FRAMING NANO:
MEDIA COVERAGE AND PUBLIC OPINION ABOUT NANOTECHNOLOGY

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by

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ABSTRACT

Recent studies have suggested that media coverage and public opinion about biotechnology was similar to nuclear energy and other "emerging technologies." To begin moving beyond individual cases and toward a broader theory, this study looks at a new emerging technology—nanotechnology—with the goal of attaining a better understanding of the complex interactions among media coverage, public opinion, and policy debates. The research attempts to provide two things: 1) an understanding of how the major news media have covered nanotechnology in recent years; and 2) a glimpse into public attitudes about nanotechnology in New York state.

Presented first is a preliminary content analysis of nanotechnology coverage in the *New York Times*, *Washington Post*, *Wall Street Journal*, and *Associated Press* for the period between January 1, 1986 and June 30, 2004. Media attention to nanotechnology seems to parallel coverage of biotechnology in its early stages of issue development—starting out low and rising sharply as it spreads from "elite" media outlets to general outlets. As with biotechnology, coverage of nanotechnology throughout this period is overwhelmingly positive, focusing on progress and potential economic benefits, and with little discussion of attendant risks. Nanotechnology coverage does, however, focus somewhat more on risks from the outset than biotechnology did, suggesting that issues of public accountability are growing more salient to journalists. Indeed, the "public accountability" frame appears surprisingly early in nanotechnology coverage and remains a significant element throughout. This frame appears more often than the "runaway" frame and on a par with the "Pandora's Box" frame. This suggests that the media may be reflecting what risk communication scholars have long known: what really worry people are not scary "sci-fi" scenarios,

but rather questions of trust and credibility, especially regarding public officials and multinational corporations.

Also presented is a survey of public attitudes about the potential applications of nanotechnology in New York state. Telephone data were collected from February to March of 2005 from a randomly generated sample of New York residents (N=800). Nearly half of respondents said they had heard "not much at all" about nanotechnology, while only about 5% said they had heard "a great deal." Of the people who were willing to make an assessment, 33.2% said "benefits will outweigh the risks"; 14.9% said "risks will outweigh the benefits"; and 52.0% said "risks and benefits will be about equal" (mean: 2.19; SD: 0.9). Support for nanotechnology significantly correlated with higher levels of education and family income. This suggests that nanotechnology is only something more "elite" people are paying attention to, which corresponds with results from the media content analysis. Support for nanotechnology also significantly correlated with how much a respondent had heard about nanotechnology. Given the very low awareness among respondents, quite a few people (more than 70%) were still willing to make assessments about an unfamiliar technology.

When synthesized with other research on this topic, these findings suggest that the general public support for nanotechnology—despite very low levels of knowledge and awareness—may be linked to the overwhelmingly positive media coverage, which has been consistently framed in terms of progress and economic prospects. In combination with their preconceived attitudes about technology in general, people may be taking cues from the media to tell them how to think about this new emerging technology. Still, nanotechnology coverage amounts to a very small part of the overall media landscape. It remains to be seen what, if anything, will launch it to a more prominent position.

BIOGRAPHICAL SKETCH

Jason Gorss is Manager of Media Relations at Rensselaer Polytechnic Institute, where he oversees a staff of science writers and public information officers covering news at the nation's oldest technological university. He has a M.S. in communication from the University of Tennessee with a focus on science journalism, and he received a B.S. in chemical engineering from the Pennsylvania State University. In addition to his professional experience as a chemical engineer, he spent several years as a science writer for the American Chemical Society, and his freelance writing has appeared in a variety of publications, including *Scientific American*, *Chemical & Engineering News*, *Environmental Science & Technology*, and *Cornell Engineering Magazine*.

To Sarah, Simon, and Elliot

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CHAPTER 1

EMERGING TECHNOLOGIES IN THE PUBLIC SPHERE

Nanotechnology as a Public Issue

Nanotechnology is the science of the very small, involving manipulation of atoms at the scale of a nanometer—one billionth of a meter, or about 80,000 times smaller than the width of a human hair. The field has been framed by some as the next industrial revolution, with the promise of producing lighter and stronger materials, energy-efficient manufacturing, advances in medical monitoring and bioremediation, much more powerful computers, and many others. As a public issue, however, nanotechnology is still in its infancy. Indeed, initial surveys show that most people haven't even heard of "nano," let alone formed opinions about it (Bainbridge, 2003; Cobb & Macoubrie, 2004; Scheufele & Lewenstein, 2005; Royal Society, 2004). But some groups in society—including businesspeople, politicians, and academics—are paying close attention to the development of this new scientific field.

Scientists—especially chemists—have been doing work at the nano level for years. A recent search of *Science Citation Index* found that more than 1,400 scientific articles dealing with nanoscience and nanotechnology were published between 1982 and February 2004 (Stephens, 2004). The number of publications is rising steadily, starting with only one in 1987 and increasing to 497 in 2003. Several scientific journals devoted specifically to nanotechnology have sprung up in recent years, including *Nanotechnology*, the *Journal of Nanoparticle Research*, *Nano Letters*, and *Small*.

The U.S. federal government is also making nanotechnology a priority, investing heavily in new research because of its potential for improving both the welfare and the standing of the country. Federal funding for nanotechnology research

and development in the United States has increased from $116 million in 1997 to more than $1 billion in 2005, with the cumulative 5-year nanotechnology investment at $4.7 billion under the Bush Administration. The business community is also investing in nanotechnology, with new companies sprouting up today as Internet and biotechnology companies did in the 1980s and 1990s. Many are eagerly jumping on the bandwagon and applying "nano" to their name, even if the moniker is not quite accurate. The National Science Foundation predicts that nanotechnology could become a $1 trillion global market by 2015, with the potential for staggering advances in pharmaceuticals, semiconductors, optics, and environmental remediation, to name but a few.

Along with all of this "revolutionary rhetoric" (Hilgartner & Lewenstein, 2004) come voices of caution and dissent. A number of interested actors are speaking up about the potential negative side of nanotechnology. Concerns focus on a number of topics: lab safety while working with nanoparticles; privacy issues, including the potential for invasive monitoring with "nanocameras"; political questions about where funding should go and who will benefit from potential technologies; and the various environmental effects of nanoparticles. In January 2003, for example, the Canadian ETC Group (2003) warned that nanotechnology is moving too fast without the proper studies of possible risks, suggesting a moratorium on research into molecular manufacturing. This same organization was instrumental in turning European public opinion against "Frankenfoods."

The issue is also slowly working its way into the popular media. In 2000, Bill Joy, then senior scientist at Sun Microsystems, wrote a widely cited article for *Wired* magazine suggesting that "the future doesn't need us," and questioning whether society is able to handle the implications of continuing development in robotics, genetic engineering, and nanotechnology (Joy, 2000). In 2004, a major story by

Washington Post science reporter Rick Weiss introduced many to the environmental implications of nanotechnology for the first time (Weiss, 2004). Michael Crichton's recent sci-fi novel, *Prey*, is a story of self-replicating nanobots run wild (Crichton, 2002). Nanotechnology has even made its way to the big screen, with cameo appearances in a number of popular movies, including *Spiderman 2*, *The Hulk*, and *Terminator 3*.

And, in a sure sign that nanotechnology is beginning to seep into the public consciousness, an article recently appeared on *Salon.com* detailing how Rabbi Yehuda Berg, Madonna's personal guide into Jewish mysticism, sees incredible similarities between Kabbalah and nanotechnology. Part of the article picks up on a key theme in the discourse about nanotechnology:

> The mantra in the nanotech industry is to learn from the mistakes made in biotechnology and the public rejection of genetically modified organisms. Partly to blame was a "top-down" attitude taken by a scientific establishment that was much too self-important to bother with public attitudes and perceptions. So, consideration of "societal and ethical implications" is No. 1 on the nanotech industry's list. (Lovy, 2004)

Scientists are increasingly realizing that the vast promise of new technologies like nanotechnology does not press forward in a vacuum, and that the public needs to be engaged "upstream" in development to discuss the challenges and opportunities presented by new technologies. From the scientists' perspective, engagement can help prevent the type of backlash that occurred with nuclear power and genetically modified (GM) food. Scientists and policymakers need to consider *implications*, not just *applications*. From the public's perspective, engagement is a tool for the exercise of democratic power, for using its ability to shape the development and use of new

technologies (Wilsdon & Willis, 2004; Dickson, 2001; Anon, 2003; Leshner, 2003; Leshner, 2005).

At an October 2004 workshop for journalists about nanotechnology sponsored by the Kavli Institute at Cornell University, Curt Suplee, director of the Office of Legislative and Public Affairs for the National Science Foundation and former *Washington Post* science reporter, compared nanotechnology to climate change (Suplee, 2004). Suplee suggested that reporters got it wrong on climate change, using a "he said/she said" approach to covering the issue, rather than demonstrating the true weight of scientific consensus. This criticism has been leveled against science reporting in general by several communication scholars (Dearing, 1995; Stocking, 1999). In Suplee's view, reporting about nanotechnology is heading down this same road. But despite the various elements of public discussion listed above, Suplee argued, the issue of nanotechnology has not been framed in a definitive way, so the public is still essentially a "blank slate." He suggested that reporters, academics, scientists, and institutions have the opportunity to do nanotechnology right, right from the start.

To supplement anecdotal propositions such as this, this study attempts to provide a more quantitative understanding of two things: 1) how the major news media have covered nanotechnology in recent years, to gain a preliminary understanding of two particular dimensions of how the media represent the issue: salience and framing. (Salience is an indicator of the attention given to an issue, while framing shows what types of arguments are being mobilized.) 2) The study also provides a glimpse into public attitudes toward nanotechnology, with the goal of understanding the potential linkages between media coverage and public opinion of this latest "emerging technology."

The Unique Nature of Nano

The intense focus on societal issues surrounding nanotechnology, which is unusual in itself, hints at another aspect that sets it apart from other scientific advances. Not only have researchers looked at social and ethical issues, but nanotechnology is also a science aimed from the outset toward societal benefit. Some have suggested that, in the case of nanotechnology, "societal benefit" is simply a euphemism for "making stuff." Nanotechnology represents what many see as a larger shift in emphasis in materials science away from testing theories and characterizing materials towards making useful products. To this end, the ever-expanding worldwide government investment in nanotechnology can perhaps be seen as an investment in national economic and commercial advantage. University scientists, who have long been viewed as dispassionate and above the fray, are also increasingly encouraged to undertake research that can be commercially exploited.

A National Research Council review of the U.S. National Nanotechnology Initiative ("Small Wonders, Endless Frontiers") explicitly underscores these themes, suggesting that nanotechnology is "ultimately about industrial competitive position, and the defining benefit is economic, as new technologies and products move from laboratories to commercial reality" (National Research Council, 2002, p. 3). The NNI was established primarily because nanotechnology is predicted to have "an enormous potential economic impact." Societal and ethical implications are considered a vital component of the NNI, in order to prepare for and adjust to the unexpected impacts of this "second industrial revolution." Note that the authors do not dub it the next *scientific* revolution. Indeed, some have even asked why we in the United States have a National Nano*technology* Initiative, and not a National Nano*science* initiative. The choice of terminology does not seem arbitrary.

Some have suggested that this focus on economic progress translates into a tangible benefit for industry, thus favoring the rich and powerful in society over the poor and powerless (Bainbridge, 2002; ETC Group, 2003). In the field of information technology, this has been expressed in the concept of the "digital divide"—the concern that disadvantaged groups will fail to benefit from computers and advanced communication networks. Similarly, some have spoken of a coming "nano divide," if governments do not develop mechanisms to ensure that the benefits of nanotechnology are equitably distributed. The United Nations Millennium Project Task Force on Science, Technology and Innovation noted that nanotechnology is likely to be particularly important in the developing world, because it requires small amounts of labor, land, and maintenance; it is highly productive and inexpensive; and it requires only modest amounts of materials and energy. Nanotechnology also offers potential applications in health and water sanitation, food security, and the environment, which are key areas of need for the developing world.

But some worry that the wealthy nations will control nanotechnology and sideline applications for developing countries. The ETC Group has already expressed concern that the control of nanotechnology research and development might remain firmly in the hands of industrialized nations, producing a bias towards applications that benefit rich countries but neglect the needs of the poor. Even as nanotechnology research is rapidly progressing, relatively few products are actually on the market. Of those that are available, none address these issues that are important for developing nations. Instead, they have focused on consumer applications such as sunscreens and stain-resistant pants.

While it may exhibit certain peculiarities, nanotechnology can still arguably be viewed as the next link in a long chain of "emerging technologies"—a list that includes information technology, biotechnology, nuclear power, and others. Such

technologies are usually discussed in terms of specific examples, such as pollution-eating nanobots and under-skin chips that carry personalized medical information. But Hilgartner and Lewenstein (2004) suggest that rather than simply viewing them as a collection of specific cases, much can be gained by seeing them as a general phenomenon. "From this perspective, what is most striking is that 'emerging technologies' have become a distinctive social world, a peculiar 'speculative space' found at the edges of technological systems, where innovations are being most actively constructed and transformed" (p. 1). In this dynamic space, emerging technologies are surrounded by their own culture, including various "speculators" making claims of promise or peril (Fortun, 2001).

In public discourse, the notion of emerging technologies conveys unmistakable connotations of revolutionary potential. This "revolutionary rhetoric" often leads to visible controversy, and to compound matters, "many issues involving emerging technologies are hashed out under the glare of media spotlights."

> Technological accidents such as the devastating 1984 chemical factory disaster in Bhopal, India, that killed thousands or the highly visible recent failure of the Columbia space shuttle can expose the hidden messiness of technological systems and the organizations responsible for managing them. Thus, it is no wonder that struggles to control the public display of information often develop. (Hilgartner & Lewenstein, 2004, p. 6)

The concept of "revolution" is thoroughly overused and ill-defined in general discourse, as is its sister term, "paradigm." The reliability of this "revolutionary rhetoric" is not always clear, but when the discourse takes place under the "glare of media spotlights," it illuminates the distinctive space in which an emerging technology operates, and thus provides an opportunity to scrutinize the process and its various actors.

Setting the Agenda

The mass media play an important role in policy-relevant issues, including those involving science and technology, providing the primary arena for debate among scientists, policymakers, industry, and other political and social interests. Not only do the media focus the attention of competing actors and the general public, but the media also shape how policy issues are defined. As Nisbet and Lewenstein (2002) have noted, "Recognizing the importance of media coverage in influencing policy outcomes, various competing interests or political actors often lobby the media to shape the attention and emphasis of coverage in a way that marshals support for their positions" (p. 362.)

How media coverage of an issue affects public opinion is highly complex and contested, but a classic description suggests that the media "may not be successful much of the time in telling people what to think, but it is stunningly successful in telling them what to think about" (Cohen, 1963). This simple, articulate statement set into motion an entire field of social science research that seeks to understand two very important things: 1) how an issue makes it onto the media, public, and/or policy agendas; and 2) how people form judgments about an issue given a limited amount of information.

The observation came at a time when modern democratic theory was replacing classical theory, with its notion of "popular competence"—a citizenry that is fully capable of grasping the range of issues at hand with sufficient depth to participate actively in governing itself. Research has continually shown that even among people who hold strong political opinions, these opinions are often based on little or no factual information or knowledge, and that people tend to screen out potentially dissonant information, perceiving stimuli selectively in terms of preconceived notions

(Cobb & Elder, 1971). The role of the individual citizen began to take a back seat to the *social* requisites of a stable and responsive government. This new model led to a range of questions about how certain issues were selected to be considered within a political system—not questions about influence over individual decisions, but rather who or what yielded influence over the range and types of alternatives available in the public sphere. For as Schattschneider (1960) has noted, "The definition of the alternatives is the supreme instrument of power" (p. 68).

This shift in democratic theory paralleled a shift in communication theory, which had originally focused primarily on the specific cognitive effects of mass media on individuals. The dominant theoretical position in mass communication research during the 1950s and 1960s was the limited effects model, first elaborated by Joseph Klapper (1960). His key observation, which was in stark contrast to the reigning "hypodermic needle" theory preceding him, was that media are more likely to reinforce or crystallize attitudes than to change them: "Mass communication ordinarily does not serve as a necessary and sufficient cause of audience effects, but rather functions among and through a nexus of mediating factors and influences" (p. 8). Klapper suggested that there are five mediating factors in the service of reinforcement: 1) predispositions and the related processes of selective exposure, selective perception, and selective retention; 2) the groups, and the norms of groups, to which the audience members belong; 3) interpersonal dissemination of the content of communications; 4) the exercise of opinion leadership; and 5) the nature of mass media in a free enterprise society (p. 19).

Klapper's notion of opinion leadership became known in communication theory as "the two-step flow"—information flows from the media to opinion leaders, and then from opinion leaders to the public. He also noted that mass communication tends to reinforce societal norms, which is mainly due to the economic nature of media

organizations. A popular newspaper, magazine, or television show is meant to reach the widest audience possible, thus it is in the best interest of editors to avoid offending audience members at all costs. Klapper suggested that this can lead to a reinforcement of the status quo, since the safest path is often the much-maligned middle way. He also noted that with certain "ego-involved" issues, it is more difficult to change attitudes, which explains why advertising is often much more successful than mass media in affecting attitude change—one has much less invested in which shampoo brand they will buy than in their opinions on corporate governance or pollution. In general, Klapper stressed that the mass media does not change; it *reinforces*, whether it be cultural norms or individual opinions.

At the same time, Marshall McLuhan (1964) extended the analysis of media effects beyond traditional modes of communication. He thought of a medium as an extension of the human body or the mind—any technology that can be considered an extension of the human being. McLuhan suggested that media come in pairs, with one "containing" the other. The medium that is contained is the message of the one containing it, but the effects of the latter are obscured for the user, who focuses on the former. This line of thinking led him to his oft-cited statement, "the medium is the message," which means, quite simply, that the message itself has much less impact than the medium that delivers it. Any medium, McLuhan said, exerts its most important effect by changing the interplay among human sensory modalities, or the way our senses relate to one another. He categorized media into "hot" and "cool." A hot medium provides a lot of information and requires little of the user, whereas a cool medium requires a great deal of user participation, but does not provide a lot of information. A telephone is a cool medium; its hot counterpart is a radio. Much has been written about McLuhan in the intervening years—particularly regarding his comment that the advent of television would re-tribalize our world into a "global

village"—but traditional media effects research headed in a decidedly different direction, returning the focus back to the message itself.

Walter Lippmann (1965) was perhaps the first to explicitly link the media agenda with the public agenda in his extremely important book, *Public Opinion*. He spoke of "the world outside and the pictures in our heads," and he suggested that the mass media was the pseudo-environment that connected these worlds together. To Lippmann, the accuracy of news reporting had become the "basic problem of democracy," because, he believed, the power of public opinion had become greater than that of the legislative branch of government. He also suggested that the problem might not just be one of faulty information, but also "an unconscious channeling by the public of unfamiliar material into familiar, but deceptive, categories" (p. xii).

Much of this work explains why it is important to examine public attitudes towards a topic such as nanotechnology, even though it can be argued that most members of the "general public" really know nothing about it. For such issues, people truly live in a pseudo-environment, with no direct knowledge of the topics they are reading about, whether the topic be laboratory studies or clinical trials. They must experience them second-hand, through the prism of a journalist's interpretation. Lippmann eventually concluded that the problem of "the world outside and the pictures in our heads" could not be solved by better and more information. He was, in essence, the first to articulate the notion that has become a cliché for practitioners of science communication—the wholesale abandonment of the "deficit model," which suggests that people will develop more favorable attitudes towards science if they are presented with more information about science. While citizens may operate in a pseudo-environment, their actions (whether they be voting or introducing legislation or making consumer decisions) are based decidedly in the real world. This explains why even uninformed opinion is worth examining—mass opinion affects policy

direction, even though it is routinely ill-informed. While mass preferences do not usually dictate scientific policy choices, public opinion can affect success or failure of new technologies and their products (Cobb, 2004).

A classic example of the disconnect between real-world indicators of issue importance and media coverage was the "war on drugs." During the mid-1980s, the issue of drug abuse became a hot topic on the media agenda, stimulated mainly by the drug-related death of basketball star Len Bias in 1986 and Nancy Reagan's "Just Say No" campaign. Yet real-world indicators of drug use showed that drug-related deaths actually decreased during the 1980s. Research indicated that during this time the intense media coverage of drugs influenced both public opinion and policy decisions. According to Dearing and Rogers (1980), "The rise and fall of the drug issue on the national agenda in the late 1980s suggests that the agenda-setting process for this issue was a social construction, bearing little relationship to the objective indicator of deaths due to drugs in the United States. This social construction of the drug issue was mainly driven by the mass media" (p. 22).

A similar situation occurred with AIDS in the 1980s. The spread of the *issue* of AIDS during this timeframe did not closely reflect the spread of the disease itself. According to Dearing (1989), both the number of survey questions asked about AIDS in public opinion polls and the mass media coverage of AIDS all increased over the six years from 1981 to 1987, suggesting that the agenda-setting function also extends to pollsters, i.e., media coverage tends to set the agenda for public opinion polls. Three major events catalyzed media coverage and polling during this time: 1) a mid-1983 report that newborn babies in New York City had AIDS; 2) the actor Rock Hudson's diagnosis with AIDS in the summer of 1985; and 3) the controversy about testing for AIDS in spring 1987 (p. 316). Yet the rise in coverage caused by these events did not accurately reflect the number of AIDS cases at the time. As Dearing noted, "Poll

results on a public issue like AIDS, when published and broadcast by the mass media, may reinforce the mass media's agenda-setting function upon the public by legitimizing the mass media's choice of an important issue" (p. 326).

The first study to really look at agenda-setting scientifically was the so-called "Chapel Hill Study" (McCombs & Shaw, 1972). The researchers studied the role of the mass media in the 1968 presidential campaign in Chapel Hill, N.C., selecting 100 undecided voters because they were presumably those most open or susceptible to campaign information. These voters were asked what they thought were the most important issues in the upcoming election, despite what any politicians said were the most important issues. Then the researchers measured the media's most important issues via content analysis. They found an overwhelmingly strong correlation between the important issues stressed by both groups, which they considered evidence for an agenda-setting function of the mass media. McCombs and Shaw stressed that the correlation was pertinent to the *salience* of particular issues, not necessarily how people were going to vote. Yet these saliences are the incidental and inevitable byproduct of journalistic practice and tradition, stemming from the structural and organizational characteristics of the profession. And contrary to what Klapper might have predicted, voters attended reasonably well to all news, regardless of which candidate or party issue was stressed. This, they noted, was evidence for agenda-setting, not for Klapper's selective perception, which would have suggested that the correlations between voters and news about their own party should be strongest.

McCombs (1994) also noted that some issues are especially salient to people even without any news coverage—e.g. unemployment or the cost of gasoline. Such issues, which literally obtrude in our daily lives, can be labeled as "obtrusive." Other issues, which McCombs calls "unobtrusive," are only put on the public agenda through media coverage: "What most Americans [know] about the situation in the

Middle East and U.S. foreign and military policy [comes] entirely from the news media" (p. 7). People have a "need for orientation" with these issues, McCombs suggests, which means that they are likely to be more susceptible to the agenda-setting function of the media. One might expect that scientific and technological issues would fall into this category, since people tend to have little real-world experience with them. Indeed, research shows that the majority of people learn about science after they graduate high school directly from the mass media. Yet McCombs also offers a counterargument that individuals sometimes have less interest in more distant, unobtrusive issues, thus lowering their need for orientation. It could just as well be argued that science issues fit snugly into this category, much to the chagrin of science enthusiasts everywhere.

As agenda-setting research has progressed, a constant issue has been the question of causality: Do the high correlations between media coverage and public opinion simply indicate that the media are successful in matching their messages to audience interests? Theories from Klapper and others about the economic nature of media organizations seem to support such an argument, since editors have a strong interest in catering to their readers' interests. The recent discussions about "civic journalism" also enter into this realm, as do the many and varied studies about the sociology of journalism. The issue has yet to be resolved, and researchers will no doubt continue exploring the complex interrelations of the media, policy, and public agendas (Bauer & Gaskell, 2002; Nisbet & Huge, 2007). But it is clear that the media play a very important role in elevating issues to the public and policy agendas, thus increasing their chances of receiving consideration by policymakers.

This agenda-setting role of the media has been demonstrated in a range of scientific controversies, most recently biotechnology and stem cell research (Nisbet et al., 2003; Nisbet & Lewenstein, 2002; Nisbet, 2005; Brossard & Nisbet, 2007). In the

early stages of development, the mass media can be a major source of people's ideas about a new technology. Thus it is important to gauge how various media outlets are treating nanotechnology, in an attempt to understand the overall climate surrounding the issue.

The agenda-setting function of the media also extends to questions of scientific risk and uncertainty. Technical risk assessment focuses narrowly on the *probability* of events and the *magnitude* of specific consequences, defining "risk" by the multiplication of the two terms. Yet social scientists and sociologists have suggested that risk events interact with psychological, social, and cultural processes in ways that can heighten or attenuate public perceptions of risk and related risk behavior (Douglas & Wildavsky, 1982; Kasperson, 1992). One of the main processes that can act to either amplify or attenuate risk occurs through the mass media.

Journalistic norms require "objectivity," which usually translates to the journalist acting as a sort of scribe and simply telling someone else's story through quotes and other attributions. This can allow various "actors" to take the stage in media stories, and when it comes to scientific issues, these actors are frequently government officials and scientists. Communication researchers have long studied how news consumers use the media, but more recently scholars have begun to recognize how the media are used (and perhaps abused) by others, including scientists.

Bucchi (1998) notes that scientists are by no means extraneous to the presentation of science by the daily press or by television, but rather they use the media in various ways to perpetuate their own needs and interests. For example, in the debate about the Big Bang sparked by data from NASA's Cosmic Background Explorer (COBE) in 1992, scientists turned to the public as a means of settling the dispute. In this case, the Big Bang became a boundary object allowing different actors to interact at the public level. Another, and perhaps more cynical, view has also

emerged in relation to how scientists use the media. This is exemplified by what Hilgartner (1990) has termed the "dominant view" of popularization. He argues that this conception rests on a two-stage model: scientists develop genuine knowledge and then popularizers spread streamlined versions to the public. Hilgartner suggests that the dominant view serves scientists as a powerful tool for sustaining the social hierarchy of expertise. The dominant view, he notes, sets science aside and says that the public cannot access it.

Nelkin (1995), in her critical look at science writing for the general public in the United States, revealed the constraints and biases of journalists and the surprisingly forceful public relations strategies of scientists, universities, corporations, and the government. She demonstrated how science journalists often act as promoters and "sellers" of science and technology, depicting scientists as miracle workers and magicians. Nelkin highlighted the "shared culture" between science journalists and scientists, which often leads science writers to favor information sources that are predominantly from scientific institutions—whether they be scientists or public information officers. They also rely heavily on routine channels of information within the scientific community, including news releases, professional meetings, science journals, and press conferences. This shared culture between scientists and journalists leads to a common and lamentable "gee whiz" brand of coverage, which usually serves the scientific community more than the public, Nelkin suggests.

The influence of science on *what* gets covered in the media also extends to *how* it gets covered. Dunwoody (1999) suggests a pattern that once a science topic becomes news, mainstream science's notion of what matters continues to drive the interpretive framework of stories. For example, in the debate over recombinant DNA in the 1970s, scholars who studied media coverage found that mainstream scientists played a much greater role in setting the media agenda than did community leaders or

scientific outliers. As a result, Dunwoody notes, coverage emphasized recombinant DNA as a scientific or technical challenge, not as a philosophical, political, or safety issue.

Dunwoody suggests that scientists have successfully set the agenda for media science coverage, and part of the reason that she and others suggest is that science journalists are not as skeptical as they should be (Crewdson, 1993). A problem that arises, however, is how a journalist can handle competing claims from scientists when the journalist does not have the technical knowledge to sufficiently scrutinize the information. One less well-known example of such a case involves an inquiry ordered by the Canadian government in 1974 to study the social, economic, and environmental impact of a pipeline to carry natural gas in the Canadian western Arctic. The inquiry lasted for three years, generating extensive debate over the impact of pipelines on the biota of the western Arctic. In this case, different organizations enlisted scientists to provide expert testimony. These experts polarized into two camps: critics and defenders (Campbell, 1985).

The event demonstrates how people use not only scientific information, but also lack of information—i.e., uncertainty. Campbell (1985) found a strong tendency among scientists allied with critics of the pipeline to argue that the knowledge base regarding environmental impacts was inadequate to push forward with the plan. On the other hand, scientists allied with defenders of the pipeline also spoke of gaps in knowledge, but they used these "ignorance claims" to assert that the potential problems were insignificant and not worthy of holding up the project (Stocking, 1999). Both sides constructed scientific ignorance in different ways, using it as a "strategic element in expert arguments" (Campbell, 1985, p. 447).

Journalists often pick up on these arguments, portraying stories in a classic "he said/she said" style. Part of this stems from the norm of journalistic objectivity, and

part is a holdover from methods of political journalism that do not necessarily work for science issues. But the above example suggests that scientific controversies naturally fall into such a format, even among scientists. This style has been criticized from many sectors, especially when journalists give space to "maverick scientists," as some have in the current debate on climate change, despite an overwhelming consensus among scientists about the cause of climate change (Dearing, 1995).

Stocking (1999) suggests that this "strategic ritual of objectivity" permits corporate and other institutional interests to amplify their claims, thus giving them a privileged place in news coverage. Interestingly, it can also be used to give legitimacy to maverick scientists and others who are far from being institutionalized. Either way, however, the consensus among scholars seems to be that this strategic ritual is hardly the best approach to science reporting.

Making the News

The debate about journalistic objectivity and "bias" is not exclusive to science writing, and it certainly is not new. Many of these themes were presaged by sociologists in the 1970s and early 1980s, who pointed to the norm of objectivity as one among many conventions and organizational constraints that lead reporters to choose the stories they write about and the sources they rely upon for information.

Cobb and Elder (1971) began by asking questions about whom or what yielded influence over the range and types of alternatives considered in the public sphere, focusing on how different interest groups articulate grievances and transform them into viable issues that require decision makers to take action. Modern democratic theory, they argued, cannot explain how at some particular time a previously dormant issue can be transformed into a highly salient political controversy when the basis of the grievance has existed for some time. The inertia of the political system makes it

extremely difficult to get an issue on the agenda and to facilitate any sort of change in the cavernous bureaucracies of federal and state governments. They noted several characteristics of groups that explain their differing abilities to get issues noticed: some groups have more resources than others or are better able to mobilize those resources; some groups are held in greater public esteem than others and thus can command greater access to decision makers (e.g., doctors, lawyers, church leaders); and some groups are located so strategically in the social or economic structure of society that their interests cannot be ignored. For example, "Farmers have an inherent advantage over minority groups in getting the system to respond positively to their needs because there are many decision makers who identify with farm groups and the pivotal position of agriculture in the American economy" (p. 908).

In the end, however, it often seems to come down to power, which in practice typically translates into money. A recent example can be found in President George W. Bush's "American Competitiveness Initiative," which he announced during the 2006 State of the Union Address. The initiative called for a doubling within 10 years of the federal commitment to basic research in the physical sciences, as well as programs to stimulate scientific and technical education in the United States. Scientists and educators have been warning for years of America's potential crisis of competitiveness in science and engineering, but in this instance it took something more to elevate the issue to the President's agenda: "What was different this year, according to a number of Capitol Hill lobbyists and Silicon Valley executives, was support on the issue by Republican corporate executives like Craig R. Barret, the chairman of Intel, and John Chambers, the chief executive of Cisco Systems" (Markoff, 2006).

Cobb and Elder were mainly interested in the policy agenda, but they also noted the potential for the media to play an important role in elevating issues to the

systemic agenda and increasing their chances of receiving consideration on institutional agendas. Certain individuals in the public sphere act as opinion leaders, bringing publicity to particular issues by commenting on them or even adopting these issues as their own. Some opinion leaders are simply people who appear frequently in the news, such as Jesse Jackson. When they speak or appear in public, it becomes news, whether or not they have anything substantial to say. Other opinion leaders can be pundits whose writings appear in the editorial pages or whose musings appear on talk shows and network news broadcasts. Thomas Friedman, an editorial columnist for the *New York Times*, is a good example. He also played an instrumental role in raising policymakers' concerns about this country's flagging competitiveness in math and science by writing columns about the topic and referring often to it in his best-selling book, *The World is Flat*.

By spending a significant amount of time in the newsrooms of the *New York Times* and the *Washington Post*, Leon Sigal (1973) shed light on the symbiotic and often uncomfortable relationship reporters have with officials, who are reporters' main source of news. He notes that news content has been explained through the years in a number of ways, including the selective processes of individual reporters; the technological considerations of the medium involved (*a la* McLuhan); the business nature of news organizations, with advertising rather than circulation driving profits; as well as the unequal amount of influence imposed by owners and publishers. Yet all of these explanations are based upon rational decisions by unitary actors, whereas "newsmen" (as Sigal refers to them) don't work on their own, but in large, bureaucratic organizations. Sigal suggests that newsmaking is a consensual process—the product of the choices of many, not of a single actor, no matter how powerful he may be. These choices, however, are governed by a set of shared values or conventions that lead to U.S. government officials dominating the news.

Journalism is filled with uncertainty. What counts as "news"? Who makes for a reliable source? Which parts of a story should be emphasized, and which should be left out? For reporters, conventions are essential in managing this uncertainty, and they are a key aspect of the consensual nature of the news. Reporters often turn to the consensus of their peers to determine what counts as news, following up on a story only after another prominent media outlet has covered the topic. This practice makes for an interesting paradox. On one hand, reporters are always looking for a "scoop," to be the first person to write about a story. Yet at the same time, they want validation from their peers that a story is newsworthy, so they want to see something having been written about first by someone else. For Sigal, understanding these processes behind how the news gets made is a pre-requisite for understanding what news means (p. 186).

When faced with unstructured, non-routine occurrences, newsmen try to fit them into a pattern congruent with these conventions, Sigal notes, and he outlines several of them (p. 66): objective reporting, reliance upon authoritative sources, news pegs, exclusives, inverted pyramids, simplification, and others. Reporting thus becomes an almost ritualistic process, where journalists define what news is and how they will cover it based primarily on instinct. For example, by covering only topics that can be simplified easily and squeezed into a specified structure, many important but complex areas of science or policy get ignored, even though readers might benefit from a deeper understanding of these topics.

Sigal's chief point is that the constraints of newsmaking and the conventions of reporting mean that journalists end up relying on routine news channels, which gives sources the opportunity to exploit them. Journalism is one of the few professions in which the practitioners rely almost completely on the "good will" of their information sources to make their product, without offering any payment in return. A good

example is the prevalence of "the exclusive." By offering exclusive information to a reporter at a time that is convenient to a source, and likewise withholding information when it is inconvenient, sources hold sway over reporters as gatekeepers of information. This type of interaction usually applies to government officials, but the same principle works in the world of science. Most reporters don't have time to mine all of the scientific literature or to keep track of the research activities at every university or laboratory, so they are often at the mercy of the scientific institutions that put out press releases and hold press conferences, as Nelkin (1995) noted.

Even the way news organizations are structured leads to reliance upon routine sources of information, according to Sigal (p. 127). The beat system, for example, concentrates reporters in locations where they are likely to get news through routine channels, particularly major cities and the nation's capital, Washington, D.C. These routine channels are the mechanism by which officials—mainly from the U.S. government—dominate the news, because a disproportionate number of reporters are assigned to the White House, Congress, and the various arms of the federal bureaucracy. The same is true with science. Most science writers focus mainly on a few major journals (*Science* and *Nature*) and scientific meetings (American Association for the Advancement of Science) to find their stories, which gives those particular "officials" the chance to dominate the news. Science reporters also turn to the same elite institutions ostensibly because of their reputation for quality, but perhaps also simply because of name recognition, which gives other institutions less of a chance to convey their work, even when it is of major importance. Likewise, reporters maintain a stable of contacts that they inevitably turn to for any kind of theme, almost as a knee-jerk reaction, which gives certain scientists repeated opportunities to interpret scientific results in the media (Dunwoody, 1980).

When a newsroom relies on a small group of sources, the sources themselves tend to be larger organizations. These larger organizations may not offer better information, but simply have more ability to provide a consistent flow of information than the smaller source with fewer staff (Berkowitz, 1987).

Beat specialization can also cause reporters to become too close to sources. As Sigal put it, "From routine reliance it is but a short step to dependence" (p. 106). For example, the uncritical coverage in the early years of the manned space program may not have been due solely to the National Aeronautics and Space Administration's (NASA) success at news management, according to Sigal (p. 48). "Many of the journalists covering Apollo were so caught up in the drama of the space race that they came to regard themselves as part of the NASA 'team.' The technical language that they used in talking to NASA personnel set them apart from other journalists and contributed to 'team' solidarity." The result is that reporters may become spokespeople for their news sources rather than dispassionate observers, becoming sloppy about recognizing that alternative views may exist. After the *Challenger* disaster, a number of reporters on the NASA beat switched assignments because their editors felt they had become too close to the organization to recognize the structural problems within NASA that may have led to the incident (Boot, 1986; Lewenstein, 1993).

In light of the potential for exploitation of reporters, what explains the reliance upon conventions and routine sources of information in the journalism profession? Most of the conventions can't be explained by economic self-interest, Sigal claims, but rather the ideological richness of the "journalist's creed" is strongly associated with the existence of role strains that the creed might ease. "A number of the tenets of the creed seem to be associated with a strain resulting from the newsman's involvement and intimate knowledge of the policy-making process in Washington

without the status and power that accrues to officials who are as deeply involved" (p. 90).

To complicate the matter, news sources of all stripes have adjusted their thinking and tailored their actions to play to these conventions and routines, in order to get maximum exposure for their views. For example, by releasing long speeches or reports to journalists ahead of time on an embargoed basis, officials can steer reporters to the sections that they want to emphasize (p. 106). It seems that the attitude among officials and other sources has become that the news is too important to be left to reporters. This has led to an explosion of growth in the public relations industry, especially in sectors where such activities have not traditionally been encouraged or sought after, such as science. Nelkin (1995) notes that scientists were not traditionally interested in public visibility, but rather they feared it could result in external controls on their work. But these attitudes have changed in recent years, as scientists have become increasingly dependent on corporate support of research or direct congressional appropriations. They see that scholarly communication with peers is no longer sufficient and that gaining national visibility through the mass media can be crucial to securing the financial support required to run major research facilities and to assuring favorable public policies toward science and technology (p. 133) (Leshner, 2003; Lane, 1996). Institutions of all varieties are realizing that they can get their message out by tapping professionals with knowledge of journalistic conventions and the ability to exploit them (not necessarily in the negative sense of the term).

Herbert Gans (1980) echoed many of Sigal's critical points in his study of *CBS Evening News*, *NBC Nightly News*, *Newsweek*, and *Time*. He found that a very small number of "knowns"—people of influence such as presidents, CEOs, federal and state officials, etc.—appeared repeatedly in his content analysis of these media outlets. And national news was operationally defined as the federal government, much as Sigal

found in his study of reporters and government officials. When "unknowns" do appear in the news, they are unrepresentative of normal people: criminals, deviants, or individuals exhibiting any sort of strange behavior. What ordinary people do rarely makes the news, according to Gans.

Gans suggests that, despite a pretense to objectivity, journalists make value judgments all the time. There is, underlying the news, a picture of how society ought to be; values come through in what actors or activities are reported or ignored, and how they are described and framed (p. 40). Gans lists several enduring values that appear frequently in the news: ethnocentrism, altruistic democracy, responsible capitalism, small-town pastoralism, individualism, moderatism, social order, and national leadership. For example, news about democracy is generally treated as a friendly political contest with winners and losers, but not an outright battle between forces of good and evil. Likewise, extreme behavior is often featured in the news, but it is almost universally criticized. By focusing on extremism and disaster (disorder), news is implicitly favoring moderatism and order (p. 57). And the news does not just reflect a generic brand of order, but specifically a "white male social order." Most news is about affluent people, and upper-middle-class practices are thus universalized as if they are shared by most Americans. When underrepresented minorities and women are featured, they are generally aspiring to or assimilating into this order. The news pays attention to and upholds the actions of elite individuals and elite institutions, focusing primarily on leaders who promote and restore order.

Journalists must routinize their task to make it manageable, relying on what Gans calls "considerations"—the unwritten rules that journalists apply to manage their work. (Sigal called these conventions; others have referred to them as norms or even strategic rituals.) Reporters don't make conscious decisions about news, but rely instead on quick, intuitive judgments or "feel" (p. 82), and the application of these

judgments requires consensus among journalists. For reporters, many story ideas come from other stories, seeking a new angle on something that is already news. This is partly because the story has already been judged newsworthy by a peer, such as the *New York Times*, which has been called the primary peer source for reporters, especially those covering science.

Gans also reviews several theories of how stories get selected: journalist-centered theories, based on an autonomous and ideological individual; organizational theories that consider the economic constraints of newsmaking and the division of labor in news organizations; event-centered theories, including the notion that events dictate the news, and journalists simply hold up a mirror to these events; and deterministic theories, such as the technological determinism of McLuhan. For Gans, however, news is primarily "the exercise of power over the interpretation of reality." Of all the considerations that dictate journalistic routines, those governing the choice of sources are the most significant. The question of access is the most salient. Gans describes the process of newsmaking as an intricate dance between sources and reporters, as each seeks access to each other (p. 116). And more often than not, it is the sources that do the leading, because journalists are generally short-staffed and don't have the time or the means to actively seek breaking news in the enterprising fashion that they might prefer.

Four factors shape access to journalists, according to Gans (p. 117): incentives, power, the ability to supply suitable information, and geographic and social proximity. Access to reporters generally reflects the social structure outside of the newsroom, with the elite and powerful more readily available to reporters. The powerless must resort to civil disturbances to obtain access, whereas at the other end of the social spectrum, the president has unlimited access to reporters. Affluent organizations have at their disposal any number of tools to influence the journalistic process, including

the ability to pre-schedule activities to meet reporters' deadlines and need for content (p. 122).

On the other side of the coin, for journalists, the main consideration when determining the suitability of a source is efficiency. Reporters are always in a hurry, and news organizations must be efficient, above all other things, because they are expected to deliver the latest news to the audience at a prescheduled time. Similarly, "past suitability" is an important factor as well, which leads to reliance upon the same stable of sources because the reporter knows they can be trusted and are easy to turn to under tight deadlines. Other considerations also lead to elite sources dominating the news, according to Gans. Reporters consider authoritativeness to be a key factor, which gives priority to public officials, heads of organizations, and certain other respected groups in society, such as doctors and academics. Articulateness is another consideration, which helps certain people who are adept at speaking in sound bytes get more attention, because they make a reporter's job easier to do, even if what they are saying lacks substance.

In a related strand of thought, sociologist Gaye Tuchman, in her book *Making News* (1978), contends that news is the social construction of reality. The book is based on a series of participant observations in media newsrooms and interviews of newspeople over a period of 10 years. The act of making news, Tuchman says, is the act of constructing reality itself rather than a picture of reality (p. 12). She asserts that the news is an ally of legitimated institutions and that it also legitimates the status quo. Tuchman links news professionalism and news organizations to the emergence of corporate capitalism. She argues that news is a social resource whose construction limits an analytic understanding of contemporary life (p. 215). She contends that "through its routine practices and the claims of news professionals to arbitrate knowledge and to present factual accounts, news legitimates the status quo" (p. 14)

Gans, however, makes an important distinction between agency beat reporters and substantive beat reporters. Agency beat reporters cover one specific branch of the bureaucracy, and thus they have to work closely with sources, which means they have to be careful what they write so it doesn't upset the sources that they are dependent upon (p. 133). Substantive beat reporters, on the other hand, don't become participant-observers in one agency, but instead rely on sources that are more spread out geographically and professionally. The resulting relationship is less symbiotic, but it still can lead to a kind of shared culture. These reporters develop close relationships with a few trusted resources, and they often become ambassadors for their specialty, which makes them even more sought-out by sources looking to promote their own views. And general reporters are a different breed altogether. There is typically much more uncertainty involved in their work, since they will frequently know nothing about a topic about which they must write a story on deadline. This leads them to lean even more heavily on "authoritative" sources, because they can't invest the time and effort into determining the quality of a source. And they also tend to develop a herd mentality, according to Gans, relying extensively upon the exchange of information with their peers. It turns out that the majority of news is actually gathered by generalists, which means that specialists like the science writer lead an uneasy existence in a generalist profession (Dunwoody, 1980).

The work of Sigal, Gans, and Tuchman highlights a tension among scholars: the issue of power as a causative agent. In essence, this is a "chicken and egg" problem. On one hand, scholars point to the structure of the journalism profession, and even to the inherent merit of the issues themselves, as the primary causative factors that put an issue on the agenda. As Dearing and Rogers (1996) put it, "Understanding how democracy works can be better achieved by studying the power of issues rather than the issue of power" (p. 16). On the other hand, some scholars suggest that

reporters are simply pawns in the hands of institutional powers that exert influence on behalf of their own parochial interests. Still others describe the process as a consensual transaction between journalists and their sources.

No clear reconciliation of this tension has emerged, but many scholars in recent years have shifted their focus from power as a causative agent to the *relationships* of power and activity that link institutions, policymakers, and the public (Lewenstein, 2005). In the world of science, this has led to a better understanding of what the field "science and the public" is all about. "Two major results have emerged from this research tradition: a distinction between 'deficit models' of public understanding and more nuanced contextual models, and an interest in participatory models for engaging the public in science, especially in science policy" (p. 170). Another outcome is a renewed focus on how people process information and form attitudes about science and technology.

Framing

One way to synthesize the sociological view of the journalism profession with agenda-setting theory is with the concept of "framing," which implies that messages are often presented (or framed) in a particular way, and different ways of presenting the same information influence the way audiences interpret the messages. Reframing an issue is critical for changing audience interpretations.

Framing first gained prominence in the writings of Erving Goffman. His notion of a frame includes definitions of a situation that are built up in accordance with principles of organization that govern events, and his goal was to isolate basic frameworks in society for making sense out of these events (Goffman, 1974). Gamson and Modigliani (1989) and Gamson (1992) were perhaps first to apply this concept to the mass media, originally in a study of media discourse about nuclear power, and

then extending the analysis to three other issues demonstrating "collective action" frames: affirmative action, troubled industry, and the Arab-Israeli conflict. Gamson suggests that when engaging in political talk, "People are not so passive, [p]eople are not so dumb, and [p]eople negotiate with media messages in complicated ways that vary from issue to issue" (p. 4). He notes that mass media is a very important tool in framing an issue, but not the only tool, as some communication scholars might like to believe. Likewise, conventional wisdom in the world of political science has always caused one to wonder how people can manage to have opinions about so many matters about which they lack even the most elementary understanding. But to Gamson, there are other kinds of knowledge, including experiential knowledge and popular wisdom, which people integrate with media discourse to form a "frame" of understanding about an issue.

When a group is trying to win support for an issue, it is labels that are often the target of symbolic action. Controlling the way an issue is labeled in the media and popular discourse is often the first battle toward winning the war, amounting to defining what the debate is actually about. For example, with the abortion debate, which is now a classic example of framing, the pro-life side is suggesting that the issue is about a baby's life, whereas the pro-choice side is trying to argue that the issue is about a woman's choice. Gamson calls attention to affirmative action in this regard (p. 9). For proponents of affirmative action, the issue is about remediation of the sins of the past, but for opponents, it is about reverse discrimination. As mentioned above, it seems that the overwhelming use of the term "nanotechnology" as opposed to "nanoscience" suggests that one side has already succeeded in winning this battle over labels.

But sometimes other factors come into play that are outside of a pressure group's control. The journalistic convention of telling "stories" dictates that articles

almost always focus on motivated actors in a debate, rather than the structural causes of events (p. 34). And not all symbols are equally potent, according to Gamson. "Some metaphors soar, others fall flat; some visual images linger in the mind, others are quickly forgotten. Some frames have a natural advantage because their ideas and language resonate with a broader political culture" (p. 135). Journalists often use media frames as guidelines in helping them select what information to spotlight and what to ignore: "Facts take their meaning by being framed in some fashion" (p. 120).

In his study of these four issues, Gamson found a strong relationship between injustice frames in media discourse and injustice frames in popular discourse. When no injustice frame was present, there was no moral indignation about an issue, which made it difficult to stir up discontent and support. This is one reason why opposition to nuclear power was never as vehement as it could have been, because people found it difficult to perceive injustice in a situation if a nuclear power plant was not going to be placed in their town. And for the four different issues, there was a different emphasis on each of the three knowledge mechanisms: media discourse, experiential knowledge, and popular wisdom. For nuclear power, people tended to get their initial information from the media, and then they would fall back on popular wisdom about technology and nature to form their positions. But rarely did anyone have experiential knowledge of nuclear power plants, making the issue what Gans would call "unobtrusive." As noted earlier, most scientific and technical issues fall into this category, since few people have experiential knowledge of them.

The specific frames that played out in each issue are also linked to broader cultural themes common to many issues, according to Gamson. In the nuclear power debate, the broader themes on the pro-side are technical progress and mastery over nature, while the counter-themes are harmony with nature and technology run amok. Again, many technological issues share these frames, including biotechnology and

nanotechnology. For Gamson, this suggests a different way of looking at the long-standing debate over the magnitude and nature of media effects on public opinion. The effects discussed here are effects *in use*: "Instead of treating media content as a stimulus that leads to some change in attitudes or cognition, it is treated as an important tool or resource that people have available, in varying degrees, to help them make sense of issues in the news" (p. 180).

In his analysis of media coverage of the emergence of the New Left movement in the late 1960s and 1970s, Gitlin (2003) shows in detail how the media first ignore new political developments, then frame aspects of the story that treat these movements as oddities. As Gans (1979) found in his media study, the media portray a picture of the world in line with the status quo, the accepted social order. According to Gitlin, "The news that man has bitten dog carries an unspoken morality: it proposes to coax men to stop biting those particular dogs, so that the world can be restored to its essential soundness. The media divide movements into legitimate main acts and illegitimate sideshows" (p. 6). And Gitlin suggests that journalistic routines naturally lead to this type of framing. Simply by doing their jobs, he says, journalists tend to serve the political and economic elite definitions of reality. Frames, according to Gitlin, are principles of selection, emphasis, and presentation composed of little tacit theories about what exists, what happens, and what matters. Media frames are largely unspoken and unacknowledged, but they serve to organize the world both for journalists who report it and for those who rely on their reports. These frames are "persistent patterns of cognition, interpretation, and presentation, of selection, emphasis, and exclusion, by which symbol-handlers routinely organize discourse, whether verbal or visual" (p. 7).

Gitlin draws together a theory of news coverage suggesting that mass media have become core systems for the distribution of ideology—a form of anti-democratic

social management. Mass media exerts its influence through a similar process as what Antonio Gramsci described as hegemony—a ruling class's domination of subordinate classes and groups through the elaboration and penetration of ideology into their common sense and everyday practice. It is the systematic (but not necessarily deliberate) engineering of mass consent to the established order (p. 253). Normally the dominant frames are taken for granted by reporters. Hegemony necessarily operates outside consciousness, Gitlin says, and it is exercised by professionals who view themselves as pursuing the seemingly neutral goal of informing the public. Gitlin also sees this process at work in media treatment of the anti-nuclear and other later movements: "In today's world, political movements feel called upon to rely on large-scale communications in order to *matter*, . . . but in the process they become 'newsworthy' only by submitting to the implicit rules of newsmaking, by conforming to journalistic notions of what a 'story' is, what an 'event' is, what a 'protest' is" (p. 3).

Entman (1993) notes that framing has become a "fractured" paradigm in the social sciences, with no general statement of a framing theory or how frames make their way into texts. He suggests that the field of communication can synthesize the disparate uses of this concept, and he offers his own definition:

> To frame is to *select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation* for the item described. (p. 52, italics in original)

Scheufele (1999) further synthesized the fragmented approaches to framing theory by breaking previous approaches down along two dimensions: the type of frame examined (media frames vs. audience frames) and the way frames are operationalized (independent variable or dependent variable). Studies of frames as

dependent variables often examine the factors that influence the creation of frames, and Scheufele notes that journalists' framing of an issue can be influenced by several social and organizational variables. Researchers have identified at least five factors that can potentially influence how journalists frame a given issue: social norms and values, organizational pressures and constraints, pressures of interest groups, journalistic routines, and ideological or political orientations of journalists (p. 109). All of these factors will be familiar from the above discussion about "making the news."

Others have looked more explicitly at how journalists cover scientific and environmental issues. Downs (1972) has suggested that public attention to issues such as the environment characteristically passes through five stages: (1) a pre-problem stage that leads to (2) a period of alarmed discovery associated with specific problems or hazards. Then (3) the public realizes the cost of making significant progress, thus followed by (4) a gradual decline of intense public interest, which finally leads to (5) the post-problem phase, in which attention toward the issue settles down, although at a higher level than that at which the cycle was initiated and subject to what Down calls "spasmodic recurrences of interest." Downs argues that environmental issues are naturally susceptible to these issue-attention cycles because of inherent aspects in the issues themselves. These inherent aspects shape public and media attention (and non-attention), according to this theory.

Downs' formulation has been criticized for a number of reasons, including his focus on the linear nature of issue-attention cycles. McComas and Shanahan (1999) suggest that a narrative perspective provides one avenue for reconciling these criticisms. They argue that it is a matter of social, institutional, and communicational choices to construct issues in certain ways, not that a particular issue has an inherent level of pre-given excitement. Journalists, they say, seek not only to cover inherently

exciting issues, but also to construct issues as exciting. In their analysis of climate change stories in the *New York Times* and the *Washington Post* between 1980 and 1995, they found that media attention to global warming was cyclical, and the authors suggest that the ability of journalists to construct narratives influenced these attention cycles.

This notion is fairly intuitive; journalists are always looking for "the story." But it also fits with a strand of communication theory first presented in detail by Walter Fisher. Narrative Paradigm Theory (Fisher, 1987) suggests that humans are essentially "storytelling animals," and therefore narratives subsume all other forms of communication. Rationality is determined by the nature of persons as narrative beings—their inherent awareness of *narrative probability*, what constitutes a coherent story, and their constant habit of testing *narrative fidelity*, whether the stories they experience ring true with the stories they know to be true in their lives. In short, the way humans make their decisions is through stories that offer "good reasons" to act one way or the other. The logic of good reasons is the method of determining a good story, based essentially on the criteria of narrative probability and narrative fidelity. As Gamson noted above, all metaphors and images are not equally potent. Some frames have a natural advantage because they *resonate* with the broader culture—in other words, they have more narrative fidelity.

In a similar vein, Nisbet et al. (2003) found that media attention to stem cell research peaked when the issue was most easily dramatized, and that the potential for drama was maximized when the issue shifted from administrative policy contexts to overtly political arenas such as Congress and the Presidency, where elevated levels of agenda-building are more likely to occur. Here, stories can be reported (or framed) using familiar storytelling themes and formats, including matters of political controversy and ethics/morality. Journalists working on a political beat are also more

likely to cover topics in these arenas, and newspapers tend to feature political reporting more prominently than science reporting.

Brossard et al. (2004) extended the discussion of issue-attention cycles to include cultural factors. In their cross-cultural comparison of newspaper coverage of global warming in France and the United States, they found that French coverage was more event-based, focused on international relations, and presented a more restricted range of viewpoints on global warming than American coverage did. They suggest that researchers move beyond studies at the national level to include cross-cultural comparisons, which may be essential to understanding how different news regimes might affect public opinion. Given the general differences in attitudes toward science and technology between Europe and United States—and toward nanotechnology in specific (Gaskell et al., 2005)—this approach offers potential for future studies that might compare differences in media coverage of nanotechnology across cultures.

Attempts to further synthesize this "fractured paradigm" abound, and much of the recent focus has been on the issue of biotechnology. In analyzing the heated debate about biotechnology in Switzerland, Dahinden (2002) suggests that frame theory is a promising approach for better understanding science communication because frames are relevant on all levels and in all phases of mass communication processes, including journalist routines, media content, public attitudes, and even public relations activities. Entman's definition of a frame is too narrow, Dahinden says, preferring to identify frames on the above levels as well as the level of the general culture, as traditional narratives and myths that also are relevant for modern societies. With Gamson, Dahinden finds that most frames are not issue-specific, but of a more general nature.

Bonfadelli (2005) suggests that the most important effect of mass media may lie in their ability to structure and organize the world for audiences. People form

judgments and opinions about issues based on "cognitive structures" planted over time by the media through selection, emphasis, and framing. Since biotechnology is a complex issue that people have little personal experience with, the media's portrayal of the topic should have a strong influence on how they perceive biotechnology, Bonfadelli asserts. In examining the knowledge gap hypothesis as it relates to biotechnology in Europe, he found that education levels and media input are both important factors in determining attitudes toward biotechnology, and that these factors operate on the country level, not just on the individual level. His study showed that people in countries with high levels of education and with intensive communication among groups and through the mass media are more knowledgeable about biotechnology than people in countries with lower levels of education and communication.

Priest's (2006) study of gene technologies in the public sphere illustrates the complex relationship between public opinion and media coverage. In seeking to explain the apparent resonance between the climate of opinion and media frames in different regions of Canada and the United States, she suggests that the dynamics of collective attitudes and behavior are not reducible to individual-level attitudes or cognition, but depend on both culture and social structure (p. 57). Priest rejects both the reduction of opinion to a characteristic of individual psychology and the reduction of risk debates to stand-offs between scientific experts and a "lay public," preferring to find a middle ground based partly in cultural theory. Within particular societies, sub-cultural groups exist that have shared values and beliefs, forming a climate of opinion that lends expression to collective views. Her results indicate that "the differences between the United States and Canada in terms of public opinion regarding particular genetic technologies may be best understood in terms of identifiable attitudinal clusters with distinct geographic distributions" (p. 70). These clusters resonate with

the available media data, which show that while reporters have the opportunity to make dissent visible and enable informed public debate, they instead depend primarily on visible events and vocal spokespersons, making it difficult to realize their potential to contribute to healthy democratic society.

With an eye toward integrating the vast literature from communication researchers, political scientists, and sociologists, Nisbet and Huge (2006) have sought to synthesize these common threads into one overarching theory linking press coverage to public opinion and the policy process—what they call "a model of mediated issue development." Seeking generalizability across a variety of scientific and technological issues, Nisbet begins with stem cell research (Nisbet et al., 2003; Nisbet, 2005), then turns his attention to plant biotechnology, intelligent design, and the Human Genome Project. The model conceptualizes several important underlying social mechanisms that drive cycles of media attention and definition to policy issues, highlighting as underlying mechanisms (1) the type of policy venue where debate takes place or is centered, (2) the media lobbying activities of competing strategic actors as they attempt to interpret or "frame" the issue advantageously, (3) the tendency for different types of journalists to depend heavily on shared news values and norms to narrate the policy world, and (4) the context relative to other competing issues (Nisbet & Huge, 2006, p. 7).

Stem cell research and plant biotechnology offer an opportune comparison. For both issues, discussions initially began in administrative policy contexts, where scientists and technical arguments held the most weight. Media coverage during this phase was scant, with stories only appearing occasionally by science reporters. Also for both issues, certain "framing events" caused media coverage to rise, but here is where the similarities end. Stem cell research has become a "celebrity issue," ever since President George W. Bush announced that he would limit federal funding for

embryonic stem cell research in 2001. But despite several seemingly important controversies related to plant biotechnology, including the Starlink and Monarch Butterfly incidents, this issue has not grabbed the media spotlight, much to the consternation of activists who oppose this technology. Despite attempts to shift the debate toward more dramatic frames by various opposition groups, media discourse in the United States around plant biotechnology has remained predominantly technical. Because the issue has remained within administrative arenas, and because the issue has remained defined in technical and scientific terms, it is likely that journalists have been unable to place plant biotechnology into a larger narrative structure, giving greater meaning to passing events, which might lead to an increase in coverage of the issue (p. 32). Stem cell research, on the other hand, was catapulted from the administrative policy arena to the overtly political arena after President Bush's announcement, which caused a shift in reporting from scientific reporters to political and general assignment reporters, and a corresponding increase in media coverage.

The model of mediated issue development also attempts to link these media issue cycles with public opinion. While a central assumption of scientists and science enthusiasts throughout the years has been that increasing public understanding of an issue via the media will automatically lead to increased public support for research, Nisbet (2005) suggests that people are essentially "cognitive misers," relying primarily on their existing value predispositions and only the information most readily available to them from the mass media to formulate opinions about complex technical policy issues. For the issue of stem cell research, Nisbet found that religious values moderate the influence of a person's awareness on their support for an issue, further complicating the perceived deficit model that many scientists still operate under. For highly religious people, an increase in awareness and understanding of stem cell research does not translate into more support, presumably because they are relying on

religious predispositions more heavily than information, according to Nisbet. However, for individuals who are non-religious or moderately religious, the more they see, read, or hear about stem cell research, the more likely they are to call upon positive considerations when forming an opinion about the subject, especially given the generally positive media coverage of the issue.

Overview

This thesis attempts to apply various aspects of these foregoing theories to the public discourse surrounding nanotechnology, with the goal of attaining a better understanding of the complex interactions among media coverage, public opinion, and policy debates about emerging technologies. While nanotechnology is new to the public agenda, several things are already clear: The few public opinion surveys that have been performed to date show that public awareness and knowledge of nanotechnology is very low. Public attitudes toward the development of nanotechnology, on the other hand, are generally positive. Media coverage in the early years was sparse, but the attention paid to nanotechnology by reporters was usually positive. The following two sections will examine media coverage (Chapter 2) and public attitudes (Chapter 3) about nanotechnology more closely, while attempting to shed light on both the mechanisms behind and the interactions between the two.

CHAPTER 2

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Content Analysis of Media Coverage

The goal of this part of the study is simply to *describe* media coverage of nanotechnology, but with an eye toward trying to understand the issue-attention cycles of nanotechnology and other emerging technologies, and to eventually uncover the social mechanisms that are behind these cycles. More broadly, the goal is also to see if media coverage and public opinion surrounding emerging technologies follows a characteristic pattern. According to Hilgartner and Lewenstein (2004), "Much work needs to be done to systematically map the contours, dynamics, and topology of the social, political, and technical features that constitute the speculative space of 'emerging technologies'" (p. 6).

Several others have studied examples of emerging technologies in the public sphere, most notably related to nuclear power and biotechnology (Gamson & Modigliani, 1989; Gaskell & Bauer, 2001; Nisbet & Lewenstein, 2002; Ten Eyck & Williment, 2003; McInerny et al., 2004). Gamson and Modigliani analyzed discourse on nuclear power from 1945 to1989 in four general audience media: television news coverage, newsmagazine accounts, editorial cartoons, and syndicated opinion columns. When the discourse was compared with public opinion surveys, they found that public opinion about nuclear power could only be understood by rooting it in an issue culture that was both *reflected* and *shaped* by the media. This classic study formed the basis for several research projects analyzing media discourse and public opinion on biotechnology in the latter part of the 20th century.

The most obvious comparison for the current study is Nisbet and Lewenstein's analysis of biotechnology in the American elite press from 1970 to 1999. They found

that media attention in the *New York Times* and *Newsweek* steadily increased across the 1980s and most of the 1990s, although it was significantly event-driven, peaking and plummeting in response to major occurrences in the scientific realm. The tone of this coverage was consistently positive, with overwhelming emphasis on the frames of scientific progress and economic prospect.

Nisbet and Lewenstein chose to base their biotechnology study on a set of narrowly defined research questions rather than hypothesizing specific media trends, because of the limited availability of previous quantitative research characterizing the nature of media coverage of biotechnology. But since nanotechnology may follow a similar trajectory as biotechnology and other emerging technologies, this should offer a basis for hypothesizing. The general hypothesis guiding this study is that media coverage and public opinion surrounding emerging technologies follows a regular pattern, and specifically that media coverage of nanotechnology will follow the same basic trajectory, in terms of salience and framing, as did biotechnology before it. More specifically, the following hypotheses are presented:

Hypothesis 1: Coverage will start out very low and then rise steadily when triggered by certain "framing events" in the scientific and public spheres.
Hypothesis 2: In the early stages of development, coverage will be overwhelmingly positive, with most stories focusing on progress and economic prospects.
Hypothesis 3: As time passes and nanotechnology seeps into the public consciousness, coverage will spread from elite media outlets to more general media outlets.

Methods

To assess the place of nanotechnology in the media, a content analysis was conducted of three "elite" media outlets (*New York Times, Washington Post, Wall*

Street Journal) and one general media outlet (*Associated Press*) for the period 1 January 1986 to 30 June 2004. The first year of the study was chosen as 1986 because it is often considered the beginning of the "canonical history" of nanotechnology—when Eric Drexler published his landmark book *Engines of Creation*, which laid out his vision of the revolutionary potential of molecular manufacturing. The final sample contained about 620 relevant articles, drawn from a pool of all articles that contained the words "nanotechnology" or "nanoscience" in the Lexis-Nexis online database (for the *New York Times* and the *Associated Press*) or the Factiva online database (for the *Washington Post* and the *Wall Street Journal*). The coding sheet was based on the coding sheet used in Nisbet and Lewenstein (2002), with changes made after exploratory coding. After training resulting in intercoder reliability of more than 75% for all items, coding was performed in waves by two graduate students and one undergraduate.

Elite media outlets were included because coverage in opinion-leading publications like these is likely to represent the prevailing tone of coverage in the United States. As Gitlin (1980) has observed, stories tend to spread vertically within the news hierarchy, with editors at regional news outlets often deferring to elite newspapers and newswires to set the national news agenda. These papers also set the science agenda because they often have much larger and more experienced science reporting staffs. And since nanotechnology is a science-related issue in its early stages of development, discourse is still most likely to take place among various elites. Studies have shown that, traditionally, leaders in America—whatever their specific discipline—focus their attention mainly on the *New York Times*, the *Wall Street Journal*, and the *Washington Post* (Weiss, 1974). Although the balance among these particular publications and newer media like all-news channels and the Web has changed in recent years, no clear analyses have emerged.

The *Associated Press* was also chosen to include a more general media outlet in the study, and print was chosen over television or radio because it is more amenable to content analysis, but also because there is some evidence that print media set the agenda for other types of news outlets (Lopez-Escobar et al., 1998; Roberts & McCombs, 1994).

The analytical approach laid out by Gamson and Modigliani (1989) and refined by Gaskell and Bauer (2001) and Nisbet and Lewenstein (2002) was adapted for this study, with some slight modifications. Using a well-tested scheme such as this provides an extra measure of reliability in the research design process. The approach, which allows for measurement of both relatively manifest article content as well as more latent and interpretive content, involves identifying key "themes" in the media coverage, as well as "frames" in the articles. The theme of the story is simply its topic, and a story can have more than one. Measuring themes provides an indicator of the type of nanotechnology research presented in the article, or the related economic, political, or social developments featured by journalists. Coders could choose from five themes: "applications" (proposed and actual uses of nanotechnology); "policy" (current legislation); "politics" (bipartisan support/disagreement, federal monies issues); "financial" (investment reports, economic opportunities); and "safety or risks." An "other" category was available for the coder to write in a different theme not articulated in this list. The coder could choose more than one theme per article, assessed on a four-point scale including "not present," "briefly mentioned," "present," and "dominant."

At first glance, the notion of "frame" differs only subtly from "theme," but it is an important distinction. The concept of a frame plays on the image of a picture that is defined at the edges, putting a drawing or a photograph into a defined context. The meaning of the picture depends on the context that is opened up by the frame. By

analogy, a news story on a certain *theme* is presented within a particular *frame* of discourse that puts the topic in a particular light and perspective (Gaskell & Bauer 2001, p. 40). These media frames offer a central organizing idea or story line that provide meaning to an unfolding series of events, suggesting what the controversy is about, and the essence of an issue (Gamson & Modigliani, 1989). When an issue does appear in the media, if interests can define their stand as well as the alternatives available for discussion, then they have "framed" the situation in more winnable terms, restricting the arguments the opposition can make and shutting them off from participation (Berkowitz, 1992). Frames also serve as working routines for journalists that allow journalists to quickly identify and classify information, packaging it for audiences. These organizing devices are especially useful when journalists find themselves in unfamiliar territory.

Table 1 presents the framing typology for nanotechnology coverage, broken down into eight categories (with a ninth option for the coder to insert "other"). Some frames are inherently more positive, such as "progress" and "economic prospects," while others like "Pandora's Box" and "runaway" are generally negative. But a frame is meant to be an organizing idea, not necessarily a positive or negative assessment. For example, "economic prospects" can also be negative if the article predicts negative effects on the economy from nanotechnology. The issue is still framed as primarily an economic one, suggesting that the economic side of nanotechnology is the most important—regardless of a positive or negative effect. Likewise, a story emphasizing the "public accountability" frame could present negative aspects, such as a lack of proper concern for public issues by the certain members of the scientific community. Or a story could be positive, extolling the virtues of an institution that engages the

Table 1. A framing typology for nanotechnology.

Progress: report of technical development; nanotechnology represents the "wave of the future."
Economic Prospects: nanotechnology's effect on the economy.
Ethical: nanotechnology is either morally necessary or morally repugnant.
Pandora's Box: developing nanotechnology will create unforeseen ills.
Runaway: nanotechnology may spiral out of human control.
Public Accountability: coverage about ethical, legal, and societal implications; influence over research and development.
Long Way Away: applications from nanotechnology will be in the distant future.
Confluence: nanotechnology represents a confluence of technologies including biotechnology, information technology, and cognitive science.

NOTE: Framing typology is adapted from Nisbet & Lewenstein (2002) and Durant, Bauer, and Gaskell (1998), and was originally developed in part by Gamson & Modigliani (1989).

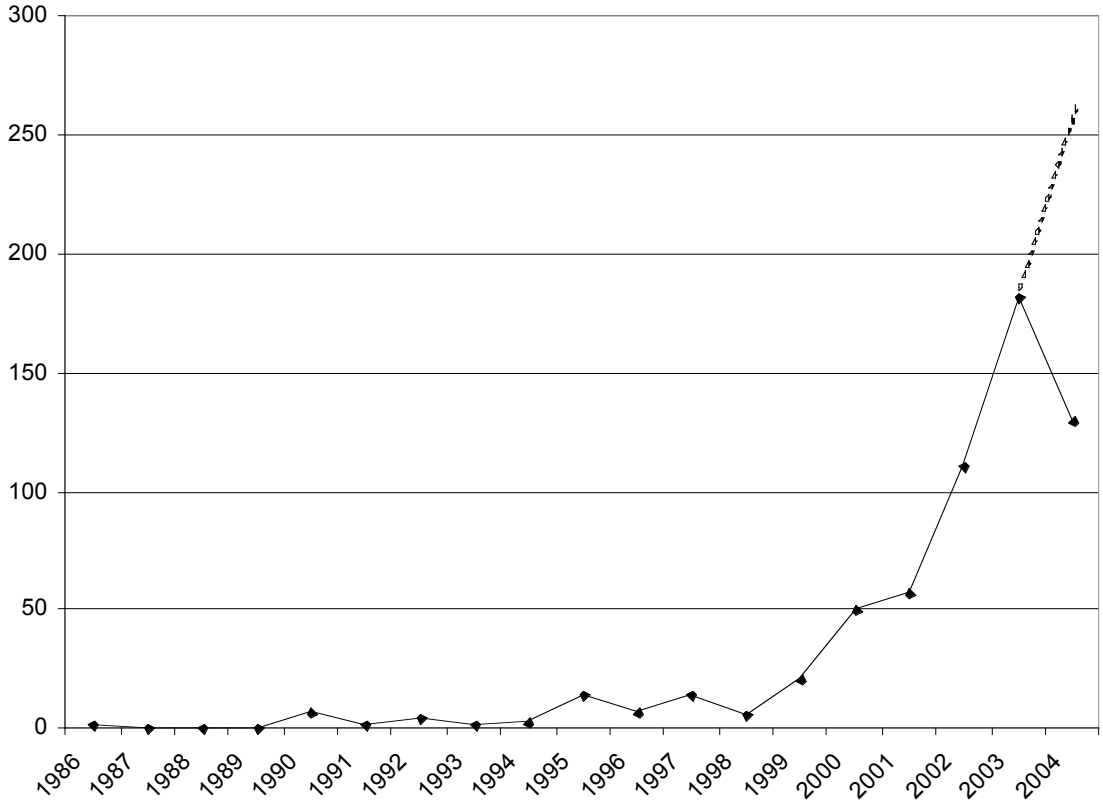
public in developing nanotechnology. In either case, the story is demonstrating that societal concerns are a particularly salient aspect of nanotechnology.

Two of the frames that were originally associated with biotechnology—globalization and nature/nurture—are not especially pertinent to nanotechnology and did not appear in preliminary readings, so they were excluded from the coding. Likewise, a preliminary analysis revealed two new frames: the idea that applications of nanotechnology will not appear for years into the future ("They're a long way away"), and the idea that that nanotechnology is part of a confluence of emerging technologies including biotechnology and artificial intelligence. The coding sheet also included questions about whether an article presented positive and/or negative aspects of nanotechnology. Rather than addressing this as an either/or option, the coders were allowed to note if an article presented both positive and negative aspects, and to what degree (a three-point scale for positive and negative, including "none," "some," and "many or strongly").

Results

Since nanotechnology is still in the very early stages of issue development, this is necessarily a preliminary study, and only descriptive observations of the data are presented. The goal is simply to begin to understand both the amount of coverage and the tone of coverage. The basic trajectory of coverage shows that media attention to nanotechnology began in 1998, rising quickly from just a few articles a year to more than 150 in 2003 (Figure 1: The apparent dip in 2004 is an artifact of having data for only half the year; the total will probably far surpass the 2003 total). This trajectory follows the same pattern as biotechnology did in its early stages of issue development.

Figure 1. Total number of articles about nanotechnology in the *New York Times*, *Wall Street Journal*, *Washington Post*, and *Associated Press*, 1986-2004. (Dotted line represents projection for 2004, since data only include half the year.)



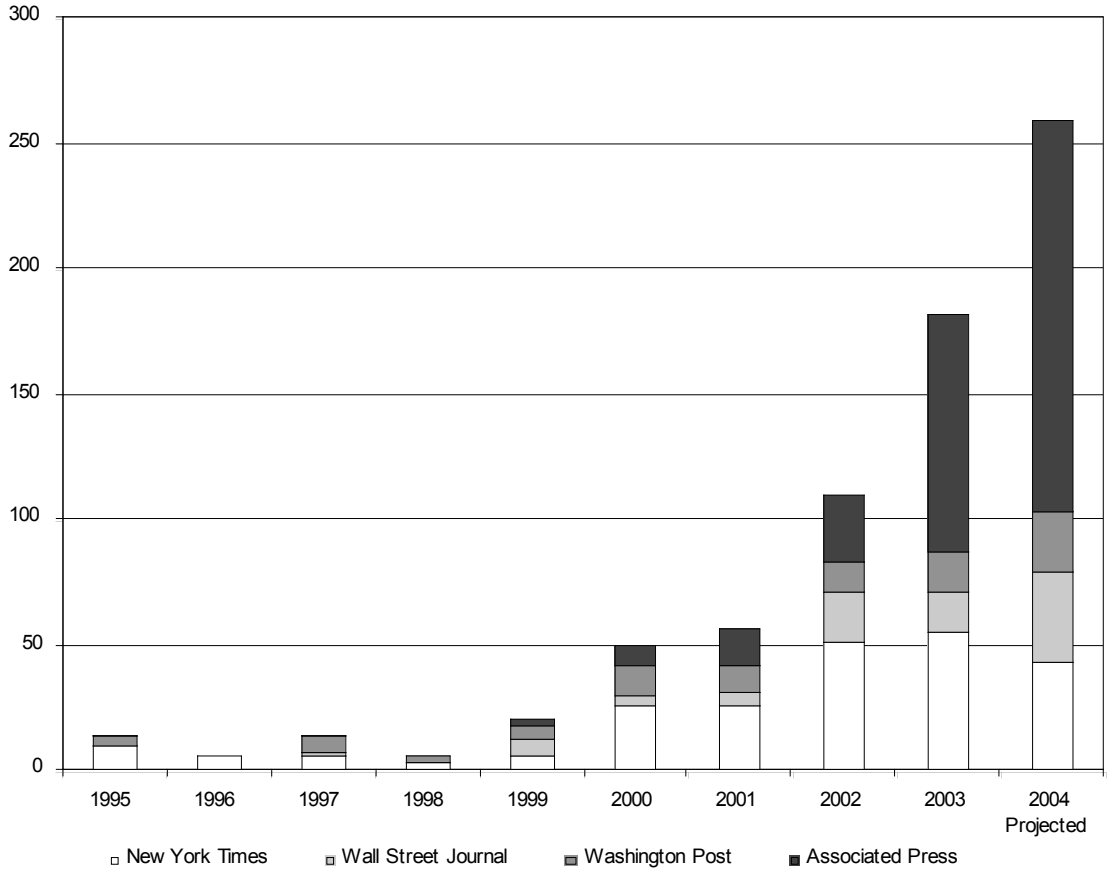
Using data from Nisbet and Lewenstein (2002), a comparison was made between coverage of biotechnology in the *New York Times* and nanotechnology coverage in the same newspaper. (The *New York Times* was the only common publication between the two studies.) Year 1 for biotechnology corresponds to 1970; for nanotechnology, year 1 is 1986. The comparison is somewhat artificial, since these are just the starting dates for both content analyses, but it showed that the amount of coverage in the early years is very similar for both emerging technologies. A somewhat more meaningful comparison emerges when the dates are shifted so that the first spike in coverage for both issues occurs at the same time, which corresponds to 1977 for biotechnology and 1995 for nanotechnology. The first spike engendered almost exactly the same number of articles for both technologies in the *New York Times*. For biotechnology, 1977 is the year when Congress held hearings and introduced legislation related to recombinant DNA. No clear framing event emerges in the media coverage of nanotechnology in 1995, except perhaps the release of a book by Ed Regis called *Nano: The Emerging Science of Nanotechnology*. The comparison also showed that nanotechnology coverage has reached the same level of coverage in 2004 as biotechnology coverage did at about this time—16 years into the study. The first major spike in biotechnology coverage occurred in 1980, producing almost 40 articles on the subject in the *New York Times*. 1980 marked the beginning of the "biotechnology boom," as industrial development of biotechnology began to take off. Nanotechnology's first major spike occurs a little later in 2000, producing about 25 articles. This was the year when Bill Joy's article appeared in *Wired*, but 2000 also saw a number of advances in nanotechnology that were covered by the *New York Times* science writing staff—from the first bacteria-size machine to a tiny "camera in a pill." Since events in the scientific realm and the public sphere rarely (if ever) follow a predictable pattern, there is no reason to expect that nanotechnology will follow the

same exact cycle as biotechnology. But taken together, these data suggest that nanotechnology coverage is event-driven, rather than issue-driven.

Across each of the four publications, coverage has generally increased steadily over time (Figure 2). Two main exceptions occur: The number of articles in the *New York Times* seems low for 2004, while *Associated Press* coverage does not really appear until 2000 and then rises very quickly in 2003 and 2004, far surpassing the other publications. (Since data was only available for the first half of 2004, it has been doubled for this graph to illustrate the projected value for the full year.) The explanation for the lower number of *New York Times* articles is unclear. The large jump in *Associated Press* coverage, however, seems to indicate that interest in nanotechnology is spreading to a wider public beyond the audience of the elite press.

Figure 3 details the total number of positive assessments and negative assessments across four time periods, including stories that were coded as presenting "some" positive aspect or "many" positive aspects (and likewise for negative assessments). Coverage throughout the entire period is overwhelmingly positive. Figures 4 and 5 show the number of stories exhibiting positive and negative assessments by theme. Articles about applications and finance dominate the coverage, and, as would be expected, these tend to be more positive in tone. Articles about risks associated with nanotechnology are clearly negative in tone, but such articles are only a small part of the overall mix. The key observation from these data is that positive stories tend to be much more strongly positive than the negative stories are negative. For each theme, the "some" and "strongly" positive assessments dominate, with only a few stories containing no positive emphasis. On the other hand, the vast majority of stories contain no negative assessment at all. Those that do tend to only have "some" negative aspects as opposed to being "strongly" negative. This demonstrates further how overwhelmingly positive the coverage is in general. Again, these tendencies

Figure 2. Number of articles by publication beginning in 1995 and including the projected value for 2004.



NOTE: The values for 2004 have simply been doubled to illustrate the projected value. No statistical inference was done to obtain these numbers.

Figure 3. Percentage of stories with positive and negative assessments over time.

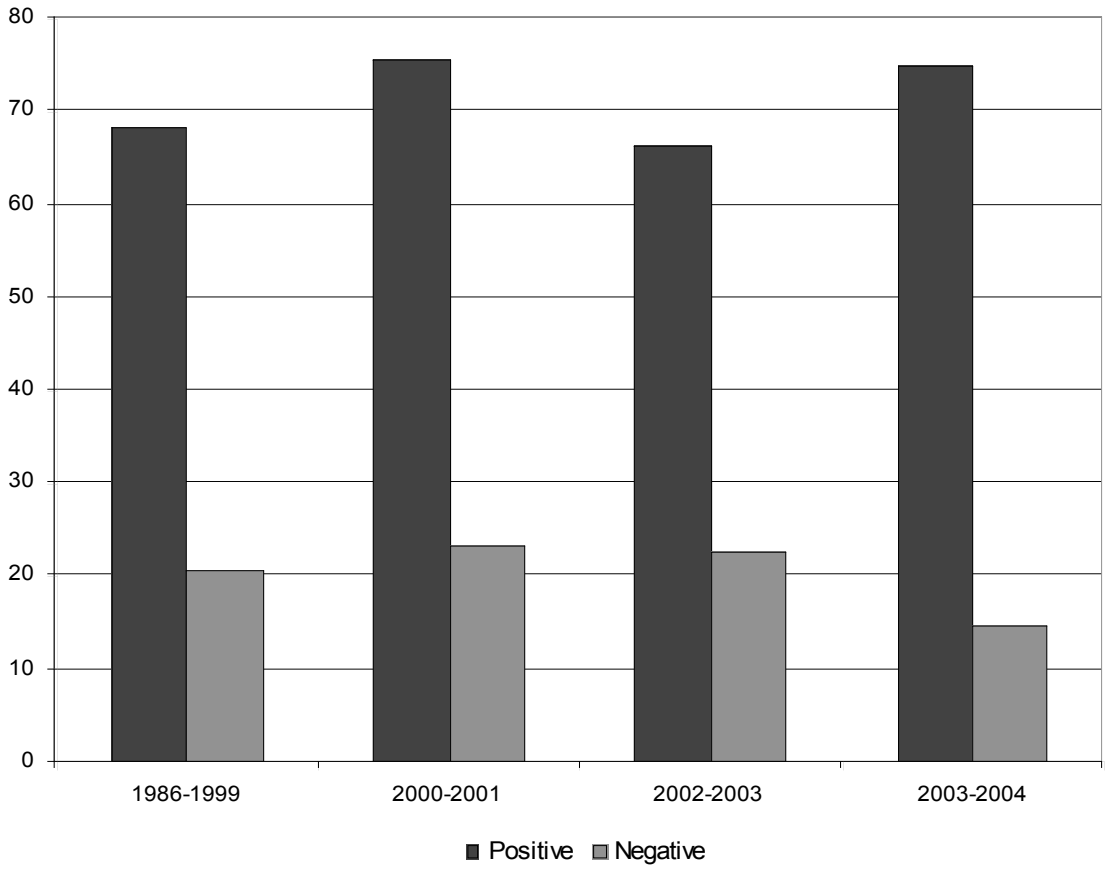


Figure 4. Number of stories containing positive assessments by theme.

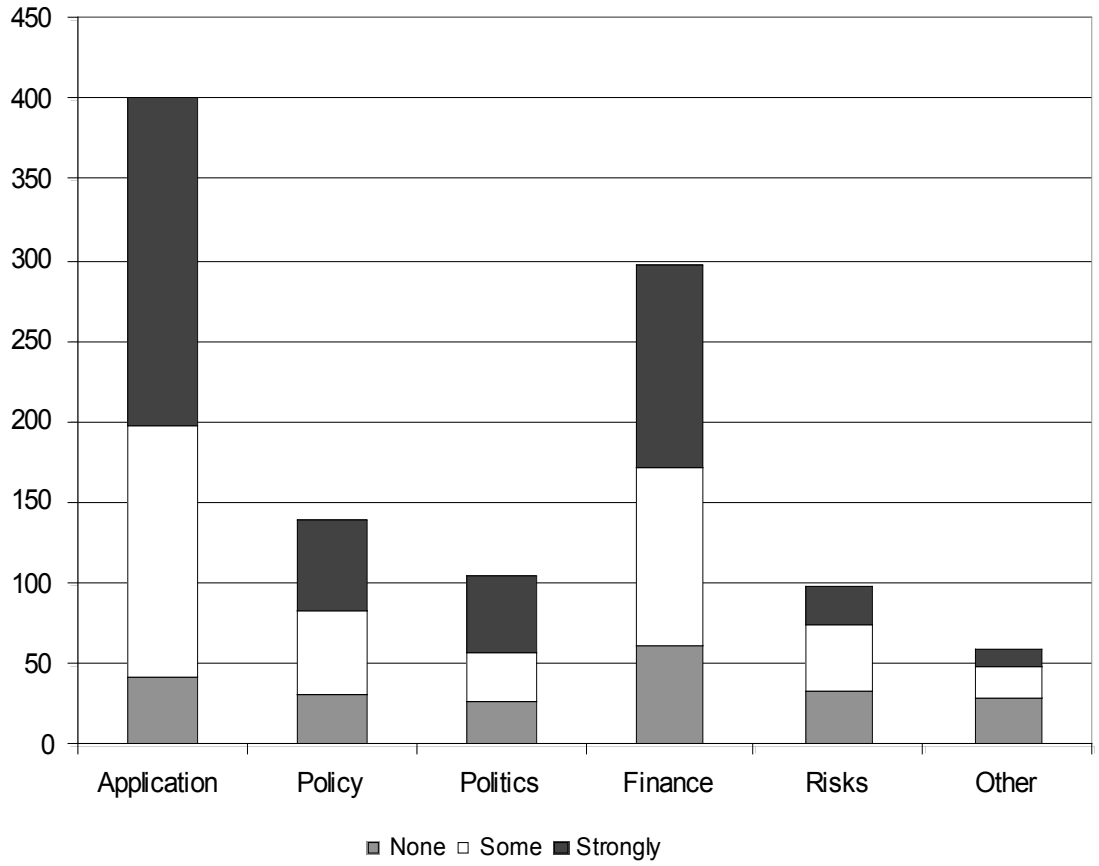
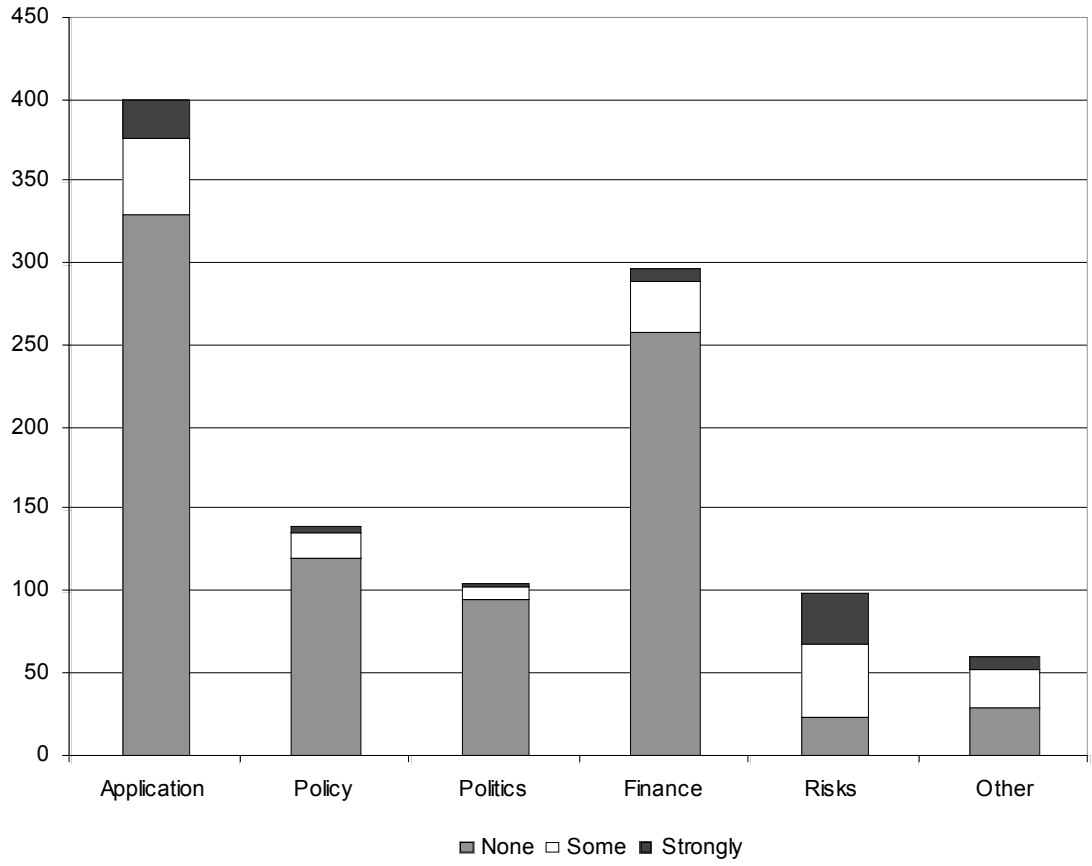


Figure 5. Number of stories containing negative assessments by theme.



roughly parallel the positive and negative assessments of biotechnology seen in earlier coverage.

Irrespective of the year, the vast majority of articles tend to frame nanotechnology in terms of progress and economic prospects (Table 2: The frames have been weighted to a percentage scale based only on the dominant frame in each story. More than one frame could actually appear in a given story). The "public accountability" frame arises fairly early and remains present throughout. "Long way away" appears in 2000 and 2001, but then does not show up again as a dominant frame. At the same time, economic frames have become a steadily larger part of the media picture, making up almost as large a percentage of the overall mix as progress frames in 2004, which may suggest that as researchers continually present more findings based on nanotechnology and as products make their way to market, these technologies do not seem as far away as they once did. Interestingly, "runaway" and "Pandora's Box" do not appear until 2002 and 2003, corresponding with the release of Michael Crichton's *Prey* in 2002 and the ETC Group's report in early 2003, which both focused on the uncontrollable nature of nanotechnology. These frames were not dominant in any stories during the first part of 2004, which would suggest that the effect of these publications might be dissipating. This would further support the notion that nanotechnology coverage is event-driven.

Figures 6 and 7 show the number of stories exhibiting positive and negative assessments by frame. As with the themes, articles about applications and finance dominate the coverage, and are much more positive in tone. Negative assessments show up significantly only with "runaway" and "Pandora's Box," as would be expected. But as Figure 6 demonstrates, these can also be framed in a positive manner. Again, the positive assessments are much more positive than the negative assessments,

Table 2. Percentage of stories exhibiting particular dominant frames, beginning in 1999

Dominant Frame	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Progress	84	46	77	65	60	63
Economic Prospects	11	6	13	14	16	26
Ethical	0	4	3	0	1	0
Pandora's Box	0	13	0	9	8	9
Runaway	0	13	0	4	4	0
Public Account.	5	9	3	3	8	2
Long Way Away	0	7	3	1	0	0
Confluence	0	2	0	3	2	0

Figure 6. Number of stories with positive assessments by frame.

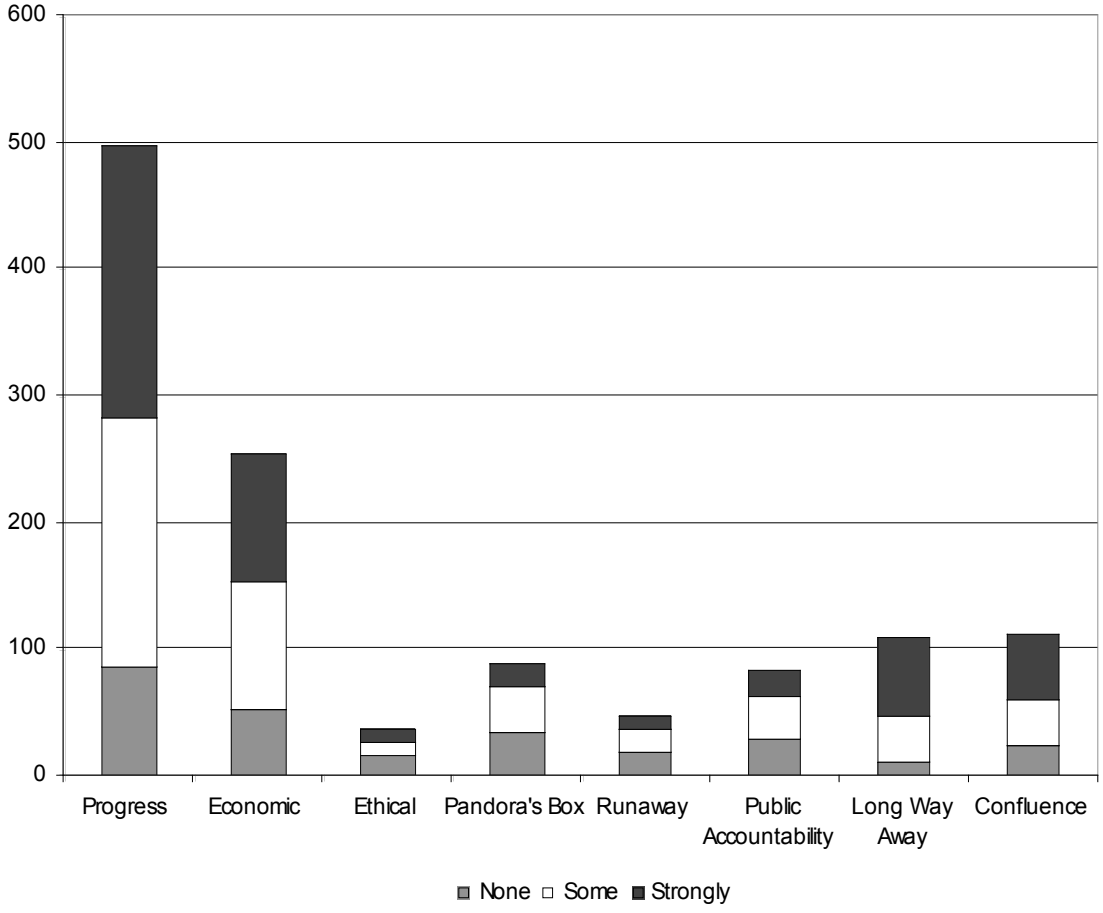
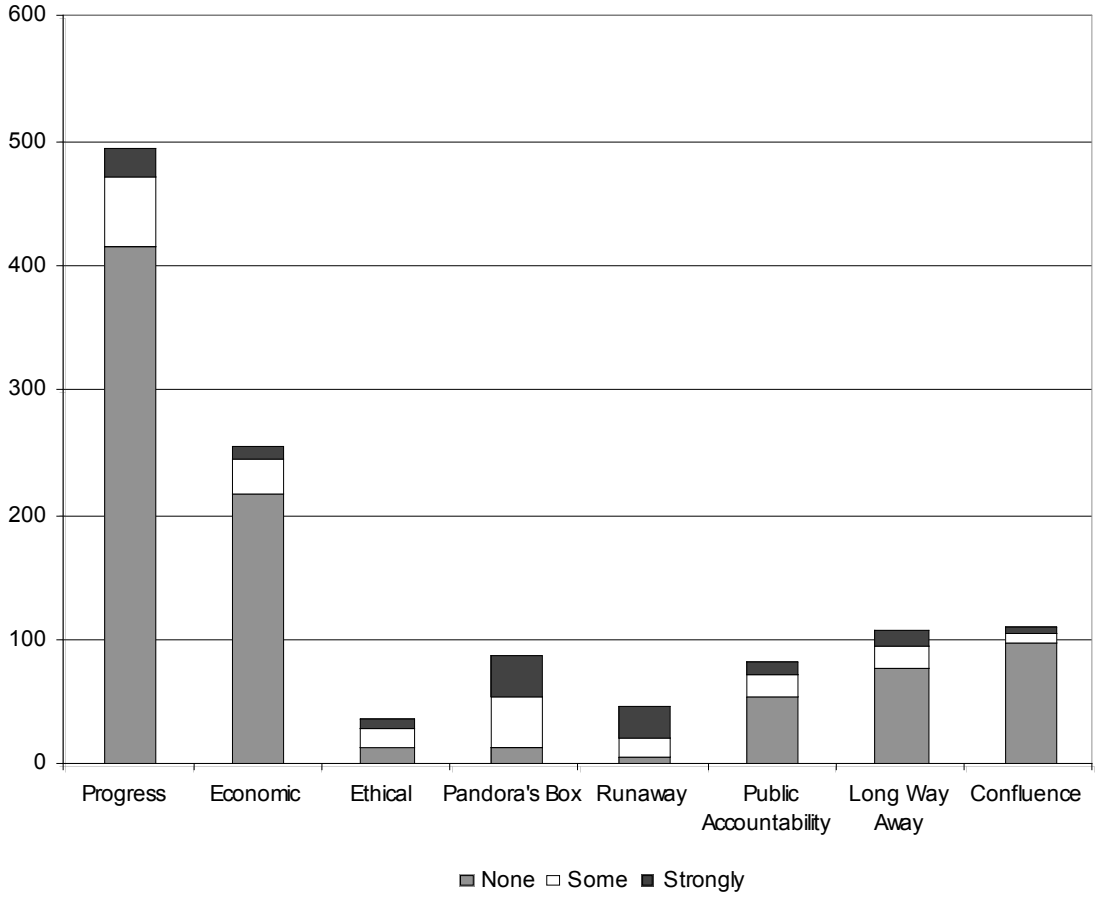


Figure 7. Number of stories with negative assessments by frame.

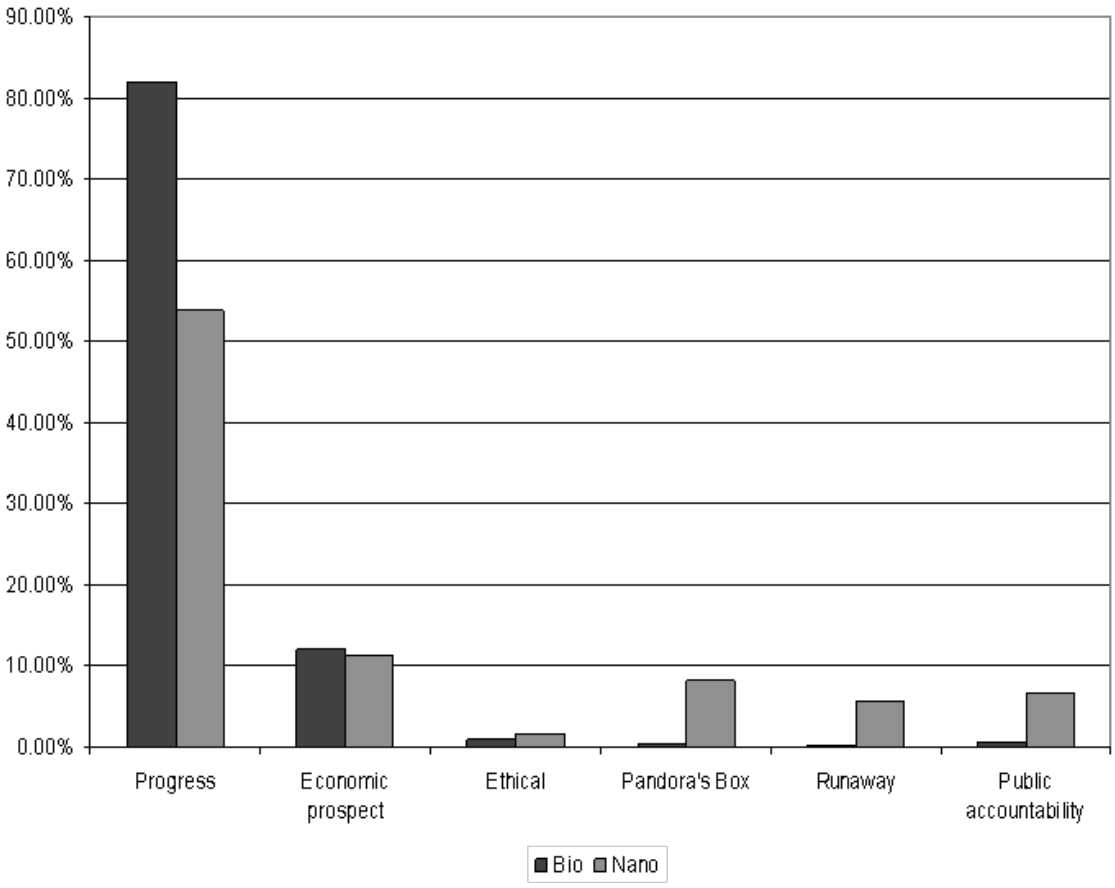


suggesting a media perception of nanotechnology as a distinctive new source of progress.

Figure 8 plots the percentage of articles in the *New York Times* with a given frame for nanotechnology and for the first 20 years of the biotechnology data. (Since the nanotechnology framing data are based on a three-level ordinal measurement, the bars represent the percentage of articles that include a frame as either "present" or "dominant.") Both technologies are framed in terms of progress, but this frame is more dominant in biotechnology coverage, and the other more "negative" frames barely appear at all. Yet the nanotechnology stories include "Pandora's Box," "runaway," and "public accountability" as a significant percentage. The explanation for this phenomenon is not clear, but perhaps the experience with biotechnology has caused journalists to be a little more skeptical about nanotechnology from the outset.

The format of news stories across each year also was examined, guided by the theory from Nisbet et al. (2003) that media attention to a scientific issue should peak when the issue can be easily dramatized, which may correspond to a shift from administrative contexts to overtly political arenas. Such a shift in issue definition often entails a shift in which type of journalist will cover a story, with a move from writers on the science beat to more general-assignment and political reporters. No definitive pattern emerges from the data, but there is certainly a shift of some sort. In 1999, 44% of the articles were from newspaper Science Desks, while only 19% came from News Desks or in the form of News Briefs. In 2003, only 10% of the stories came from Science Desks, yet 48% came from News Desks and News Briefs. The ratio shifts even further in 2004, with 6% from Science Desks and 65% from straight news formats.

Figure 8. Percentage of stories by frame for biotechnology and nanotechnology in the *New York Times.* (Data is just for the first 20 years of biotechnology coverage).



Spearman's Rho correlations were run among all themes and frames to examine potential unexpected correlations. Unlike the Pearson product-moment correlation coefficient, Spearman's rank correlation coefficient does not require the assumption that the relationship between the variables is linear, nor does it require the variables to be measured on interval scales; it can be used for variables measured at the ordinal level. Correlations among individual frames produced the most interesting results, which are presented in Table 3. "Pandora's box" and "runaway" appear to be very strongly correlated (.632, significant at the .01 level). These two frames would be expected to appear together frequently, given their similarity. But this also suggests that perhaps the frames are too similar, and the coders may have had difficulty distinguishing between them. In future studies, it might make sense to collapse the two frames into a single variable.

The "long way away" frame is strongly correlated in a positive direction with five other frames: "progress", "ethical", "Pandora's box", "runaway", and "confluence". It is not surprising that "long way away" would be correlated with frames of a positive nature, since exploratory coding indicated that this frame was tied to an expectation that the benefits of nanotechnology are still a long way in the future. However, perhaps its correlation with "ethical", "Pandora's box", and "runaway" suggest that the concerns about nanotechnology presented in news coverage are tempered by the same expectation: If the applications of nanotechnology are a long way away, then the risks that may arise are also too far in the future to raise concern. This is further supported by data presented in Figures 6 and 7, which show the number of positive and negative assessments broken down by frame. The "long way away" frame appears in an overwhelmingly positive light, despite its strong correlation with frames of a negative nature.

Table 3. Spearman's Rho correlations among frames.

	Prog	Econ	Ethic	Pand	Run	Pub	Long	Conf	Oth
Progress	1.000	.035	-.009	-.169**	-.123**	-.095*	.253**	.091*	.099*
Economic	.035	1.000	-.034	-.100*	-.094*	.011	-.076	-.022	-.064
Ethical	-.009	-.034	1.000	.346**	.282**	.140**	.115**	.021	.102*
Pandora	-.169**	-.100*	.346**	1.000	.632**	.146**	.129**	-.021	.153**
Runaway	-.123**	-.094*	.282**	.632**	1.000	.078	.184**	.009	.129**
Public	-.095*	.011	.140**	.146**	.078	1.000	.013	-.037	.022
Long	.253**	-.076	.115**	.129**	.184**	.013	1.000	.125**	.198**
Conf	.091*	-.022	.021	-.021	.009	-.037	.125**	1.000	.218**
Other	.099*	-.064	.102*	.153**	.129**	.022	.198**	.218**	1.000

* = Correlation is significant at the .05 level

** = Correlation is significant at the .01 level

Discussion

Hypothesis 1 was confirmed, with nanotechnology coverage frequency starting out very low until the late 1990s when the number of articles took a dramatic leap. What were the events that spurred this rise in coverage? Further research should examine this connection more rigorously, but the anecdotal evidence suggests that popularized accounts like Bill Joy's article in *Wired* and Michael Crichton's *Prey* may have had a dramatic effect on the *amount* of coverage, but not on the *tone* of coverage. Journalists seemed to focus more on the revolutionary potential of nanotechnology as a force for economic and technological progress. The so-called "*Prey* effect," however, may not have played much of a part in the coverage at all. Prior to analyzing the data, it was suspected that *Prey* might cause a bump in coverage that would eventually die down in 2003 and 2004, but this does not appear to have been the case. The number of articles about nanotechnology continues to rise rapidly.

The data also support Hypothesis 2. The coverage of nanotechnology is overwhelmingly positive in general; and even when stories are negative, they are not strongly negative. Much has been written about the "shared culture" between scientists and journalists, which often leads to media coverage of science that is highly colored by a scientific viewpoint. Given that the supporters and promoters of nanotechnology have been characterized by a heavy focus on marketable applications and economic development, could it be that this shared culture has made journalists "complicit" in perpetuating this vision of nanotechnology? It is important to note, however, that the coverage of nanotechnology is not quite as overwhelmingly positive as biotechnology was in its first 20 years. With biotechnology, the more negative frames barely appear during this period, while the coverage of nanotechnology includes them at a more significant level. Further studies should examine the reason for this difference: Is it an

inherent aspect of nanotechnology as an issue? Or is it an effect of the current climate in the United States and around the world—partly influenced by biotechnology controversies—where people are more inclined to pay attention to risks, whether they come from terrorism or technology?

Hypothesis 3 is also supported, as the number of stories about nanotechnology in the *Associated Press* has increased rapidly and even eclipsed all of the other elite media outlets. This tentatively suggests that the issue is becoming more salient to the general public, but questions remain. Are the journalists at the *Associated Press* just following the lead of the elite media? Or are they reflecting a growing interest by the general public in nano-related issues? These and other questions should be addressed in future studies.

One other interesting bit of information came out of the study. The "public accountability" frame appears surprisingly early in nanotechnology coverage and remains a significant element throughout. This frame appears more often than the "runaway frame" and on a par with the "Pandora's Box" frame—both of which encompass the scary "sci-fi" scenarios that nanotechnology could engender. This suggests that the media may be reflecting what risk communication scholars have known for years: what really worries people are not scary "sci-fi" scenarios, but rather questions of trust and credibility, especially regarding public officials and multinational corporations. Public uncertainties are rarely focused on the state of the science, but on whom to trust (Friedman et al.,1999; Irwin & Wynne, 1996). Gaskell and Bauer (2001), for example, showed that arguments against GM food in Britain were pushed largely by the collapse of trust in the U.K. regulatory system after the poor handling of the "mad cow" scare.

From the perspective of many scientists, the attitude surrounding new technologies should follow a "diffusion of innovation" approach, which first assumes

that the technology is good, and then uses social science research to find ways to speed up public acceptance. But Gregory and Miller (1998) advise that scientists should focus more on cultivating trust, and less on cultivating "understanding" or "acceptance." No amount of information will create favorable public opinion unless social contexts are addressed, and in issues that involve great uncertainty, science "literacy" is beside the point, they suggest. In this tradition of thought, Irwin and Wynne (1996) suggest that the public's view of risk is less naïve than scientists believe, and in fact the public often knows more about science than science knows about the public. The problem with risk communication, then, is not the public's inability to understand and accept scientific risks, but rather a problem with credibility of groups involved.

CHAPTER 3

THE (TINY) PICTURES IN OUR HEADS

Public Opinion Survey

Clearly, content analysis research needs to be coupled with studies of public opinion in order to understand the linkages between the public presence of information and the actual public debate that occurs. Three recent public opinion studies (Royal Academy, 2004; Cobb & Macoubrie, 2004; Scheufele & Lewenstein, 2005) reveal some common themes: In general, people have heard little (if anything) about nanotechnology, and they know even less about it—whether on a self-assessed basis or on a miniature "test" administered as part of the survey. Yet despite this lack of knowledge, the overwhelming majority of people view nanotechnology in a positive light, saying that they think the benefits will outweigh the risks.

To add another level of data to these studies, this survey offers an early glimpse into public attitudes about the potential applications of nanotechnology in agriculture and food production in New York state. While the data were limited to one state, providing less of a basis for generalization when compared to national surveys, the results do address an important specific issue that is near to respondents' hearts. Nanotechnology as it is applied to new materials and manufacturing methods can seem distant from a person's everyday experience, but the techniques that lead to putting food on the table would seemingly be of more vital interest. And these questions bring nanotechnology closer to a key part of the biotechnology debate that has been studied so thoroughly—plant biotechnology and genetically modified foods.

The study was guided by the following broad research questions, meant to provide a preliminary understanding of public opinion about nanotechnology in New York state:

Research Question 1: What is the level of awareness of nanotechnology among the general public in New York state?

Research Question 2: How do people in New York state perceive the relative risks and benefits of nanotechnology?

Research Question 3: What are the levels of support and opposition in New York state to the application of nanotechnology to agriculture and food production?

Methods

Telephone data were collected from February to March of 2005 from a randomly generated sample of New York residents (N=800). Three questions were included about nanotechnology. (The first question was also included on the 2004 poll to give a basis for comparison, while the other two are new.)

> *Question 1*: Nanotechnology works at the molecular level, atom by atom, to build structures, materials, and machines. On a scale from one to 10, with one being NOT MUCH AT ALL and 10 being A GREAT DEAL, would you tell me how much you have heard or read about nanotechnology?
>
> *Question 2*: People have frequently noted that new technologies have produced both benefits and risks. Do you think the benefits of nanotechnology will outweigh the risks, or the risks will outweigh the benefits, or the risks and benefits will be about equal?
>
> 1. BENEFITS WILL OUTWEIGH THE RISKS
> 2. RISKS WILL OUTWEIGH THE BENEFITS
> 3. RISKS AND BENEFITS WILL BE ABOUT EQUAL
>
> *Question 3*: Overall, would you say you oppose or support the use of nanotechnology in agriculture and food production? Let's use a 10-point scale

again where one means STRONGLY OPPOSE and 10 means STRONGLY SUPPORT.

Results

For question 1, 43% of respondents said they had heard "not much at all" about nanotechnology, and about 5% said they had heard "a great deal." These findings are almost exactly the same as those from the previous year's survey, suggesting what every other survey to date has pointed out: that nanotechnology is still not on most people's radar screens. However, the mean response in the previous year was 3.3 (SD 2.7), while in this survey the mean response rose to 4.2 (SD 2.9), which indicates that perhaps people are somewhat more aware of nanotechnology on average.

Of the people who were willing to provide a response to question 2, 33.2% said "benefits will outweigh the risks"; 14.9% said "risks will outweigh the benefits"; and 52.0% said "risks and benefits will be about equal" (mean: 2.19; SD: 0.9). This also is fairly consistent with findings from other studies, particularly in United States. However, it should be noted that 29.3% of all the respondents said "do not know," indicating at first blush that a large chunk of people would not make an assessment about a technology that was unfamiliar to them. Still, considering the very low awareness among the respondents indicated in question 1, it seems that quite a few people (more than 70%) are still willing to make assessments about nanotechnology. This should come as no surprise, given the previous discussion of theories about how people make decisions based on little or no knowledge—as "cognitive misers" who use existing predispositions to mediate information received from the media and other outside sources.

Of those willing to make an assessment in question 3, 19.6% said they "strongly oppose" the use of nanotechnology in agriculture and food production, and

10.9% said they "strongly support" it. 23.4% of respondents said they "do not know," and the mean response was right down the middle at 5.17 (SD: 2.827). In this case, the opposition to nanotechnology is fairly high when compared to other studies, perhaps because the question is geared toward applications in agriculture and food production, which directly affect what people eat. The question wording may also call to mind other recent issue such as the debate about genetically modified organisms. Other studies that have focused on more standard commercial applications, such as new materials, have seen higher levels of support.

Pearson correlations were run between question 1 ("heard about nanotechnology") and the controlling variables, yielding the following correlations that are all significant at the .01 level:

.153 (Attended a community forum or public meeting in the past 12 months)

.239 (Household income level)

.240 (Education level)

-.100 (Liberal/conservative on social issues—negative number means that liberals are more likely to have heard about nanotechnology)

Pearson correlations also were run between the other continuous variable, question 3 ("support nanotechnology in agriculture and food production"), question 1, and the controlling variables, yielding these results that are significant at the .01 level:

.274 (Heard about nanotechnology)

.229 (Household income level)

.177 (Education level)

Discussion

In general, the results are fairly intuitive. How much one has heard about nanotechnology correlates strongly with being politically liberal and being more

engaged in the political process. That is, the type of person who would attend a public meeting is also the type of person who is more likely to be informed about a seemingly abstract scientific issue like nanotechnology. This raises an interesting question: Is this type of person simply exposed to a greater amount of media coverage, or do they seek information more actively than others? Such a question goes beyond the scope of this study, but it could be a good topic for further research into the ways that people engage in public deliberation.

Support for nanotechnology significantly correlates with higher levels of education and family income, as well as how much a respondent had heard about nanotechnology. This suggests that nanotechnology is only something more "elite" people are paying attention to, which corresponds well with the media content analysis in the previous section. Thus far, only the more "elite" media outlets are paying any sort of significant attention to nanotechnology, although this does seem to be changing. The content analysis showed that coverage in the Associated Press has spiked dramatically in recent years, which indicates that interest in nanotechnology is spreading to a wider public beyond the audience of the elite press. Likewise, the survey findings also show a small increase in general awareness of nanotechnology over the previous year, which corroborates this finding from the media analysis.

Support for nanotechnology also correlates strongly with how much one has heard about nanotechnology. On the face of it, this seems fairly obvious. It has long been accepted wisdom that the way to create greater support for science and technology is by simply increasing awareness among the general public. But this accepted wisdom has been called into question by a number of scholars in recent years. For example, one view might hold that people simply lump nanotechnology into the general category of "science and technology"—a category that most in the United States tend to support, saying the potential benefits outweigh the risks (National

Science Board, 2004, p. 7-23). A survey by Gaskell et al. (2005), however, reveals that attitudes toward nanotechnology are different in Europe and the United States. They suggest that people in the United States assimilate nanotechnology within a set of pro-technology cultural values, while Europeans tend to have more concern about the impact of technology on the environment, less commitment to economic progress, and less confidence in regulation. They also note that European media coverage of nanotechnology is less overwhelmingly positive than in the United States, which mirrors public attitudes at the moment.

Perhaps the most striking result from the current survey is that more than half of all respondents were ambivalent about their position, suggesting that people in New York State are not quite sure what to make of this emerging technology. This correlates strongly with what researchers have found in the many surveys of attitudes toward plant biotechnology in the United States. Despite what seems to be a topic that should generate significant strong feelings and a great deal of media coverage, the debate over plant biotechnology and genetically modified foods has yet to heat up in the United States, although it has definitely taken off in Europe, as Nisbet and Huge (2006) have discussed.

Cobb and Macoubrie (2004) point out an interesting trend from their study: Being exposed to Michael Crichton's *Prey* significantly affects respondents' perceptions of risks versus benefits, but not in the expected direction. "A whopping 63% predicted that benefits of nanotechnology would exceed the risks if they were exposed to *Prey*, compared to just 38% if they weren't exposed to it" (p. 11). It has been suggested that this effect stems from the fact that most people who read science fiction books like *Prey* already have a positive view of science and technology, although Cobb and Macoubrie say this can be ruled out because there are hundreds more respondents who like science fiction but have not been exposed to *Prey*. Another

possible explanation is that humanity eventually triumphs at the end of the book, painting scientists and science in a more positive light.

CHAPTER 4

CONCLUSION

The current study is just a preliminary analysis, but the data point to a similar pattern of media coverage for biotechnology and for nanotechnology—in terms of both salience and framing. There is, of course, no reason to expect that coverage of the two issues will be exactly the same, but perhaps some of the lessons from biotechnology can be applied to nanotechnology, while also providing a foundation to begin understanding a new and distinct theoretical category: "emerging technologies." To understand media coverage of science and its effects more fully, we need, as David Edge suggests, "a more detailed understanding not only of the topography of the public's image of science but also of how (and to what extent) that image can be manipulated by those in whose interest it is to do so" (Edge, 1995). To examine what shapes media coverage of an emerging technology, further studies could attempt to correlate specific events with peaks in coverage and shifts in tone, while also examining the "agenda-building" activities of various actors in the public sphere, such as press releases. Several studies of this nature have already been conducted for biotechnology-related issues (Nisbet & Lewenstein, 2002; Ten Eyck & Williment, 2003; McInerny et al., 2004; Nisbet et al., 2003).

Once an issue is framed by the media, it can be very difficult for actors in the public sphere to shift the image to another perspective. This was clearly illustrated in the debates over nuclear power and genetically modified food. Yet the preliminary public opinion data about nanotechnology, coupled with anecdotal evidence, suggests that the framing for nanotechnology is yet to be established. Why should this be? Narrative and conflict seem to be important factors. As Thurs (2005) has noted in his study of popular representations of "gray goo," there do not appear to be two obvious

sides in conflict in the nanotechnology debate, with no definitive spokesperson or group for proponents and for skeptics. In scientific circles, much has been made of the heated debates between Eric Drexler and Richard Smalley—a Nobel Prize-winning chemist with a drastically different vision for nanotechnology than Drexler's (Baum, 2003). But the popular media have not picked up on this, perhaps because the debate centers mostly on highly technical disagreements about the fundamental principles of nanotechnology. Gray goo is an eminently plausible popular metaphor (remember *The Blob*), but according to Thurs, the media just has not grabbed it. Interestingly, Thurs does suggest that there is not so much a fear of gray goo portrayed in the media, but rather a fear of the public having a fear of gray goo. In a sense, public opinion is the gray goo, he says. Public opinion is seen as a capricious and powerful force, which is difficult to hold back once it gains momentum. This further illustrates the increasing prominence of the "public accountability" frame in media coverage, which is perhaps mirroring the lingering taste of the GM food controversy in scientists' mouths.

What, if anything, will eventually define nanotechnology in the public and the media, since it does not seem to have been the release of *Prey* or the gray goo metaphor? Perhaps it will not be some environmental calamity or icon of popular culture, but rather a shift from administrative science contexts to more overtly political contexts, as Nisbet et al. (2003) suggested was the driving force behind media coverage of stem cell research. When policy debate is located within an administrative policy arena, only a few actors have a seat at the table, and policymaking has been described as following an "inside access" mode of agenda-setting (Nisbet, 2003). For these actors, it is in their best interest to exclude wider public involvement in the issue, and they typically frame it in narrowly technical terms, which leads to minimal media coverage. When another group that is linked to the issue finds themselves disadvantaged and without a seat at the policy table, these actors push for expansion of

the issue by attempting to shift the debate to more overtly political arenas. This process has been called "outside access" agenda-setting, and it can move the debate from behind closed doors into the public eye. Framing in this context is usually characterized by emotionally charged symbols, as opposed to the technical framing of the "inside access" mode. Research has demonstrated that the shift in framing of an issue from technical terms to moral terms is a key element in media coverage and public opinion about science-related controversies (Nisbet, 2003).

For the stem cell controversy, Nisbet et al. (2003) suggested that insider scientists initially wanted to keep the discussion technical until a group of outsiders chose to raise the public profile, leading to "moral panic" and heightened media coverage. Interestingly, media coverage of nanotechnology has certainly spiked in recent years, but without any readily apparent outside initiatives, other than a few reports—such as those from the ETC Group—that have not seemed to garner large amounts of media coverage. The issue arguably still resides in an administrative science context, yet something has spurred growing media attention. One possibility is that the unique nature of nanotechnology development, with its early focus on societal implications, is responsible for the change. In this instance, the insiders have made it an explicit goal to include the public in the technology's development from the outset, rather than keeping the issue hidden behind closed doors to avoid moral panic over potential risks. This might be why the media coverage is so high and growing, even though there is no real narrative for journalists to hang their stories on. This might also explain why the media coverage is so overwhelmingly positive and focused on economic development.

The idea of a "shared culture" between science journalists and scientists does seem to be in effect with nanotechnology, as the tone of coverage reflects a decidedly uncritical take on the view of prominent scientists and institutions that see

nanotechnology as primarily about commercial benefit. Much of the reporting about nanotechnology follows quite closely with Nelkin's (1987) description:

> Conveyed in these reports is a sense of awe about the power of technology, resembling in some ways the presentation of science in the press. But there is a difference: whereas science appears in the press as an ultimate authority, technology appears as the cutting edge of history, as the new frontier. . . . [T]he coverage of technology is mainly promotional; the dominant message conveyed is that the new development will give society the magic to cure economic or social ills. (pg. 34)

On an anecdotal level, there does seem to be growing evidence that media coverage is shifting from this progress/economic prospects frame to a more prominent focus on the societal impacts of nanotechnology. A major theme in recent years has been the potential environmental and health effects of nanotechnology—and specifically nanomaterials. Two particular events triggered spikes in stories: a 2004 study by researchers at Southern Methodist University suggesting that buckyballs could cause brain damage in large-mouth bass; and a 2006 report that a spate of respiratory illnesses in German workers was caused by a cleaning product called MagicNano. Both incidents set off a number of feature stories in the ensuing months, allowing reporters to follow up on debates about the actual danger of buckyballs and whether MagicNano really contained any nanoparticles. The advent of these more introspective features suggests that journalists are beginning to ask more questions and think more skeptically about the nascent nanotechnology industry.

This shift in focus just might lead to a shift in where the debate about nanotechnology takes place—from the administrative policy arena to a more overtly political context, pitting the forces of environmentalists and advocates for the public against corporate interests and even some scientists. Still, such a shift does not

compare in magnitude with the way issues like climate change and stem cell research have been catapulted to the media stage. It remains to be seen if the new focus on environmental and health effects of nanotechnology will really cause nanotechnology to become a major force in public discourse.

Of course, media coverage cannot really be well understood without examining its linkage to public opinion. The two are inextricably linked, although precisely how is a matter of some debate. Unfortunately, the funds were not available to include media-related variables in this survey, but several other studies have looked more closely at the connection between media coverage and public opinion about nanotechnology, offering a good baseline to begin the discussion of media effects.

In 2004, the Royal Society claimed that low awareness among the public "implies that much will hinge upon how attitudes to nanotechnologies are shaped over the next few years." And the Royal Society report emphasizes the role of the media in shaping attitudes. This has become a bit of a truism—that the tone and amount of media coverage directly affects people's attitudes toward (and therefore support for) science and technology. But is it in fact true? Or put another way: Is it possible that the general public support for nanotechnology, despite very low levels of knowledge and awareness, is an effect of the overwhelmingly positive media coverage focusing on progress and economic prospects?

As might be expected, the answer, according to the few studies that have looked at this, is *maybe*. Scheufele and Lewenstein (2005), for example, found that public attitudes toward nanotechnology in their survey were heavily influenced by the amount and nature of media coverage, with the most influence coming from science news coverage in newspapers, on television, and online. A respondent's knowledge about nanotechnology did not have much effect on their attitude, but their exposure to science-related news did.

In an investigation of U.S. citizens' concerns about nanotechnology development, Macoubrie (2006) found that people's concerns were largely based on experiential knowledge about past "breakthroughs" whose limitations and negative effects were poorly understood initially, and even when these effects became well-known, they were poorly managed. If supporters of nanotechnology want to avoid a backlash like that which occurred against genetically modified foods, then they would do well to pay attention to the lessons learned from these past issues. According to Scheufele (2005), one of the main lessons from the debates surrounding genetically modified foods and stem cell research is that the public does not think like scientists. "Michael J. Fox, Ron Reagan and the Christian Coalition have probably had a more profound influence on public opinion about stem cell research than any scientific fact. And based on all we know about how people gather and process information, things won't change anytime soon" (p. 1).

Citizens use heuristics, or cognitive shortcuts, when dealing with emerging technologies, rather than trying to understand all the complexities of an issue. It makes sense for people to use this kind of "low-information rationality," Scheufele notes, because they must rely on the information most easily available to them amid the torrent of potential options. And it is important to realize that people rely on these heuristics in *addition* to information when making decisions about issues such as nanotechnology. Thus media and education campaigns cannot be sufficient if the campaigners do not understand how people actually receive information.

Importantly, Scheufele and Lewenstein (2005) found that information and heuristics can clash. In their national survey, both informed and uninformed supporters of nanotechnology reported lower levels of religiosity than the two segments of people who opposed nanotechnology. And the segment reporting the highest levels of religiosity were the informed opponents—the people who were generally opposed to

nanotechnology, even though they were significantly more informed about the issue than more than half of the population. They suggest that citizens use value systems and predispositions as "perceptual filters" when making sense of a new technology such as nanotechnology.

When synthesized with other research, the findings presented in this thesis suggest that a "heuristic/framing model" is more relevant to people's decision-making process with regard to nanotechnology than a "deficit model" or "science literacy model." The general public support for nanotechnology—despite very low levels of knowledge and awareness—may be linked to the overwhelmingly positive media coverage, which has been consistently framed in terms of progress and economic prospects. But the linkage most likely occurs through the "perceptual filters" of value systems and predispositions. In combination with their preconceived attitudes about technology in general, people may be taking cues from the media to tell them how to think about this new emerging technology. The media coverage is providing clues about what aspects of nanotechnology are important—in this case, that it is primarily a story about economic competitiveness and technological progress.

This corresponds with recent research in social psychology, political science, and risk communication, which suggests that knowledge plays a marginal role at best in shaping people's opinions and attitudes about science and technology (Scheufele, 2006). Future studies of media effects related to nanotechnology—and emerging technologies in general—could use this model as a basis for more rigorous examinations of the connections among media coverage, public opinion, and the policy arena. Specifically, studies should focus on the effects of knowledge and awareness on support for technology, in conjunction with mediating factors such as cues from news coverage, trust, values, and other predispositions about science and

technology. Understanding these aspects is crucial to effective science communication in today's rapidly changing media, public opinion, and policy landscape.

Postscript: February 2008

The research that forms the basis of this study was completed in 2005, and the text of the thesis was finalized in early 2006. It presents a snapshot of current knowledge at that time, but several developments that bear mention have occurred in the intervening years:

1) Framing scholarship has continued to advance, and the concept of "framing science" has recently entered a much more public venue, spurred primarily by twin editorials in *The Washington Post* and *Science* magazine, along with an extended companion article in *The Scientist* magazine (Nisbet & Mooney, 2007a; Nisbet & Mooney, 2007b; Nisbet & Scheufele, 2007). These articles have caused a heated debate in the scientific community, and especially in the blogosphere. Many scientists and science enthusiasts have openly embraced the concept (e.g., Gallagher, 2007), but others find it utterly offensive, suggesting that "framing" is simply a euphemism for "spin."

The argument goes like this: Contrary to what many scientists might believe, research shows that citizens are rarely well enough informed or motivated to weigh competing arguments and draw up reasoned conclusions. When faced with a daily torrent of news, people use their value predispositions as perceptual screens, reducing the choices of what they pay attention to or accept as valid. Therefore scientists must learn to actively "frame" information about highly contested issues to make them relevant to different audiences, without misrepresenting the scientific information (Nisbet & Mooney, 2007a). The standard criticism is that this is a model more for politicians than for scientists. Scientists should not trade their reliance on fact-based

arguments for ones more slanted toward the interests of specific groups (Holland, 2007). The debate continues, but progress is being made. Both sides seem to agree to the need for a constructive dialogue about this important topic. Scientists have long had a tendency to treat communication as an afterthought, so it is a welcome development to see it launched to the top of their agenda.

2) New studies about the interactions between public opinion and media coverage of nanotechnology have emerged. These studies all generally support the preliminary conclusions presented in this thesis: awareness remains low, although it is growing; attitudes are generally positive; and the relationship between knowledge, understanding, and support is complicated—in part by the role of the media.

McComas et al. (2007) presented preliminary results from a summer 2006 mail survey of residents in Tompkins and Ontario counties in New York State. The survey explored how individual views about local scientists and scientific research may affect support for several areas of emerging science, including agricultural biotechnology, agricultural nanotechnology, and gene therapy. The researchers included similar questions about nanotechnology to those presented in this thesis, and they obtained similar responses. The majority of respondents did not consider themselves well informed about nanotechnology, and of those who were willing to make an assessment, the majority supported the use of nanotechnology in commercial applications and thought the benefits would outweigh the risks. Still, as in the findings presented in this thesis, about half of all respondents would not make an assessment regarding the applications or benefits verses risks.

National telephone surveys conducted in 2006 and 2007 by the project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scholars both found that Americans' awareness of nanotechnology remains low. In 2007, only 6% of Americans said they had "heard a lot" about nanotechnology, as compared with

10% in 2006. In 2007, 21% said they had "heard some" about nanotechnology, unchanged from the previous year. Similarly, as in 2006, about 70% of adults said they had heard "just a little" or "nothing at all" (Hart, 2007).

Only 7% of respondents said they would purchase food enhanced with nanotechnology, while slightly more (12%) said they would buy food-storage containers enhanced with nanotechnology. Substantial majorities said they need more information about health risks and benefits before deciding whether to purchase such products. Adults who had heard a lot about nanotechnology were almost three times more likely to use food storage products enhanced with nanotechnology (31% compared to 11%), and were two-and-a-half times more likely to use foods enhanced with nanotechnology (15% compared to 6%). About half (51%) of the respondents were unwilling to make any judgment about the anticipated risks and benefits of nanotechnology, and another quarter thought risks and benefits will be about equal. Of the remainder, 18% said benefits will outweigh risks and 6% thought risks will exceed benefits.

Lee and Scheufele (2006) used data from a national telephone survey to examine the pathways between different types of media use and attitudes toward nanotechnology, particularly potential mediating roles of nanotechnology knowledge and trust in scientists. The goal was to identify specific heuristics the public uses when making decisions about nanotechnology, clarifying the linkages from science media use to public attitudes. They found that science media use had direct links with public attitudes toward nanotechnology, as well as indirect effects through knowledge and "deference toward scientific authority"—a construct which suggests that citizens should not develop their own ideas about what is good or bad relative to a scientific controversy when legitimate authorities have already laid down the rules. In essence, deference to scientific authority boils down to trust in scientists and scientific

institutions. Lee and Scheufele also found that television science use was associated with public attitudes through deference toward scientific authority, whereas the influences of newspaper science use are at least partly mediated by nanotechnology knowledge. However, respondents used the Web differently: as a complementary tool for gathering additional information because mass media coverage of nanotechnology is still minimal.

Scheufele et al. (2007) compared responses from 1,015 adults and 363 nanoscientists in the United States. Not surprisingly, they found that researchers working on nanoscience and nanotechnology were more optimistic than the general public about the potential benefits of research in their field, such as the potential for nanotechnology to lead to breakthroughs in medicine, environmental cleanup, or national defense. However, scientists expressed more concerns than the general public about two areas of potential risks: more pollution and new health problems as a result of nanotechnology. This makes nanotechnology unusual among emerging technologies in that scientists working directly with the technology express stronger concerns about specific potential risk areas than the general public does.

Friedman and Egolf continued their longitudinal study of risks in nanotechnology media coverage. In their first study (Friedman & Egolf, 2005), they found that health and environmental risks related to nanotechnology did not dominate U.S. or U.K. newspaper and wire service coverage of nanotechnology from January 2000 through December 2004. The majority of the articles in the study were balanced, describing risks with both positive and negative information. From these results, they concluded that the mild concern about risks clearly did not counterbalance the overwhelming number of positive stories about the benefits and promises of nanotechnology. However, in preliminary results from their latest iteration (Friedman & Egolf, 2007), they found that coverage of nanotechnology risks in 2006 was almost

twice the amount from the previous year. Almost 50% of all articles about risk regulations in the United States were based on calls for regulatory action by interest groups, non-profits, and think tanks. More than a third of all reasons provided in support of increased regulatory oversight were to "protect the environment" and to "protect people's health and safety." These findings provide additional context for the Scheufele et al. (2007) study of nanoscientist opinions, suggesting that the higher level of concern among scientists may be driving an increased focus on environmental, health, and safety topics in the mass media.

Even as coverage of nanotechnology grows, it still remains a very small part of the overall media landscape, especially when compared with scientific controversies such as climate change and stem cell research. What, if anything, will eventually define nanotechnology in the public and the media? Will it be a major environmental, health, or safety incident? Or perhaps a high-profile political debate? One recent development, in combination with the increased focus on risk in media coverage, highlights the type of framing that could be successful in elevating nanotechnology on the public agenda. Some critics of nanotechnology have begun referring to it as the "asbestos of tomorrow," alluding to the potential unknown and long-term risks connected with nanoparticles. This metaphor is a highly effective way of using asbestos to evoke an existing interpretive frame that many people share (Scheufele, 2006). If critics of nanotechnology combine this framing with continued calls for more regulation, this could lead to a shift in where the debate about nanotechnology takes place—from the administrative policy arena to a more overtly political context, pitting the forces of environmentalists and advocates for the public against corporate interests and even some scientists. Media attention to a scientific issue often peaks when the issue can be easily dramatized, which may correspond to a shift from administrative contexts to overtly political arenas. Such a shift in issue definition often entails a shift

in which type of journalist will cover a story, with a move from writers on the science beat to more general-assignment and political reporters (Nisbet et al., 2003).

3) This leads to another development that has taken place behind the scenes of media coverage about science and technology. Cutbacks in the news business, particularly newspapers, have meant a decline in the number of jobs for fulltime staff science writers. A number of longtime science reporters have taken "buyouts" and moved to freelance or other career options. The cutbacks also have led to a drop in the number of weekly science sections. Those that remain have increasingly become consumer-oriented sections that specialize more in soft health and fitness trends than research information based on scientific studies. Newspaper science sections rose to prominence in the late 1980s as a popular venue for in-depth science coverage, reaching a peak of 95 sections in 1989. Since then, they have been dropping in number and size, particularly among smaller papers. Those that remain have shifted dramatically toward softer consumer-oriented, "news you can use" medicine and personal health coverage. Thirty-four American newspapers listed weekly health and science sections in the 2005 *Editor and Publisher International Yearbook*, with more than two-thirds focused primarily on health (Russell, 2006).

Despite a great deal of hand-wringing over these developments, it is not yet clear what the implications are for science communication. On some fronts, the demise of dedicated science sections is seen as positive. Some critics, including science reporters themselves, question the need for separate sections, arguing that they have the danger of preaching to the converted by sequestering important science and health coverage in a section that may be read primarily by readers who are already interested in science (Russell, 2006).

Some reporters and editors feel that science coverage needs to be pushed to the front of the paper, competing in the news section with other national and international

stories, and that science writers themselves need to be stronger advocates for science and technology coverage. Science has taken center stage in an ever-growing array of complex and often controversial public policy issues, such as climate change, stem cell research, genetically modified foods, and the teaching of evolution in public schools. Science is increasingly being covered in a variety of beats, including education, business, investigative reporting, religion, agriculture, politics, and foreign coverage. Perhaps the definition of "science writer" needs to be expanded to embrace the coverage of science in the larger context of societal and public policy issues.

This notion echoes the calls by Nisbet, Scheufele, and others that scientists need to be more willing to jump into the fray of media coverage. With fewer dedicated science reporters and editorial sections, scientists and scientific institutions need to think about ways to engage non-specialist reporters and to reach broader audiences in the public. And to a certain extent, this seems to be happening. Institutional public information offices as well as scientific professional organizations are increasingly promoting media training and outreach for scientists. For example, at the 2008 annual meeting of the American Association for the Advancement of Science (AAAS), the AAAS Center for Public Engagement with Science and Technology, in partnership with the National Science Foundation, announced a new Web site for scientists and engineers who communicate science with public audiences. The purpose of the Web site is to encourage scientists and engineers to proactively interact with the news media and the public by offering relevant tools for improving communication and discovering broader outreach opportunities.

4) The fourth and final development is that the author has found himself working as a professional in the field of scientific and university public relations. In an effort to bridge the gap between communication scholarship and practice, this thesis will close with a brief discussion of implications for practitioners of strategic

communication, especially those working in fields related to nanotechnology and other emerging technologies.

As mentioned above, the decline of science reporting offers both challenges and opportunities for professional science communicators. There are fewer traditional outlets for dedicated science news, but new media technologies offer tremendous prospects for expanding science coverage, allowing scientists and institutions to reach the public directly through blogs, videos, and other online content. Strategic communicators should continue exploring and tapping these outlets, but they must remember that audiences use different media in different ways. For example, Lee and Scheufele (2006) found that television science use was associated with public attitudes toward nanotechnology through trust in scientists, whereas the influences of newspaper science use are at least partly mediated by nanotechnology knowledge. However, respondents used the Web differently: as a complementary tool for gathering additional information because mass media coverage of nanotechnology is still minimal. These and other considerations must be a part of any communication strategy that involves the Web.

Journalists do not typically consider themselves to be educators, but communicators at scientific institutions often see education as part of their roles as advocates for science and technology. With fewer science reporting specialists, editors do not have the time or the resources to vet scientific information as it comes across the transom. Many Web-based news outlets, for example, have taken to re-writing press releases from scientific institutions and posting them with no original reporting or fact-checking. As science coverage becomes even more heavily reliant on public information officers and other information directly from scientific institutions, professional communicators have an opportunity (and perhaps an obligation) to

engage with reporters outside of the science beat to help them understand why science and technology matter.

This is where framing comes in. Most reporters outside of the science beat are accustomed to having information packaged in certain ways, and strategic communicators—especially in politics and business—have become quite savvy in this regard. They realize that it's not what you say, but how you say it that really matters. If scientific institutions are to build and maintain their relevance in the current media landscape, then they need to develop a better understanding of how public opinion is formed and of how individuals make sense of emerging technologies. If people make decisions using low-information rationality, then science communicators need to frame their messages in ways that will resonate with the public. Increasingly, this means taking a page from the book used by political strategists—speaking in sound bytes and symbols that resonate with personal experience or social values. Facts alone are not enough to educate people, but rather facts must be carefully packaged to wield the maximum impact. Despite criticisms of the so-called "deficit model," the foregoing study suggests that people do in fact use information to form opinions about issues related to science and technology. But there are several other potential factors that can act to mediate the effects of knowledge and awareness about a certain issue. Some of these factors include media coverage, which can tell readers which issues are important (salience), as well as which *aspects* of certain issues are important (framing); general attitudes about science and technology, which may be based on past experiences and exposure to scientific issues; trust in various individuals and institutions, including the business community and government officials; religious beliefs; political ideology; value systems; and emotions. Each mediating factor may have a particular impact when applied to different subjects.

For the issue of nanotechnology, the research presented here suggests that certain approaches to framing may work better than others. Critics have increasingly had success by focusing on the unknown long-term health effects of nanotechnology, with a particular emphasis on the asbestos analogy. The asbestos frame works well because it evokes an existing interpretive frame that many people share and understand; it is difficult to counter since it refers to risks that we will not be aware of until decades down the road; it calls to mind prior instances of regulatory incompetence; and it gives journalists an easy way to discuss risks in their stories. It is important to remember that framing is not just used by strategic communicators, but it also can be a tool for journalists to organize their stories and make their jobs easier.

To counter the critics, proponents of nanotechnology have a few options. One recent approach is that companies are marketing nanotechnology-based products as "natural." The emphasis here is that they are not "playing God," but rather that they are creating products that are "inspired by nature." By emphasizing the approach as mimicking nature, not controlling it, these companies are contrasting nanotechnology with biotechnology and genetically modified foods.

In the United States, science and technology have long been framed in terms of economic prospects and social progress, and this approach still seems to offer a number of opportunities—especially in a country that is increasingly focused on staying competitive on the global playing field. Nisbet and Scheufele (2007) suggest that the issue of stem cell research highlights one recent success in the realm of framing science. Proponents of stem cell research have countered criticisms based on moral concerns by suggesting that not pursuing this research can have significant impacts on regions, states, and the entire country in the competition for technological and economic dominance. This approach may also work for nanotechnology,

especially in areas of the country that have struggled to shift from manufacturing-based economies to knowledge-based economies.

A final approach that may be beneficial to proponents of nanotechnology is a continued emphasis on building trust. Industry and university scientists are increasingly realizing that the vast promise of new technologies like nanotechnology does not press forward in a vacuum, and that the public needs to be engaged "upstream" in development to discuss the challenges and opportunities presented by new technologies. As the research presented here suggests, the "public accountability" frame is playing a significant role in media coverage of nanotechnology. Proponents would do well to focus on messages and activities that build trust. As noted previously, Lee and Scheufele (2006) found that science media use had direct links with public attitudes toward nanotechnology, as well as indirect effects through knowledge and "deference toward scientific authority"—a construct which suggests that citizens should not develop their own ideas about what is good or bad relative to a scientific controversy when legitimate authorities have already laid down the rules. In essence, deference to scientific authority boils down to trust in scientists and scientific institutions.

Of course, it is important to emphasize that institutional representatives naturally have interests beyond simply promoting nanotechnology as a public good. A critical question must be addressed: What is the difference between "framing" and "spin"? In essence, the difference lies in the realm of motivations. To "spin" is to purposely emphasize or de-emphasize certain information for the purpose of deception. While this may be a simple distinction, determining where the line exists in practice is a much more complicated project—one that falls outside the realm of objective social science and into the arena of ethics.

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