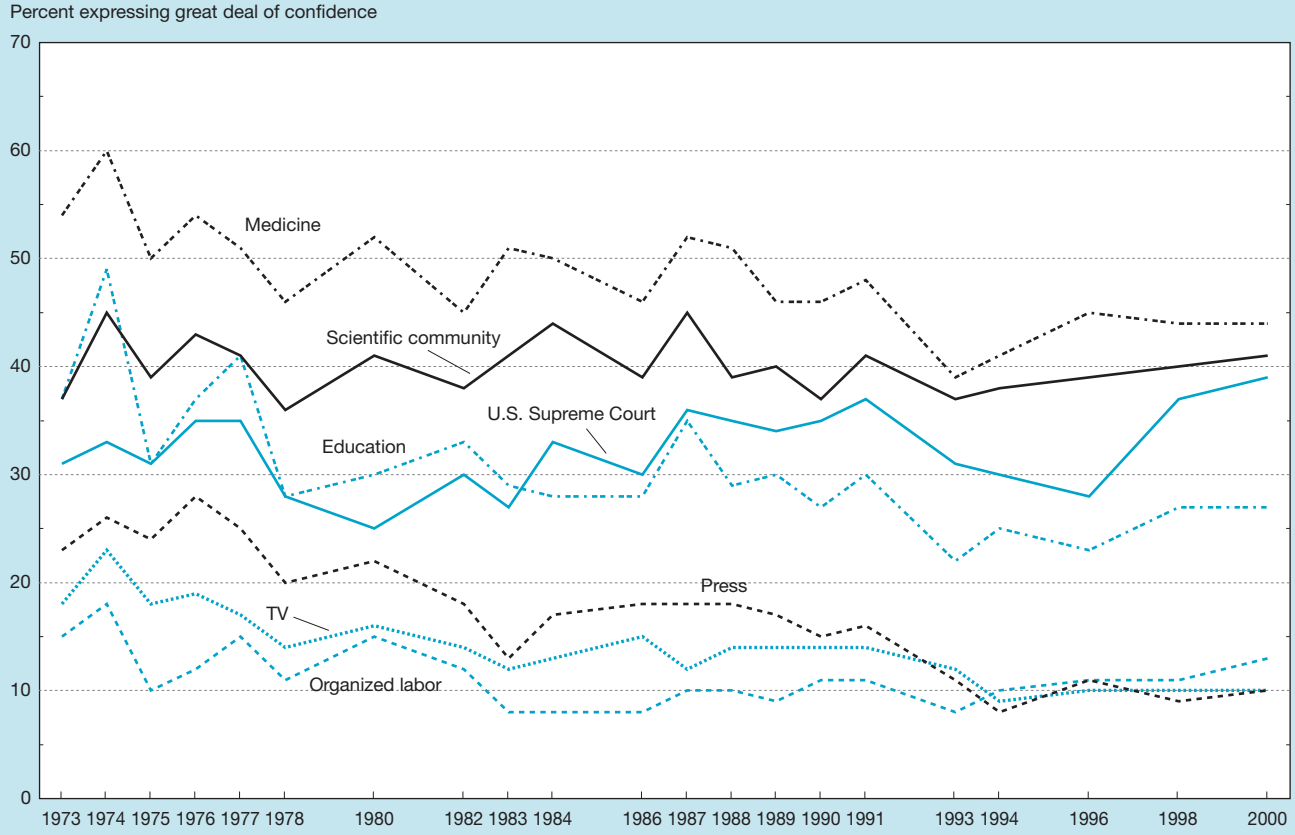
> The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses…He may wear a beard, may be…unkempt.…He is surrounded by equipment…and spends his days doing experiments (Mead and Metraux 1957).

In the years since Margaret Mead first recorded her observations, several social scientists have administered the "Draw-a-Scientist" Test (DAST) to children. In this test, students are asked to draw pictures of scientists. Those pictures are then examined to see if they contain certain features normally associated with the stereotypical image of a scientist, including:

- a lab coat (usually white),
- eyeglasses,
- facial growth of hair (including beards, mustaches, or abnormally long sideburns),
- scientific instruments and laboratory equipment,
- books and filing cabinets,
- technology or the "products" of science, and
- captions, e.g., formulae, taxonomic classification, the "eureka!" syndrome.

Other features also are noted, such as the size of a scientific instrument in relation to the scientist; evidence of danger; the presence of light bulbs; the sex, race, or ethnicity of the scientist; and figures that resemble Einstein or "mad scientists" like Frankenstein (Chambers 1983). By counting the number of these indicators in the drawings, the researchers have been able to document the existence and prevalence of the stereotypical image of a scientist, one that contains at least several of the features cited above.

Figure 7-14.
Public confidence in leadership of selected institutions: 1973–2000



See appendix tables 7-31.

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According to the DAST research, the stereotypical image of a scientist is alive and well in the minds of children. Moreover, children seem to form this image early in life, by the time they reach the second grade. It is even more ingrained and pronounced among older children. That is, the older the children, the more identified features their drawings contain. One study found little difference between the images held by college students and those of younger students, despite the fact that the former had probably had contact with actual scientists during their years at college (Barman 1997; Fort and Varney 1989; Barman 1999; Rahm and Charbonneau 1997).

In 2001, the NSF survey included questions intended to measure public perceptions of scientists. Respondents were asked whether they agreed or disagreed with certain statements. For example, almost everyone (96 percent) agreed that "scientists are helping to solve challenging problems," and 86 percent agreed that "scientific researchers are dedicated people who work for the good of humanity." (See appendix tables 7-32 and 7-33.) Less than 20 percent thought that "a scientist usually works alone" and "scientists do not get as much fun out of life as other people do." (See appendix tables 7-34 and 7-35.) Among these four statements, there was little, if any difference in perception between the sexes. However, the more formal education one had, the more positive the perception. This was true for two of the four items. For example, more than a third (37 percent) of those who had not graduated from high school thought that scientists did not get as much fun out of life as other people. This statistic dropped to 18 percent for high school graduates and to 11 percent for college graduates.

Four other statements included in the survey generated larger numbers of negative perceptions than the four items discussed above. However, fewer than half of those surveyed agreed that scientists:

- were apt to be odd and peculiar people (25 percent agreed),
- had few other interests but their work (29 percent), and
- were not likely to be very religious people (30 percent). (See appendix tables 7-36, 7-37, and 7-38.)

In contrast to the first group of questions, each of these statements produced a notable gender gap in perception, with more men than women having negative perceptions. For example:

- 28 percent of men agreed with the statement that scientists were odd and peculiar people compared with 22 percent of women,
- 33 percent of men but only 25 percent of women thought that scientists had few interests other than their work, and
- 34 percent of men versus 26 percent of women thought scientists were not likely to be very religious people.

Public Perceptions of Science Occupations

Despite the persistence of a stereotype that is difficult to dislodge, most people believe that scientists lead rewarding professional and personal lives. In fact, when asked how they would feel if their son or daughter wanted to become a scientist, 80 percent of respondents to the 2001 NSF survey said they would be happy with that decision (18 percent said they would not care and 2 percent reported they would be unhappy).[37] "Daughter" and "son" received equal percentages of positive responses, and men and women both "voted" the same way for *both* sons and daughters. (See appendix table 7-39.)

A Harris Poll Pilot Study conducted for the American Association of Engineering Societies in July 1998 produced what seems like an even higher level of enthusiasm for science as a career choice. This survey asked participants the following question:

> Using a scale of 1 to 10, with 1 being extremely displeased and 10 being extremely pleased, if your son or daughter or other family member said they wanted to be a scientist, technician, or an engineer, how pleased would you be?

"Scientist" received the highest level of endorsement, a perfect 10 for a median response, followed by engineer at 9, and technician at 8 (American Association of Engineering Societies 1998). One of the many scientific professional societies, the American Chemical Society, recently commissioned a survey of the public's attitudes toward its members and the work they do. Although the chemical industry did not receive high marks, its members did. (See sidebar "Public Perceptions of Chemistry, the Chemical Industry, and Chemists.")

Despite these positive perceptions of science occupations, 53 percent of respondents to the 2001 NSF survey agreed that "scientific work is dangerous." Equal percentages of men and women chose this response, but the level of agreement declined as the level of formal education rose. That is, 70 percent of those who had not completed high school agreed with the statement compared with 56 percent of high school graduates and 30 percent of college graduates. (See appendix table 7-40.)

Prestige of Science Occupations

Perceptions of science occupations can also be assessed by examining the prestige that the public associates with each. Respondents to the most recent Harris survey ranked "scientist" second among 17 occupations in terms of prestige; however, the engineering profession ranked eighth (Taylor 2000).[38] More than 50 percent of respondents chose "very great prestige" for three occupations: doctor (61 percent), scientist (56

[37] In a study conducted in the United Kingdom, 74 percent of those surveyed said that science and engineering represent good career choices, while only 4 percent had the opposite point of view. The adjectives used most often to describe scientists and engineers were "intelligent, enquiring, logical, methodical, rational, and ...responsible" (Office of Science and Technology and The Wellcome Trust 2000).

[38] The question asked in this survey was: "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?"

Public Perceptions of Chemistry, the Chemical Industry, and Chemists

The American Chemical Society (ACS) commissioned a survey of public attitudes towards chemistry and chemists. This survey, conducted in 2000 by The Wirthlin Group (The American Chemical Society 2000), had the following objectives:

- find out what the average person thinks about chemistry and chemists,
- assess public attitudes toward chemical companies and the chemical industry,
- measure public perceptions of chemists and chemistry as a career, and
- discover what factors influence perceptions of chemistry and the chemistry profession.

Perceptions of Chemistry

When asked to think about the word "science," 20 percent of respondents mentioned "medicine" or "biology"; 14 percent mentioned astronomy; 11 percent, chemistry; 7 percent, space; and 6 percent, physics. Those with higher levels of education and income were more likely than others to mention chemistry.

Perceptions of the Chemical Industry

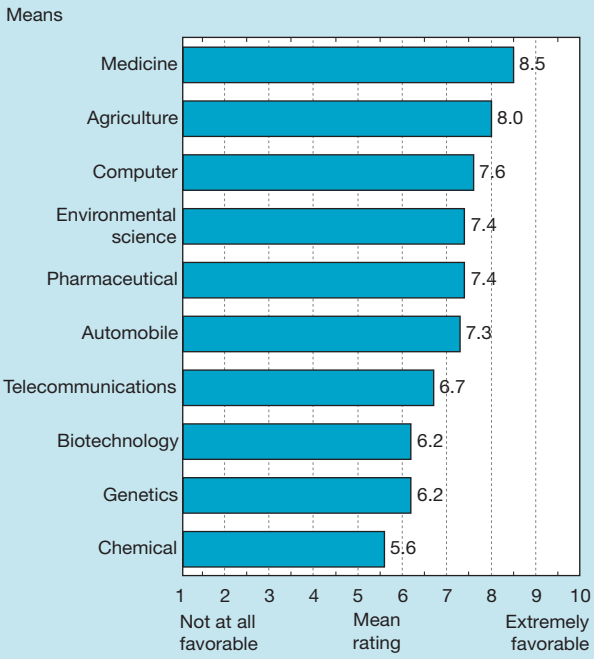
About one-third of those surveyed had an unfavorable opinion of chemical companies. Among the 10 industries included in the survey, the chemical industry ranked last. In contrast, medicine and agriculture had the most favorable ratings, followed by the computer, environmental science, pharmaceutical, automobile, telecommunications, biotechnology, and genetics industries. (See figure 7-15.)

Respondents expressing the least negative attitudes toward the chemical industry were those who had college degrees and/or household incomes exceeding $60,000, Caucasians, those not concerned about the effects of chemicals on human health and safety, and those who thought chemicals had made their lives better.

The survey participants who gave chemical companies a favorable rating (43 percent) were more likely than others to mention the positive social effects of chemicals and to express the belief that chemicals improve the quality of life. This group also cited the positive role of chemistry in research and development, cleaning uses, and pesticides.

Those with unfavorable opinions toward chemical companies (34 percent) cited the environmental impact of chemicals, harm to health, and the bad publicity the industry receives. According to this set of respondents, chemical companies harm the environment by disposing of waste irresponsibly and polluting in other ways. The Exxon Valdez and other oil spills were also mentioned. Bad publicity includes the perception that companies do not communicate with consumers.

Figure 7-15.
Industry favorability for selected industries



NOTE: Responses are to the following statement: "Next I would like to read you a list of industries. For each one I mention, please tell me how favorable you are toward that industry using a 1 to 10 scale where 1 means you are not at all favorable and 10 means extremely favorable. You may use any number between 1 and 10."

SOURCE: Figure reproduced from the American Chemical Society, National Benchmark Telephone survey, conducted by Wirthlin Worldwide, draft report, July 2000, Washington D.C.

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A strong majority—three out of five of those surveyed—felt that chemicals make their everyday lives better. The remaining respondents were split evenly between those who were neutral (20 percent) and those who thought chemicals had made their lives worse (20 percent).

The positive aspects of chemistry mentioned fall into two categories: (1) health-related, e.g., medicine and finding cures for diseases, and (2) specific products, e.g., cleaning or agricultural, that make their lives easier. Those who feel chemicals have made their lives worse cited environmental and health concerns.

Public Perceptions of Chemists and Chemistry as a Career

Although the chemical industry suffers from an image problem, the public seems to have a positive attitude toward chemistry as a profession. ACS survey respondents ranked a career as a chemist higher than that as an environmentalist, physicist, mathematician, psychologist/psychiatrist, and astronomer. Only physicians and pharmacists ranked higher. In addition, the public recognizes chem-

ists' contributions to health maintenance. With respect to this criterion, chemists once again ranked second only to physicians and pharmacists, and about even with environmentalists.

Although only 8 percent of respondents had offered advice to a friend or family member about becoming a chemist, of those who had, an overwhelming majority (87 percent) gave positive advice. The reasons given for offering encouragement included supporting the individual's choice, considering chemistry a good field with a good future, and believing that chemistry would not only provide the opportunity to help people and benefit society but also pay well.

Other findings included the following:

- A majority of survey respondents (72 percent) considered a career in basic chemical research more appealing than a career in the chemical industry (14 percent chose the latter). The reasons cited for the former included having the opportunity to make new discoveries that will benefit mankind and help others. Those who chose the latter career option cited better opportunities for career advancement and better pay.
- The leadership traits most closely associated with chemists included being a visionary, being innovative, and being results oriented.

Other Survey Findings

- Respondents said that their views were influenced almost entirely by newspaper, magazine, and television coverage of science topics. For most of the public, the primary sources of information for new developments and innovations involving chemists, chemistry, and chemicals are newspapers (34 percent), national television reports (28 percent), magazines/periodicals (27 percent), and local television reports (24 percent). The role of the Internet is still quite small: only 5 percent named it as a primary information source. (See "Where Americans Get Information About S&T.")
- Nearly 60 percent of respondents thought that they were poorly informed about new chemical developments and innovations. Only 12 percent of the respondents reported feeling very well informed about the role of chemicals in improving human health; 60 percent considered themselves somewhat informed. The remaining respondents indicated that they were not at all informed. Despite the low levels of knowledge of the role of chemicals in improving human health, 52 percent were very concerned and 35 percent were somewhat concerned about the effects of chemicals on human health and safety.
- When a chemical substance had become a danger to consumer health and safety, most people (54 percent) said that government regulators were to blame; 39 percent thought that the companies that sold the substance were responsible. Only 14 percent thought that the chemists who had discovered the substance were the most culpable.

percent), and teacher (53 percent). Although these percentages changed little between 1998 and 2000, the prestige of teachers has risen dramatically, from 28 percent in 1982 to 53 percent in 1998. During the same period, there was a relatively small gain in prestige for doctors and a relatively small loss for scientists.

This survey shows that engineers are accorded not only less prestige than doctors, scientists, and teachers, but also less prestige than ministers, military officers, policemen, and members of Congress.[39] According to a recent study, "engineers have enjoyed a consistent but mediocre prestige for the past 20 years" (American Association of Engineering Studies 1998). However, engineers command more respect than architects, lawyers, athletes, and entertainers. The bottom tier includes journalists, union leaders, businessmen, bankers, and accountants.

Are Public Perceptions Based on Knowledge?

Although people perceive science and other occupations in terms of prestige or other value measures, on what do they base their perceptions? That is, how much do people actually know about science occupations and science professionals?

In response to the American Association of Engineering Societies survey in July 1998, sizable minorities of those surveyed did not consider themselves well informed about science and scientists (47 percent) or technology and technicians (41 percent). In addition, sizable percentages of survey respondents thought that the media did only a fair or poor job covering science (56 percent), technology (53 percent), and medical discoveries (44 percent).

The same survey produced telling statistics about the engineering profession. For example:

- 61 percent of respondents did not consider themselves well informed about engineering and engineers,[40] and
- 70 percent of respondents thought that the media did only a fair or poor job covering engineering.[41]

In addition, the public frequently underestimates the role engineers play in S&T advancement. For example, engineers

[39]In a study conducted in the United Kingdom, engineering was perceived as a mostly male profession. Although the respondents tended to view the personalities of engineers as "cold and detached," they also saw them as more "socially responsible" and "sympathetic" than scientists (The Office of Science and Technology and The Wellcome Trust 2000).

[40]The comparable figures for science and scientists and technology and technicians were 47 and 43 percent, respectively.

[41]The comparable figures for science, technology, and medical discoveries were 56, 53, and 44 percent, respectively.

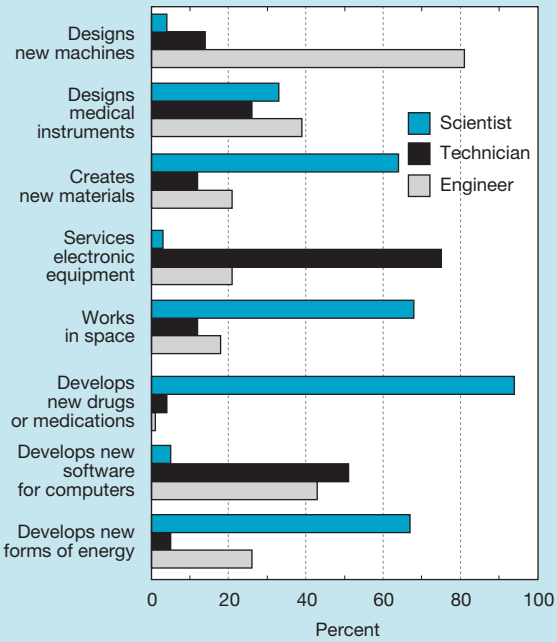
have a much larger role in conducting space research, developing new forms of energy, and creating new materials than the public gives them credit for. (See figure 7-16.) In addition, they are "perceived as pragmatic contributors to society—more so than are technicians—but are less attuned to societal issues than are scientists." (See figure 7-17.)

Where Americans Get Information About S&T

Science on the Internet

Has the Internet displaced television and the print media as Americans' primary source of news about current events or S&T? According to a 2000 Pew Research Center survey, the Internet is making inroads. Apparently, part of the time Americans used to spend watching the news broadcasts of ABC, CBS, NBC, and Fox is now being used to browse various news-oriented websites. (See sidebar "More Americans Are Turning to the Internet for News.") In addition, people who have access to the Internet at home seem to know more about science and the scientific process and have more positive attitudes toward S&T. (See sidebar "Internet Access Is an Indicator of Both Attitudes Toward and Knowledge of S&T.")

Figure 7-16.
Who does what—scientists, engineers, or technicians : 1998



NOTE: Responses were to the question, "As I mention some activities, tell me who you *mostly* associate with that activity—a scientist, a technician, or an engineer?"

SOURCE: Louis Harris & Associates, Inc. "American Perspectives on Engineers & Engineering." A "Harris Poll" Pilot Study conducted for the American Association of Engineering Societies. July 1998.

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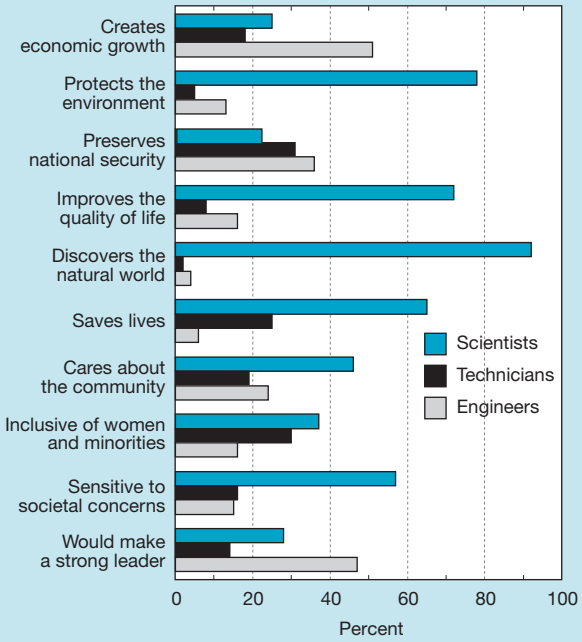
Figure 7-17.
Public perception of scientists, engineers, and technicians: 1998



NOTE: Responses were to the question, "As I mention some characteristics, who first comes to mind—scientists, technicians, or engineers?"

SOURCE: Louis Harris & Associates, Inc. "American Perspectives on Engineers & Engineering." A "Harris Poll" Pilot Study conducted for the American Association of Engineering Societies. July 1998.

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Despite its growing popularity, the Internet ranks a distant third as Americans' chief source of news in general. Only 7 percent of respondents to the NSF survey identified it as their main source of information about what is happening in the world around them. In contrast, 53 percent of those surveyed identified television, and 29 percent said that they got most of their information about current news events from newspapers. The corresponding statistics for radio and magazines are 5 and 3 percent, respectively. (See figure 7-19 and appendix table 7-42.)

Although 9 percent of respondents to the 2001 NSF survey said that the Internet was their main source of information about S&T, this percentage is still substantially below the percentage of respondents who identified television (44 percent), newspapers (16 percent), and magazines (16 percent) as their primary source of S&T news. (See figure 7-19 and appendix table 7-43.)

The Internet, however, is the preferred source when seeking information about specific scientific issues. The following question was asked in the 2001 NSF survey: "If you wanted to learn more about a scientific issue such as global warming or biotechnology, how would you get more information?"

The response to this question makes it clear that encyclopedias and every other information resource have lost a substantial number of customers to the Internet. A plurality (44

More Americans Turning to the Internet for News

Surveys conducted by the Pew Research Center (Pew Research Center for the People and the Press 2000b) show the Internet displacing network television as a source of news in some U.S. households.* (See figure 7-18.) The trend is most noticeable in the homes of younger, more affluent, and better educated survey participants. A majority of daily Internet news consumers (61 percent) are men, 75 percent are under 50, and 47 percent have a college education. Half have family incomes of $50,000 or more. This finding holds true only for news programs on the broadcast networks (ABC, CBS, NBC, and Fox). Cable news channels, daily newspapers, and radio news seem unaffected by Internet usage.

In 1998, 59 percent of two groups, those who regularly obtained news online (Internet users) and those who did not (nonusers), reported that they watched television news on a typical day. Two years later, the percentage of Internet users watching television news had dropped to 53 percent; the corresponding statistic for nonusers remained at 59 percent. Moreover, Internet users are spending less time watching news shows. That is, the percentage of Internet users reporting that they watched at least a half-hour of television news on a typical day fell from 48 percent in 1998 to 40 percent in 2000. In contrast, there was almost no change for the nonuser group: 49 percent in 1998 versus 47 percent in 2000. The data show that even when demographic variables such as sex, age, and level of education (factors associated with both watching the news and Internet access) are taken into account, Internet users are significantly less likely to watch network news than those not using the Internet.

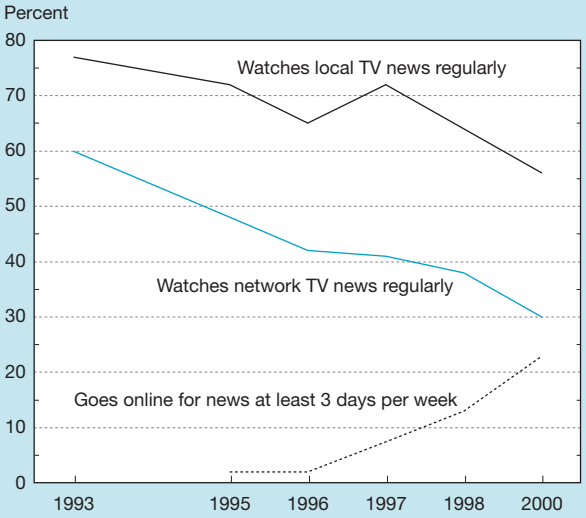
Internet users are also less likely than nonusers to watch other network news programs, including morning shows like *The Today Show* and evening news magazines like *60 Minutes*. For example, 28 percent of Internet users said that they regularly watched network news magazines compared with 34 percent of nonusers.

Text table 7-6 shows the most popular types of news sought online by Internet users. Weather, science/health, and technology are at the top of the list.

Americans who regularly get news online are more interested than non-Internet users in news about science and technology, business and finance, and sports. For example, 22 percent of those who got news online at least once a week said that they follow news about science and technology very closely compared with just 14 percent of those who did not go online. (See text table 7-1.)

*The percentage of Americans saying they enjoy keeping up with the news has declined steadily since the mid-1990s. The generational divide on these questions is striking (Pew Research Center for the People and the Press 2000c).

Figure 7-18.
U.S. public viewing broadcast news versus online news



SOURCE: Pew Research Center for the People and the Press, "Internet Sapping Broadcast News Audience: Investors Now Go Online for Quotes, Advice." Biennial Media Consumption Survey, June 11, 2000. http://www.people-press.org/media00rpt.htm.

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Text table 7-6.
Online news topics for which people go online: 2000

News topic	Internet news consumers (percent)		
	All	Men	Women
Weather	66	68	64
Science and health	63	60	67
Technology	59	72	45
Business	53	62	43
International	45	51	38
Entertainment	44	40	47
Sports	42	57	27
Political	39	44	34
Local	37	35	39

SOURCE: Pew Research Center for the People and the Press, "Internet Sapping Broadcast News Audience: Investors Now Go Online for Quotes, Advice," Biennial Media Consumption survey (Washington, DC, June 11, 2000). Available at <http://www.people-press.org/media00rpt.htm>.

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Internet Access an Indicator of Both Attitudes Toward and Knowledge of S&T

People who have access to the Internet at home seem to harbor fewer reservations about S&T than those who do not have access at home. They may also have more knowledge of science and the scientific process than their no-access counterparts. Although the differences in attitudes and knowledge are the most striking among those whose highest level of formal education is a high school diploma, differences exist even among those having college degrees.

In 2001, 59 percent of those responding to the NSF survey said that they had access to the World Wide Web (WWW) at home. Given how much the so-called digital divide has been in the news, it is not surprising to see access strongly correlated with level of education, in terms of both formal education and number of math and science courses completed. In addition, this question produced a sizable gender gap; 63 percent of men said that they had home access, compared with 55 percent of women. (See appendix table 7-41.)

Those having access to the Internet at home harbor fewer reservations about science. For example:

- 43 percent of those having access to the WWW from home agreed with the statement "we depend too much on science and not enough on faith" compared with 60 percent of those without access;
- 30 percent of those having access agreed with the statement "science makes our way of life change too fast" compared with 50 percent of those without access; and
- 78 percent of those having access agreed that the benefits of scientific research outweigh the harmful results, compared with 63 percent of those without access.

In addition, 85 percent of those with access to the WWW from home, but only 75 percent without access, agreed with the statement: "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." However, this difference was entirely attributable to those without college degrees. Among college graduates, there are almost no differences in the percentages of respondents agreeing with the statement.

Responses to the knowledge questions on the survey reveal major differences between those who have access to the Internet and those who do not. For each of the knowledge questions, the percentage of correct responses given by respondents in the "access" group was higher—and for most questions, substantially higher—than the percentage of correct responses given by respondents in the "no access" group. For example:

- 56 percent of respondents in the access group knew that electrons are smaller than atoms compared with 36 percent of those in the no-access group;
- 61 percent knew that antibiotics do not kill viruses (compared with 36 percent);
- 52 percent knew that humans did not live at the same time as dinosaurs (compared with 41 percent);
- 83 percent knew that light travels faster than sound (compared with 67 percent); and
- 84 percent knew that Earth goes around the Sun and not vice versa (compared with 63 percent).

Even among college graduates responding to the survey, those with Internet access at home were more likely than those without access to respond correctly to most of the knowledge questions in the survey.

Among all survey respondents, 37 percent of those with access to the WWW at home were deemed to have an understanding of the scientific process, compared with 19 percent of the no-access group. For the access group, 48 percent of those with just a bachelor's degree and 56 percent of those with a graduate or professional degree met the criteria for understanding the scientific process. The comparable percentages for the no-acess group were 32 and 48 percent, respectively.

percent) of those surveyed chose the Internet as the resource they would use to look up information on the two scientific issues. About half as many (24 percent) chose books or other printed material. No other source, for example, magazines (8 percent), television (6 percent), or newspapers (4 percent), scored above 10 percent. (See figure 7-19 and appendix table 7-44.)

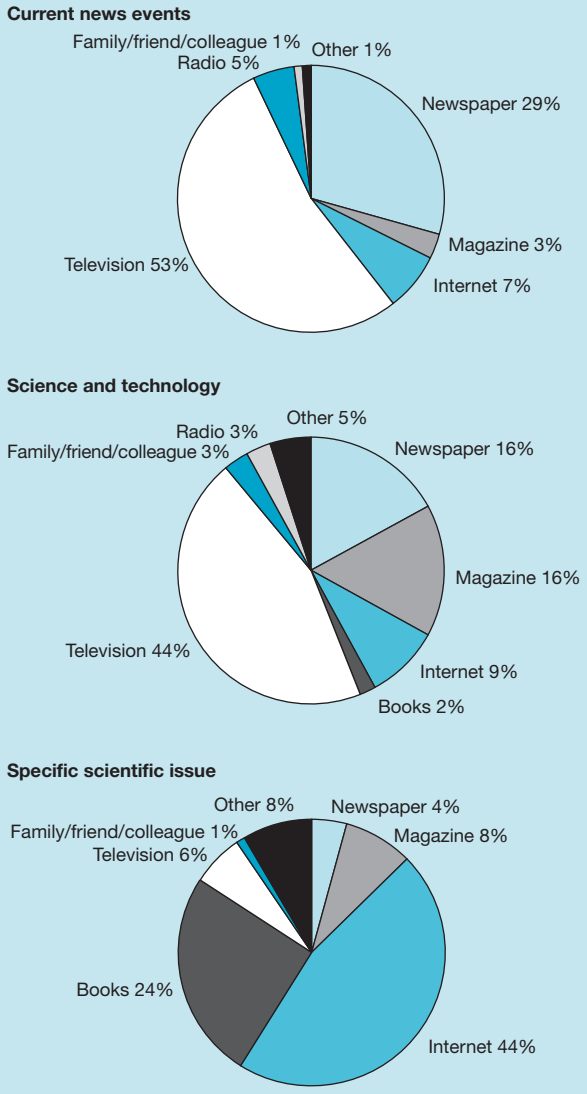
Although it is safe to conclude that the Internet is affecting what Americans know about S&T, it is also true that what most of them know about the latest developments in these subjects comes primarily from watching television.

Science on Television

When most people think about science on television, their first thoughts are probably about educational series, like *NOVA*, on Public Broadcasting Service (PBS) programming, or programs aimed at children, such as *Bill Nye the Science Guy*. In addition, most U.S. households now have access to cable television or satellite systems (see appendix table 7-45), so many Americans are also aware of the Discovery Channel and its mostly science-related offerings.[42] Although

[42] In March 2000, a two-hour special on the Discovery Channel, "Raising the Mammoth," drew 10.1 million viewers, the largest audience for a documentary in the history of basic cable television. Although a sequel, "Land of the Mammoth," attracted an audience only half the size of the original, that was still a laudable showing for a basic cable program (Carter 2001).

Figure 7-19.
Leading source of information: 2001



NOTE: Percentages may not sum to 100 because "Don't know" responses are not shown.

See appendix tables 7-42, 7-43, and 7-44.

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programs and documentaries on PBS and the Discovery Channel are highly regarded, their audiences are relatively small. (See appendix table 7-46.) Other types of programming such as evening and morning news broadcasts and news magazines like *60 Minutes, 20/20*, and *Dateline* reach far more people. Therefore, most television viewers are exposed to information about S&T from news shows and news magazines that occasionally cover these subjects.[43]

In response to the 2001 NSF survey, 90 percent of adults said they watched television news reports or news shows every day (63 percent) or a few times a week (27 percent).[44] (See appendix table 7-47.) In addition, 31 percent said that they watched television news magazines like *60 Minutes, 20/20*, or *Dateline* regularly or most of the time, and 52 percent said that they watched those shows occasionally.[45] (See appendix table 7-46.) These television news magazines can be a leading source of news about science for the public, including members of Congress; for example, a *60 Minutes* segment on cloning humans was shown at the beginning of a March 28, 2001, hearing held by the Oversight and Investigations Subcommittee of the House Energy and Commerce Committee.

According to the 2001 NSF survey, 8 percent of Americans watch *NOVA* regularly or most of the time, and 29 percent watch the series occasionally. Twenty-two percent said they regularly watched public television programs other than *NOVA*, and 49 percent said they occasionally watched such programs.[46] Not surprisingly, a positive relationship exists between watching *NOVA* (as well as other PBS programs) and level of formal education. For example, 15 percent of those who had a graduate or professional degree said they watched *NOVA* regularly, compared with 11 percent of those who had only a bachelor's degree, 7 percent of those who had only a high school degree, and 4 percent of those who had not graduated from high school. Those who had a bachelor's or higher degree were also more likely than others to watch other PBS programs. (See appendix table 7-46). In response to a Pew Research Center survey, 37 percent said that they regularly watched documentaries on cable channels such as the History Channel or the Discovery Channel. More men (43 percent) than women (31 percent) said that they watched these shows.

[43]Science also shows up in entertainment programming, for example, children conducting science experiments on *Late Night with David Letterman*, or in an occasional storyline in a long-running show like *Friends* in which one of the characters is a research scientist. Also, each episode of *The West Wing* usually contains a science-related storyline. Because shows like these draw such large audiences, their conveying of information about science and science policy should not be discounted. They provide information and shape attitudes. A recent example of the influence of television on public opinion illustrates this point. During the 2000 presidential campaign, it was hard not to notice that a lot of voters were getting political news from entertainment talk shows, not just those on Sunday morning or the cable news networks or *Nightline*. Almost all major candidates felt compelled to do the talk show circuit, to appear on the *Late Show with David Letterman*, the *Tonight Show*, or the *Oprah Winfrey Show*, because of the growing recognition that their appearances on such shows proved to be an effective way of reaching Americans who do not watch the news or read a newspaper (Pfau et al. 2001).

[44]According to another survey (Pew Research Center for the People and the Press 2000b), the percentage of Americans who report watching a nightly network news program has been declining significantly for more than a decade, from 71 percent in 1987 to 65 percent in 1995, 59 percent in 1998, and 50 percent in 2000.

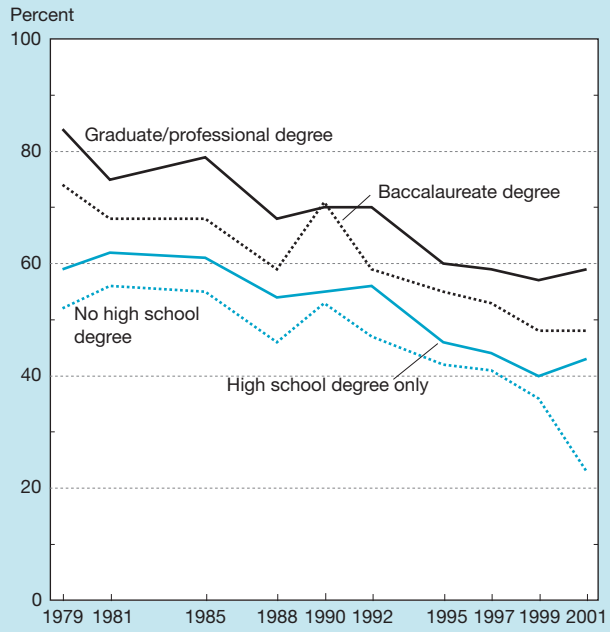
[45]According to the Pew Research Center survey, the percentage of Americans who say they regularly watch news magazines such as *20/20* and *Dateline* dropped from 37 percent in 1998 to 31 percent in 2000. Audiences for the three network morning shows also decreased, but by a smaller amount, during the past two years.

[46]According to the Pew Research Center survey, PBS viewership has remained stable.

Science in Newspapers and Museums

The decline in newspaper readership during the past decade has been well documented. According to the NSF survey, the percentage of all adults who read a newspaper every day dropped from 57 percent in 1990 to 41 percent in 1999. The decline is apparent at all education levels and continued for the less-than-high-school-education group through 2001. However, newspaper readership among the other three education groups either rose or stayed the same between 1999 and 2001, indicating that the overall decline in newspaper readership may have leveled off in recent years.[47] (See figure 7-20 and appendix table 7-48.)

Figure 7-20.
U.S. public reading a daily newspaper: 1979–2001



See appendix table 7-47. *Science & Engineering Indicators – 2002*

Sixty-six percent of those surveyed in 2001 reported that they had visited a science or technology museum at least once during the past year, the highest level of museum attendance ever recorded by the NSF survey. Museum attendance is positively related to formal education and attentiveness to S&T. (See appendix tables 7-45, 7-49, and 7-50.)

[47]Data from the Pew Research Center also show a recent leveling off in the decline in newspaper readership. Data from the center show 47 percent of whites reading a daily newspaper compared with 37 percent of blacks and 32 percent of Hispanics. However, blacks are somewhat more likely (60 percent) than whites (56 percent) to watch TV news. In addition, weekly news magazines, such as *Time* and *Newsweek*, have lost readers. In 2000, only 12 percent reported that they regularly read a news magazine; the corresponding statistics in 1996 and 1993 were 15 and 24 percent, respectively.

Science Fiction and Pseudoscience

Interest in Science Fiction

According to renowned physicist Stephen Hawking, "science fiction is useful both for stimulating the imagination and for diffusing fear of the future." Interest in science fiction may affect the way people think about or relate to science. For example:

- Interest in science fiction may be an important factor in leading men and women to become interested in science as a career. Although it is only anecdotal evidence, found on Internet discussion lists, for example, scientists often say they were inspired to become scientists by their keen interest in science fiction as children.

- It is useful to discover whether interest in science fiction is a possible indicator of positive attitudes toward S&T. For example, one study found a strong relationship between preference for science fiction novels and support for the space program.[48]

Thirty percent of those participating in the 2001 NSF survey said that they read science fiction books or magazines. (See appendix table 7-51.) The positive relationships that exist between reading science fiction and level of education, number of math and science courses completed, and attentiveness to science and technology are interesting, yet predictable. However, another finding is contrary to conventional wisdom. That is, there does not seem to be a gender gap: nearly equal percentages of men (31 percent) and women (28 percent) report that they read science fiction books or magazines. (See appendix table 7-51.)

However, a difference does exist with respect to watching science fiction television programs. For example, the Sci Fi channel is watched by more men (55 percent) than women (45 percent) (Brown 2000). In contrast, women make up the majority of the viewing audience of almost every other television network except the sports networks.

In response to the 2001 NSF survey, 35 percent of men reported that they watched any of the *Star Trek* series either regularly (12 percent) or occasionally (23 percent), compared with 28 percent of women who watched either regularly (10 percent) or occasionally (18 percent). There does not seem to be a relationship between level of education and watching *Star Trek*. (See appendix table 7-52.)

The *X-Files* is a show that focuses more on pseudoscience than science fiction. About 15 percent of those surveyed said they watch the show regularly, and another 28 percent said that they watch it occasionally. Those with more formal education are less likely than others to watch the show. (See appendix table 7-52.)

[48]The same study also found that students who read science fiction are much more likely than other students to believe that contacting extraterrestrial civilizations is both possible and desirable (Bainbridge 1982).

Relationships Between Science and Pseudoscience

What Is Pseudoscience?

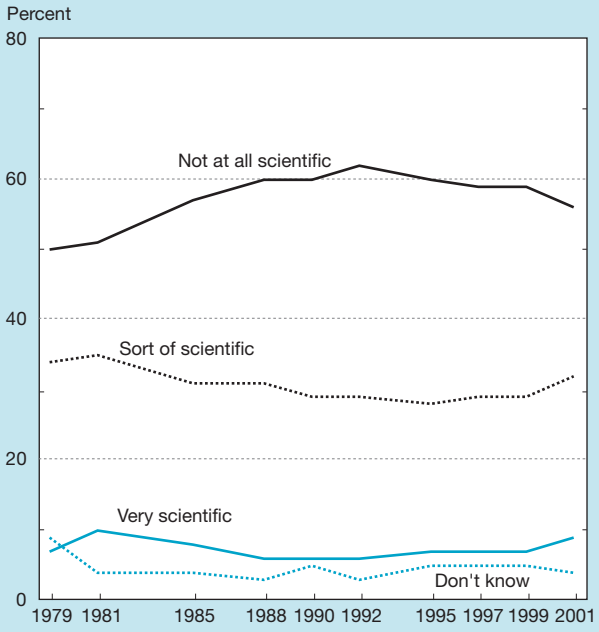
Pseudoscience is defined here as "claims presented so that they appear [to be] scientific even though they lack supporting evidence and plausibility" (Shermer 1997, p. 33). In contrast, science is "a set of methods designed to describe and interpret observed and inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation" (Shermer 1997, p. 17). According to one group studying such phenomena, pseudoscience topics include yogi flying, therapeutic touch, astrology, fire walking, voodoo magical thinking, Uri Gellar, alternative medicine, channeling, Carlos hoax, psychic hotlines and detectives, near-death experiences, Unidentified Flying Objects (UFOs), the Bermuda Triangle, homeopathy, faith healing, and reincarnation (Committee for the Scientific Investigation of Claims of the Paranormal <http://www.csicop.org>).

How Widespread Is Belief in Pseudoscience?

Belief in pseudoscience is relatively widespread. Various polls show the following:

- More than 25 percent of the public believes in astrology, that is, that the position of the stars and planets can affect people's lives. In one recent poll, 28 percent of respondents said that they believed in astrology; 52 percent said that they did not believe in it; and 18 percent said that they were not sure (Newport and Strausberg 2001). Nine percent of those queried in the 2001 NSF survey said that astrology was "very scientific" and 32 percent answered "sort of scientific"; 56 percent said that it was not at all scientific. (See appendix table 7-53 and figure 7-21.) A minority of respondents (15 percent) said that they read their horoscope every day or "quite often"; 30 percent answered "just occasionally." (See appendix table 7-54.)
- At least half of the public believes in the existence of extrasensory perception (ESP). The statistic was 50 percent in the latest Gallup poll and higher in the 2001 NSF survey, in which 60 percent of respondents agreed that "some people possess psychic powers or ESP."[49] (See appendix table 7-55.)
- A sizable minority of the public believes in UFOs and that aliens have landed on Earth.[50] In 2001, 30 percent of NSF survey respondents agreed that "some of the unidentified flying objects that have been reported are really space vehicles from other civilizations" (see appendix table 7-56), and one-third of respondents to the Gallup poll reported that they believed that "extraterrestrial beings have visited earth at some time in the past."

Figure 7-21.
Public perception of whether astrology is scientific: 1979–2001



See appendix table 7-53. *Science & Engineering Indicators – 2002*

- Polls also show that one quarter to more than half of the public believes in haunted houses and ghosts, faith healing, communication with the dead (see figure 7-22), and lucky numbers (see appendix table 7-57).

Surveys administered periodically even show increasing belief in pseudoscience. Of the 13 phenomena included in the 2001 Gallup survey, belief in 8 of them increased significantly during the past decade, and belief in only 1 (devil possession) declined. Belief in four of the phenomena, haunted houses, ghosts, communication with the dead, and witches, had double-digit percentage point increases. Movies like *The Sixth Sense* and *The Blair Witch Project* as well as the plethora of mediums on the small screen may have been fueling such beliefs.

In most cases, more women than men believe in these types of pseudoscience. In response to the 2001 NSF survey, women were more likely than men to believe in ESP.[51] The percentages of men and women who said that they believed in UFOs were about equal, which contrasts with the findings of other surveys. In fact, in most other surveys of this type, aliens-from-outer-space-type questions are the only ones that show higher levels of belief among men than women (Irwin 1993).

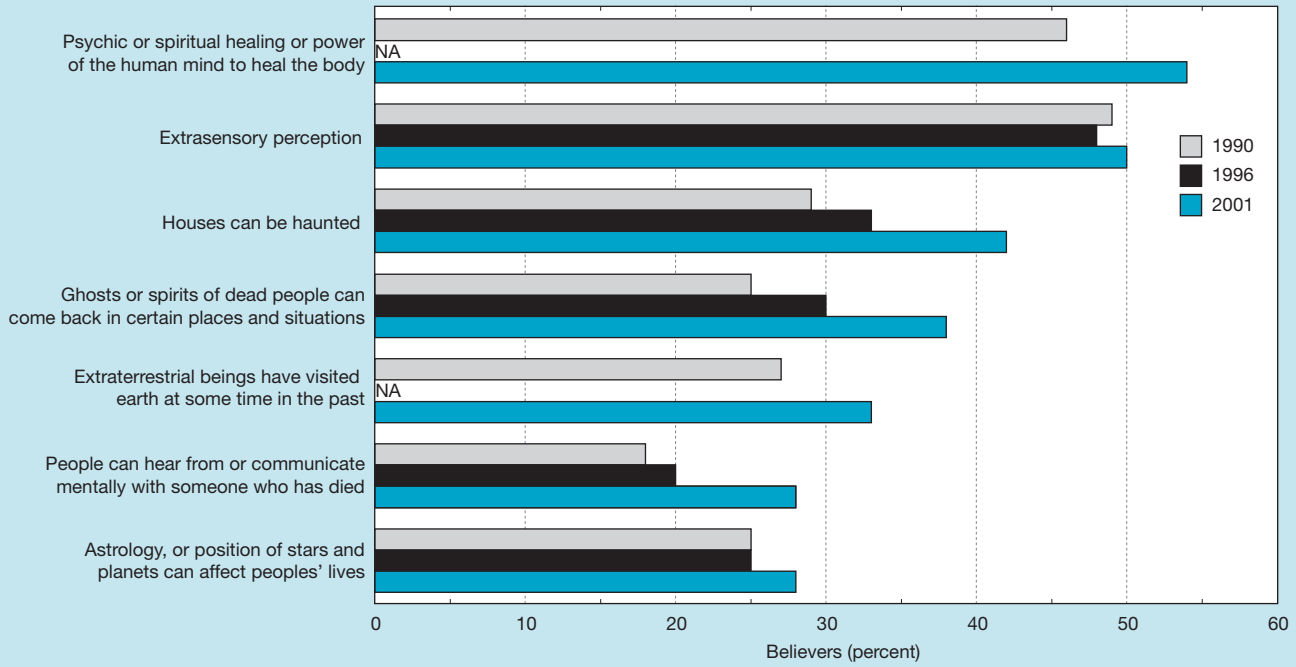
The relationship between level of education and belief in pseudoscience is not as straightforward, although for some topics such as astrology, a strong negative relationship exists. In response to the 2001 NSF survey, only 45 percent of those with less than a high school education and 52 percent of those who

[49]Between 1972 and 1995, the Central Intelligence Agency and the Department of Defense spent $20 million on "psychic" research (Barrett 2001).

[50]In a poll commissioned by *Popular Science* magazine, 45 percent thought that intelligent aliens had visited Earth (Popular Science 2000).

[51]Although women account for only 45 percent of the Sci Fi Channel's viewing audience, one show on that network, *Crossing Over*, which features a medium, has a largely female audience (Brown 2000).

Figure 7-22.
Belief in paranormal phenomena



NA = not available

SOURCE: Gallup Organization, "Americans' Belief in Psychic Paranomal Phenomena is up Over Last Decade," (Princeton, NJ, 2001).

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had completed high school but not college said that astrology "is not at all scientific" compared with 74 percent of those who had at least a bachelor's degree. (See appendix table 7-53.)

Is Belief in Pseudoscience Harmful?

Concerns have been raised, especially in the science community, about widespread belief in pseudoscientific phenomena.[52] Scientists and others believe that the media, and in particular, the entertainment industry, may be at least partially responsible for the large numbers of people who believe in astrology, ESP, alien abductions, and other forms of pseudoscience.[53] Because not everyone who watches shows with pseudoscientific themes perceives such fare as merely entertaining fiction, there is concern that the unchallenged manner in which some mainstream media portray pseudoscientific phenomena is exacerbating the problem and contributing to the public's scientific illiteracy.[54] Belief in pseudoscience may indicate a lack of critical thinking skills (Maienschein et al., 1999).

Although scientists are concerned about scientific illiteracy, including the public's gullibility regarding pseudoscience, few choose to say much about it. According to physicist Robert L. Park, most scientists would rather talk about their latest cutting-edge research, not the basic laws of thermodynamics.[55] Park has been speaking out for many years. In explaining why, he recently said:

> [P]eople drawn to [pseudoscience long] for a world that is some other way than the way it is. They pose no great threat to science. [Pseudoscience] is a sort of background noise, annoying, but rarely rising to a level that seriously interferes with genuine scientific discourse. The more serious threat is to the public, which is not often in a position to judge which claims are real and which are [not]. Those who are fortunate

[52]The rise of pseudoscience in China has become a growing concern for scientists in that country. According to one scientist, "the number of high-profile attempts to pass off superstition and money-making scams under the respectable cloak of science is one of the most disturbing features of Chinese science and society" (Tsou 1998).

[53]Groups like the Committee for the Scientific Investigation of Claims of the Paranormal <http://www.csicop.org> contend that shows like *The X-Files* fuel belief in misinformation about science and conspiracy theories, and several studies of this subject also support this contention (Sparks, Nelson, and Campbell 1997). Others have spoken out similarly: "[t]he UFO conspiracy theory has been fed and watered by *The X-Files* series on television" (Borger 2001). According to Richard Dawkins, in his 1998 treatise *Unweaving the Rainbow: Science, Delusion, and the Appetite for Wonder,* the show "systematically purveys an anti-rational view of the world which, by virtue of its recurrent persistence, is insidious."

[54]Another recent example of the media covering, and thus giving credence to, pseudoscience was a story posted on the Fox News website (Patrick Riley, "After 25 Years, Martian 'Face' Still Raises Questions") on September 8, 2000, about whether or not there's a "face" on Mars, two years after the Mars *Global Surveyor* sent back data providing conclusive evidence that the object was a natural geographical formation. An online poll on the website produced the following results: 37 percent said it was made by aliens, 31 percent thought it was a natural geographical feature, and 32 percent answered that they thought there was not enough data to decide either way.

[55]Robert Park, speech at the National Press Club, July 13, 2000.

enough to have chosen science as a career have an obligation to help the public make that distinction (Park 2000).

How Are Policymakers and Scientists Confronting Public Belief in Pseudoscience?

Members of the science policymaking community concerned about scientific literacy among the general public tend to focus on improving the quality of formal science and mathematics education, usually at the precollege level, and the communication of science-related information to adults, for example, media coverage of topical issues such as biotechnology and global warming. Special committees at both the NSF and the National Academy of Sciences have been studying how to improve the latter. Several reports have been issued (National Science Board 2000). All of these endeavors seem to be directed at how to increase media coverage of science. However, none of the reports addresses the subject of *miscommunication* of science by the media. Most of this miscommunication involved the promotion of pseudoscience and the inaccurate portrayal of the scientific process.

A recent example of this miscommunication was the purported documentary, shown on the Fox Network, "Conspiracy Theory: Did We Land on the Moon?"[56] Astronomers and other members of the scientific community were highly critical of the way science (and everything else) was portrayed on the show.[57] However, the program was so popular with the public it was repeated twice within a six-month period.[58]

Belief in Alternative Medicine

Alternative medicine is another concern. As used here, alternative medicine refers to all treatments that have not been proven effective using scientific methods. A scientist's view of the situation appeared in a recent book (Park 2000):

> Between homeopathy and herbal therapy lies a bewildering array of untested and unregulated treatments, all labeled *alternative* by their proponents. Alternative seems to define a culture rather than a field of medicine—a culture that is not scientifically demanding. It is a culture in which ancient traditions are given more weight than biological science, and anecdotes are preferred over clinical trials. Alternative therapies steadfastly resist change, often for centuries or even millennia, unaffected by scientific advances in the understanding of physiology or disease. Incredible explanations invoking modern physics are sometimes offered for how alternative therapies might work, but there seems to be little interest in testing these speculations scientifically.[59]

In response to the 2001 NSF survey, an overwhelming majority (88 percent) agreed that "there are some good ways of treating sickness that medical science does not recognize." (See appendix table 7-58.) The American Medical Association defines alternative medicine as any diagnostic method, treatment, or therapy that is "neither taught widely in U.S. medical schools nor generally available in U.S. hospitals." However, at least 60 percent of U.S. medical schools devote classroom time to the teaching of alternative therapies, generating controversy within the scientific community. Critics have also been quick to note that one of these therapies, "therapeutic touch," was taught at more than 100 colleges and universities in 75 countries before the practice was debunked by a nine-year-old child for a school science project (Rosa 1998).

Nevertheless, the popularity of alternative medicine appears to be increasing. A recent study documented a 50 percent increase in expenditures and a 25 percent increase in the use of alternative therapies between 1990 and 1997 (Eisenberg et al. 1998) A large minority of Americans (42 percent) used alternative therapies in 1997 and spent a total of at least $27 billion on them. In addition, the authors of the study reported that the use of alternative therapies was:

- at least as popular in other industrialized nations as it was in the United States;
- more popular among women (49 percent) than among men (38 percent) and less popular among African Americans (33 percent) than among members of other racial groups (44.5 percent); and
- higher among those who had attended college, among those who had incomes above $50,000, and among those who lived in the western United States.

Furthermore, among the 16 therapies included in the study, the largest increases between 1990 and 1997 were in the use of herbal medicine (a 380 percent increase), massage, megavitamins, self-help groups, folk remedies, energy healing, and homeopathy. [60]

Among those who reported using energy healing, the most frequently cited technique involved the use of magnets. In 2001, NSF survey respondents were asked whether or not they had heard of magnetic therapy, and if they had, whether they thought that it was *very scientific, sort of scientific,* or *not all scientific*. A substantial majority of survey respondents (77 percent) had heard of magnetic therapy. Among all who had heard of this treatment, 14 percent said it was *very scientific* and another 54 percent said it was *sort of scientific*. Only 25 percent of those surveyed answered correctly, that is, that it is *not at all scientific*.[61] These percentages vary by level of formal education. That is, among those who had not completed high school, only 18 percent chose the *not-at-all-sci-*

[56]The program first aired on February 15, 2001, and was repeated on March 21, 2001.

[57]A comprehensive critique of this program can be found at <http://www.badastronomy.com>.

[58]A 1999 Gallup poll showed that about 6 percent of Americans have doubts about the moon landing; the Fox show claimed the number is 20 percent.

[59]In 1992, Congress created the National Center for Complementary and Alternative Medicine within the National Institutes of Health. With an annual budget of around $100 million, the Center funds research on alternative therapies to find out if they really do work. In addition, a White House Commission on Complementary and Alternative Medicine Policy is currently studying and will be making recommendations to Congress on how to promote research and training in alternative medicine.

[60]The massive increase in herbal medicine is probably attributable to passage of the Dietary Supplement and Health Education Act of 1994, which allows manufacturers to market and sell herbal remedies without having to prove that they are effective.

[61]Researchers have yet to demonstrate that magnetic therapy is effective in treating pain or any other ailment (Park 2000).

entific response, as did 22 percent of the high school graduates, compared with 35 percent of the college graduates. Among those classified as attentive to S&T, 34 percent answered correctly. (See appendix table 7-59.)

Conclusion

Although Americans express a high level of interest in S&T, they lack confidence in their knowledge of these subjects. In 2001, less than 15 percent thought that they were well informed about S&T. In addition, few Americans follow news stories about scientific breakthroughs, research, and exploration. Those with more years of formal education and those who have taken more courses in science and mathematics are more likely than others to express a high level of interest in S&T and to believe that they are well informed.

Data on science literacy in the United States indicate that most Americans do not know a lot about S&T. The percentage of correct responses to a battery of questions designed to assess the level of knowledge and understanding of science terms and concepts has not changed appreciably in the past few years. In addition, approximately 70 percent of Americans do not understand the scientific process. Individuals with more years of formal schooling and who have completed more courses in science and mathematics were more likely than others to provide correct responses to the science literacy questions.

Americans have highly positive attitudes toward S&T, strongly support the Federal Government's investment in basic research, and have high regard for the science community. In addition, most people believe that scientists and engineers lead rewarding professional and personal lives, although a stereotypical image of these professions, rooted in popular culture, does exist and has been difficult to dislodge.

Some individuals harbor reservations about science and technology, especially about technology and its effect on society. Although anti-biotechnology sentiments are much more common in Europe, U.S. support for genetic engineering has declined during the past 15 years.

The vast majority of the public believes that global warming exists and that it should be treated as a serious problem. However, Americans think that environmental pollution is not one of the most important problems facing the country today. They are more concerned about economic and especially education issues—more than two-thirds believe that the quality of science and mathematics education in American schools is inadequate.

Belief in pseudoscience is relatively widespread and growing. In addition, the media have come under criticism, especially by scientists, for sometimes providing a distorted view of science and the scientific process and thus contributing to scientific illiteracy.

Americans get most of their information about the latest developments in S&T from watching television, although the Internet is beginning to make inroads. It is now the leading source of information on specific scientific issues. The rapid growth of information technologies, including the Internet, is thoroughly explored in chapter 8, "Significance of Information Technologies."

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