Media Portraits of Nanotech in North American Written Media, 1986-2000[1]

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Abstract

Media reports of nanoscale science and technology (NST) from 1986-2000 represented the field as an elite science emerging from well-known universities and corporate research centers. Media reports were overwhelmingly positive and based largely on speculation and opinion with fewer articles citing specific data or research methods. A small majority of articles presented NST as a natural progress within scientific fields, other articles argued that NST was necessary simply because nanoscale devices create efficiencies or because a nanoscale revolution was inevitable. NST was affiliated most closely with computer research, medical applications, and electronic applications. We did not find a frame or concept which successfully characterized media reporting of NST throughout this period. Sustained coverage of societal issues did not emerge until 2000 and this reporting was based entirely on opinion and speculation. It is crucial that media reports be accurate, informative, and critical. While some of this responsibility passes to the those providing source data for journalistic research, science writers must also recognize the role they play in explaining, critiquing, and legitimizing NST.

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This study reports on the public representation of nanoscale science and technology (NST) in North American written popular media from 1986-2000. We are using the term nanoscience to describe pure research at the molecular level. Such research endeavors to identify the unique physical properties and characteristics of matter at the scale of one-billionth of a meter. We use the term *nanotechnology* to describe the application of these principles and structures, typically in the creation of *nanoscale* devices. This article begins with a brief orientation to NST for readers less familiar with this emerging field. This review is followed by a description of two studies we have completed on the representation of NST in written public media from 1986-2000: a pilot study and a more comprehensive analysis of our data. Readers more familiar with NST may wish to jump directly to the study data. The paper concludes by reviewing our major findings and speculating about future trends in NST media coverage.

There's plenty of room at the bottom: A tiny history of nanotechnology [2]

The term, "nanotechnology" was coined by K. Eric Drexler, an early proponent of molecular manufacturing. Drexler introduced the term and the concept while a student at MIT. Drexler's concept was informed by a 1959 speech titled *There's plenty of room at the bottom* given by Nobel Prize-winning physicist Richard Feynman. Feynman speculated that in the future, scientists would be able to arrange atoms into any substance desired. Drexler took this concept and applied it to a variety of different fields claiming that molecular-sized machines could repair damaged cells, create endless amounts of fuel, structure microscopic computers, and even provide the technology for cryonics, the hope of bringing dead cells back to life.[3] This vision was the conceptual foundation of Drexler's 1986 book *Engines of creation: The coming era of nanotechnology.*[4] *Engines* was a popularized account of Drexler's vision and was embraced by many fringe science fiction and fantasy groups. Drexler's more complex *Nanosystems: Molecular machinery, manufacturing, and computation* presented the

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2 Some of the material presented in this historical section is adapted from Faber, B. (2006, forthcoming). Popularizing nanoscience: The public rhetoric of nanotechnology 1986-1999. *Technical Communication Quarterly*.

3 Trausch, S. 24 January, 1988. "Cool customers believers in the relatively new science of cryonics are banking on the idea that there could be life after death. *Boston Globe* p. 16.

4 Drexler, E. 1990 Reprint. *Engines of Creation. The Coming Era of Nanotechnology*. New York: Anchor Books. Original edition, NY: Anchor Books, 1986).

scientific case for molecular manufacturing.[5] But, *Nanosystems* was not well received in scientific communities. Critics argued that the concept of molecular manufacturing was a fundamental misunderstanding of chemistry. Others noted that nothing in the book had been demonstrated or replicated.[6]

While Drexler's vision of nanotechnology started at the molecular level, others working in the field started with larger chunks of matter which they then broke down to nanosized particles. This approach was enabled by new technologies such as the scanning tunneling microscope, introduced by Gerd Binning and Heinrich Rohrer at IBM's Zurich Research Laboratory in 1980 and the atomic force microscope invented in 1985 by Binning. These technologies enabled scientists to obtain three dimensional images at the nanoscale from metal surfaces. Such images are useful for determining the size, arrangement, and connections among the molecules and aggregates on the surface of the metal. In 1985, Richard Smalley and Robert Curl at Rice University and Sir Harry Kroto, from the University of Sussex, discovered a new form of carbon which they called a "buckyball" as its structure mirrored the domes created by inventor Richard Buckminster Fuller.

Smalley was a strong critic of Drexler's vision of nanotechnology and of the concept of molecular manufacturing. In 2001, in *Scientific American,* Smalley contested the basic premise of molecular manufacturing claiming that Drexler's ideas were not possible. Smalley wrote, "Selfreplicating, mechanical nanobots are simply not possible in our world. To put every atom in its place--the vision articulated by some nanotechnologists-would require magic fingers. Such a nanobot will never become more than a futurist's daydream."[7] Although Drexler's vision did much to popularize the field, by the year 2000 Smalley's carbon Buckyballs had become the image and principle marketing tool of the nano-industry.

5Drexler, E. 1992. *Nanosystems: Molecular Machinery, Manufacturing, and Computation*. Hoboken NJ: Wiley.

6Regis, E. 2004. The incredible shrinking man. *Wired 12.10* available on-line at *http://www.wired.com/wired/archive/12.10/drexler.html*

7Smalley, R. 2001. How soon will we see the nanometer-scale robots envisaged by K. Eric Drexler and other molecular nanotechologists? The simple answer is never. *Scientific American 285(*3) p. 76-77.

Throughout the late 1980's and 1990's discoveries and new measuring technologies encouraged further interest and progress in top-down approaches to nanoscale research. In 1988, AT&T Bell Labs chemists Paul Alivisatos, Moungi Bawendi, and Michael Steigerwald showed that molecules behave differently at the atomic level. This work empirically tested claims which had been theorized by quantum mechanics. Other projects, including the formation of the IBM logo out of xenon atoms (by IBM scientist Don Eigler in 1990), and the creation of a 10 micrometers sized guitar (at Cornell in 1997) demonstrated the potential for exact manipulation of atoms at the molecular scale. The industrial applications of nanotech were improved following the discovery of carbon "nanotubes," which were Buckyballs linked and shaped into hollow carbon tubes. Nanotubes showed researchers that molecules could be shaped in different ways at the nanoscale.

Predictions about nanotechnology have been broad ranging and fantastic. Articles in the public media have claimed that nanotechnology will lead to cryogenics and the repair of damaged (or dead) cells,[8] a cure for cancer, self-repairing highways, bullet-proof clothing as thin as a rain jacket (Berger, 2003),[9] and affordable, abundant, energy.[10] Although not a prominent part of the literature, cautions about nanotechnology have been raised as early as a 1986 article in *Omni Magazine,* which was one of the first popular accounts of nanotech research.[11] Those cautious about building molecular sized machines have coined the term "grey goo" to refer to intelligent swarms of Nano robots the size of a virus that devour everything in their path.[12] This nano-terror was the plot of Michael Crichton's novel *Prey* released in November 2002.[13] Other writers have claimed that nanosized particles, because of their size and ability to seep into skin and vital organs, may be toxic to

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8 Drexler, E. 1990 Reprint. *Engines of Creation. The Coming Era of Nanotechnology*. New York: Anchor Books. Original edition, NY: Anchor Books, 1986), p. 135.

9 Berger, E. 2 March, 2003. "Science of the Tiny / Nanotechnology Enthusiasts Laying Path for Innovation." *Houston Chronicle*, p. A1.

10 Economist. 15 March 2003. *The Wizard of Small Things,* pp. 31-32.

11 Hapgood, F. 1986. "Tinytech." *Omni* 9/2: 56-62, 102.

12 Radford, T. 29 April 2003. "Brave New World or Miniature Menace? Why Charles Fears Grey Goo Nightmare: Royal Society Asked to Look at Risks of Nanotechnology." *The Guardian*, p. 3.

13 Crichton, M. (2002). *Prey*. New York: HarperCollins.

humans.[14] In April 2003, The Manitoba-based ETC group became the first advocacy group calling for a moratorium on the manufacture of synthetic nano-particles created in the absence of health, safety, and environmental impacts.

Despite these wide ranging claims, the initial applications of nanotechnology have been rare and selective. In some cases, existing technologies have been problematically re-situated as nanotechnology..[15] Nanotechnology has been applied in electronic computer memory technology and in polymer coatings. Because of their high conductivity and strength, carbon nanotubes are useful for making computer chips and memory storage devices. However, these applications are not novel and have been in place for several decades. For example, much of the work in nanoscale electronic memory storage intersects with what is called MEMS (or MOEMS) Technology, or micro (optical)-electrical-mechanical systems, which apply molecular layers onto silicon to integrate mechanical elements, sensors, and other electronics. In polymers, molecular sized particles have been blended and layered on surfaces since the 1960s. More recent uses of nanotechnology have occurred in automobile manufacturing to create stronger materials, textile manufacturing to increase stain resistance, and in various beauty products such as skin cream and suntan lotions.[16]

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14 Feder, B. 4 April 2003. "Research shows hazards in tiny particles." *New York Times* , C.8.

15 In April 2004, the investment firm Asensio & Company, complained to New York attorney general Eliot Spitzer that a nanotechnology index fund established by Merrill Lynch included companies that had little to do with actual nanoscale work. Merrill Lynch defined nanotechnology as any product or production process that is measured at 100 nanometers or smaller. This definition included processes that did not exploit the unique characteristics of materials at the nanoscale and products developed before actual research in nanotechnology. Cases like these have led Drexler to recently complain that the term nanotechnology is used so broadly "it is almost meaningless" (Feder, B. 12 April 2004. Concerns that nanotech label is overused. *New York Times*. p. C2.)

16 Hearn, K. (2003, March 24). The next big thing (is practically invisible); nanoparticles—objects on a scale of 0ne-billionth of a meter—now turn up in everyday products from tennis balls to sunscreen. *Christian Science Monitor: 17.*

PILOT STUDY: RESULTS FROM PRIOR RESEARCH

From 2002-2004 we conducted a preliminary study of written media reporting of nanotechnology.[17] The goal of this first preliminary, historical study was to describe the early emergence of NST in the public media and examine how a new scientific field gains legitimacy within a mass media context. The study method generally followed the process outlined by Huckin for blending quantitative data gathering and qualitative results.[18] Articles were selected from the ABI/Proquest on-line database. Using trial and error, we determined that the first reference to "nanotechnology" or "nanoscience" in the database occurs in 1986 with the word "nanotechnology."[19] For this reason, we used January 1, 1986 as the start date. December 31, 1999 was used as the end date in order to collect articles that appeared in the early emergence of the field. The keywords "nanotechnology" and "nanoscience" were used as the search string and "article text" as the search criteria. Publication type was entered as "all."

The search generated 885 articles ranging from several lines to several pages in length. Given that the research goal to was examine popular written representations of nanoscience and technology we read through the data set but manually selected articles published in newspapers, general interest magazines (e.g.,Time, Newsweek) and popularized scientific publications (e.g., Popular Science). This created a second data set of 203 articles. These articles were printed and filed by month and year. Figure 1 presents the number of articles in the data set per year.

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17 Faber, B. (2006, forthcoming). Popularizing nanoscience: The public rhetoric of nanotechnology 1986-1999. *Technical Communication Quarterly*.

18 Huckin, T. 2004. "Content Analysis: What Texts Talk About." In *What Writing Does and How it Does it: An Introduction to Texts and Textual Practices* (pp. 13-32). Ed. Charles Bazerman and Paul Prior. Mahwah NJ: Lawrence Erlbaum Associates, p. 16-19.

19 Hapgood, F. 1986. "Tinytech." *Omni* 9/2: 56-62, 102

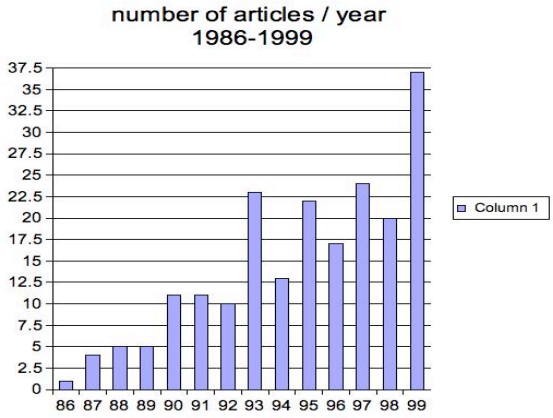

Figure 1 Number of Articles 1986-1999

This study characterized thirty nine (39) different representations of NST in 262 occurrences of the term. On average, each representation occurred 6.89 times. Those representations that occurred more than the average (6) were identified as "high occurring representations." Table 1 lists these representations.

Representations of Nanoscale Science & Technology High Count
(n>6 from data set of 262 occurrences)

Molecular Manufacturing (n=48)	Future Computers (n=23)	Medical Applications (n=19)
Science Fiction (n=15)	Biology/Cybernetics (n=11)	Future Electronics (n=11)
Eric Drexler Biographical (n=10)	Inventions: New & Possible (n=9)	Ed Regis Biographical (n=9)
Micro-Machines/Self assembly (n=9)	Cryogenics (n=8)	Foreign Competition (n=8)

Table 1. High occurring representations (Source: Faber, 2006)

These representations situated NST as an extension of existing science and scientific application (biology, computer science, medicine). Nanoscale work added different approaches and methods within each existing field. However, the category "molecular manufacturing" was an exception to the above characterization as it was not overtly linked to an existing science or application and in many cases was situated in opposition to existing disciplinary practices. Biographies about pioneers in the field (Eric Drexler, Ed Regis) were also high-mention

categories. These more social representations appeared to play important roles in promoting and sustaining interest in the emerging area. As noted above, Eric Drexler was an early promoter of the concept of molecular manufacturing and molecular self-assembly and his biographical representations implicitly supported the representation "molecular manufacturing."

This first study concluded that the early emergence of nanoscience and technology in the popular media occurred as a competitive but transitional process in which the new emerged within existing and established understandings of science. Although national media situated NST within existing and established understandings of science, this accounting was mediated by biographical and other human-interest narratives about the research and its applied technologies. These reports were almost uniformly positive. In addition, we found few accounts (critical or positive) of the societal, environmental, and health and safety implications of NST.

Finally, the pilot study also found that these early accounts emphasized technical applications of nanoscale research but did not differentiate between actual science and pseudo-science (what Hass and Kleine have called "Junk Science")[20]. Cybernetics, cryogenics, and molecular self-assembly received similar treatment as medical devices (coatings on medicines) and in-use applications for computer memory. Later representations solidified the science into marketable categories closely aligned with business and investment opportunities. By 1999, those areas not aligned with existing and recognizable practices (e.g., molecular manufacturing) were beginning to be displaced by existing and established fields and interests.

CURRENT STUDY

Our current research is a detailed examination of these early public accounts of NST. The goal of this study is to more accurately describe and characterize these early media reports in order to better understand the underlying assumptions social processes that have been associated with NST reporting. Using "narrative" as the gross unit of our analysis, our objective is to determine how the narrative depicts NST within six specific topic codes. Taken from Zimmerman et al., the topics codes include: Social Context, Method, Theory/Agent, Data/Statistics,

20Hass, B., and Kleine, M. 2003. "The Rhetoric of Junk Science." *Technical Communication Quarterly*, 12: 267-284.

Related Research, and Relevance.[21] These are elaborated in Table 2. Following the results of the pilot study, we retained the term "representation" to categorize the interpretations of NST reported in written media.[22]

Topic Code Categories

Topic code	*Description*
Social Context	Prestige/bias: who conducted, funded research, where conducted, published
Method	How research was conducted, research design and procedures
Theory/agent	Why effects occurred, properties of causal agents, underlying mechanisms
Data/statistics	What was observed in the reported study or statistical tests
Related research	Replication of or connections with other results
Relevance	Importance or applicability of findings

Table 2. Topic code categories (adapted from Zimmerman et. al. 2001, p. 40)

Method

Data Set

The pilot study only used the terms "nanoscience" and "nanotechnology." In order to build a more comprehensive database, we expanded the search terms to include the phrases: *scanning tunneling microscopy; atomic force microscopy; nanolithography; self assembly;* and *nanostructure*. These terms were identified by James Murday, Executive Secretary, National Science and Technology Council's Subcommittee on Nanoscale Science, Engineering, and Technology in his literature citation count review of nanoscience topics in specialized technical literature.[23]

The follow-up study also used more selective criteria to establish the data set. Newspaper and news magazine selection was made more consistent with data sets established by similar projects in the literature (see Friedman,

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21 Zimmerman, C. , G. Bisanz, J. Bisanz, J. Klein, and P. Klein. 2001. Science at the supermarket: A comparison of what appears in the popular press, experts' advice to readers, and what students want to know. *Public Understanding of Science 10*: 37-58.

22 As Zimmerman et al., note, the topic code taxonomy "provides a basis for more detailed analysis of media articles" including coding specific methods reported, types of research designs, and the interconnections between and among various research projects (p. 40).

23 Murday, J. 2000. The coming revolution: Science and technology of nanoscale structures. *AMPTIAC Newsletter 6* (1): 5-10. Advanced Materials and Processing Technology Information Analysis Center, p. 5.

et al. for widest coverage).[24] In addition, newspapers from geographical areas cited as "top 10 nanotechnology development areas" were added to the data set.[25] A list of media used is included in Appendix A. The new dataset is comprised of 303 articles.

Findings

Below, findings from four of the six categories will be discussed. Our examination of the categories Data/Statistics and Relevance is ongoing. In summary, most of these findings confirmed the pilot study findings but with some distinctions. We found that media reports of NST represented the field as an elite science emerging from well-known universities and corporate research centers. Despite the academic and research context established for NST, media reports were based largely on speculation and opinion with few articles citing specific data or research methods. We found that regional media played an important role in promoting the local development and infrastructure of NST. This reporting was eventually tied to the reporting of an economic impact and regional economic development associated with NST. Ideologically, a small majority of articles presented NST as a natural, progressive step within scientific fields. Though, 45% of reports argued that NST was necessary because a nanoscale revolution was inevitable or simply because nanoscale devices create efficiencies. We did not find a unique or central concept that framed or suitably categorized the field. NST was affiliated most closely with computer research, medical applications, and electronic applications. But these associations occurred in broad, general, and quite disconnected ways. Molecular manufacturing was prominent as research category in the early data but declined by 1999. Societal issues were not prevalent in media coverage. Sustained coverage of societal issues did not emerge until 2000 and this reporting was based entirely on opinion and speculation.

Social Context

The articles positioned NST within an elite social context. In its early emergence, nanoscience and technology was overwhelmingly affiliated with well-known universities and corporate research labs. Over time, universities

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24 Friedman, S., Villamil, K., Suriano, R., and Egolf, B. 1996. Alar and apples: Newspapers, risk and media responsibility. *Public Understanding of Science 5,* p. 8.

25 Stuart, C. 2003. Choosing the right ensemble: Top 10 states are those that can fashion the perfect small tech outfit. *Smalltimes 3*(2):35-46.

remained prominent social contexts for nanotechnology reporting but by 1998, the field become closely associated with business activity and economic development, cultural events and phenomenon (movies, fiction, comedy), and to a lesser extent, government policy and activity.

From 1986-1988 universities and corporate research centers were cited by 86% of articles as generative spaces of NST. Business was cited as a social context for NST by 2% of articles and government was cited by 1% of articles. Four percent (4%) of these early articles represented nanoscience and technology with specific individuals through biographical reports. Eric Drexler was the subject of all of these biographies. Four academic fields were associated with NST: physics, biology, chemistry, and computer science. Computer Science was the more frequently mentioned academic field. NST was not associated with social groups or institutions (nonprofits, development agencies, hospitals).

This general distribution continued through 2000. In the full data set, 49% of articles associated nanoscience and technology with university and corporate research centers. Business interests became more prominent, cited by 28% of articles, while government citations remained limited (14%). Nanoscience and technology was indicated as a cultural phenomenon by 25% of articles. Biography remained a small social context with 11% of articles associating the field with specific individuals. As noted above, business interests grew as a social context for nanoscience and technology research, rising from citations in 24% of articles in 1989-1994 to 33% in 2000.

Societal issues were not prominently featured as generative contexts for nanoscale work. When societal issues were considered, links to these issues (poverty, food supply, disease treatment) were initiated within and subordinated by narratives about elite institutions (research universities, for-profit corporations) or biographies about specific researchers or advocates in the field. For example, articles would profile a university or corporate context noting that the results of their work could lead to solutions for various social issues (healthcare, transportation, communications) but these issues were not used to constitute the social context of the articles.

National/Regional Coverage. As part of the Social Context categorization, articles were examined for national or regional emphasis and the geographical scope of the information reported in the article (national/regional).

For example, the category National/National represents articles written by a national media (e.g., *Washington Post*) that discussed nationally occurring events (e.g., research in more than one geographical area). The category Regional/Regional represents articles written by regional media (e.g., *Boston Globe*) that discuss regional events (research at a Boston-area university). Figure 2 displays this categorization.

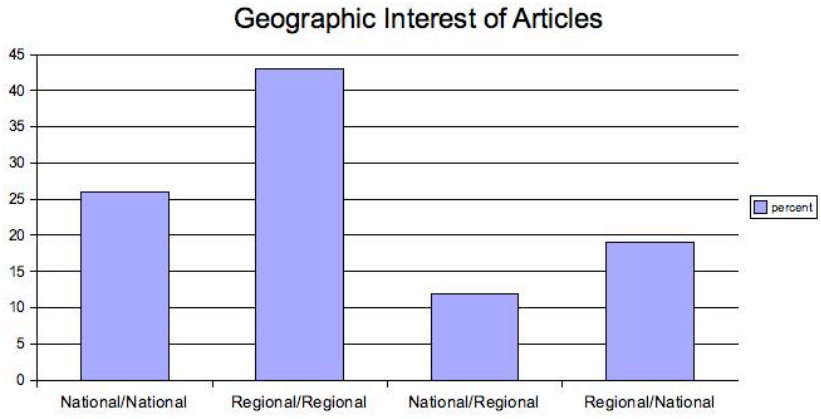

Figure 2 Geographic Interest of Articles

This distribution showed that the largest category of coverage was undertaken by regional media and focused on the regional social context, suggesting that regional media have used nanoscience research and technology as a promotional device for their local interests and economic development. For example, Clarke, a writer for the *San Francisco Chronicle,* profiled Silicon Valley as a new center for nanotechnology research and product development (published in *Seattle Post-Intelligencer*).[26] Don Gillmor, writing a column in the *San Jose Mercury News* published a feature article on nanotech research at IBM in San Jose, Stanford University, and

26Clark, D. 23 November, 1992. Nanotechnology may radically alter industry. Seattle Post-Intelligencer, p. B3.

other local San Jose companies.[27] Similarly Schubert, reporting about a University of Washington (*Seattle Post-Intelligencer*) Internet initiative, claimed that the new Internet hub would enable the school to profile the latest in nanoscience research.[28] By 1999, the media had begun to tie NST with regional economic development. For example, Baca, writing for the *Albuquerque Journal,* describes various government initiatives which have led to growth in high tech companies and their impact on the local Albuquerque economy. Baca specifically notes the growth in nanotechnology firms in New Mexico.[29]

Research and Technological Methods Cited by Articles

The category "research method" reported how the research was conducted, specifically the research design and procedures that led to specific findings. In addition, we added to this category descriptions of how specific technologies functioned or how specialized equipment was developed and operated. Data from this category was categorized in four ways: no method, description of process, speculative/interpretive, and not applicable (e.g., articles that reported about new nanotechnology buildings on college campuses). Figure 3 shows these categorizations.

27Gillmor, D. 17 July 1998. Dan Gillmor Column. *San Jose Mercury News*.

28Schubert, R. 16, March, 1999. UW is helping pioneer the Internet of the future. *Seattle Post-Intelligencer* p. B1.

29Baca, A. 19 September, 1999. High tech now major player in N.M. economy. *Albuquerque Journal* p. C13.

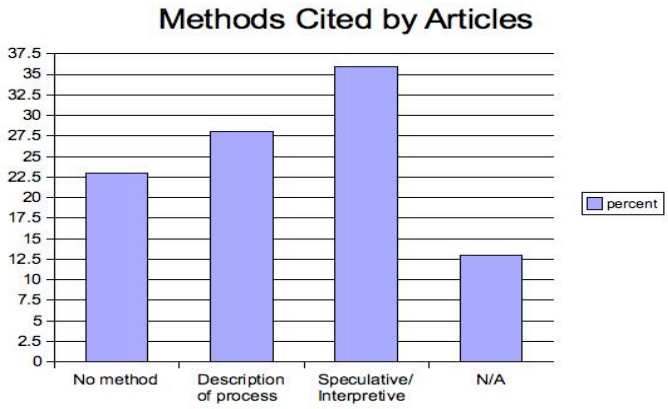

Figure 3 Methods Cited by Articles

The majority of articles we examined (59%) either did not provide a description of research methods (23%) or relied on speculative and interpretive claims based on the opinion of the writer (30%). This finding was reversed in early reports about nanoscale work. From 1986-1988, 53% of articles we examined included a description of the process used in the research and only 27% were speculative. However, the proportion of descriptive reports to speculative reports and reports not citing any methods was reversed by 1993. From 1989-1993, the number of articles based on a description of a research process declined to 28% while those that did not cite any methods increased from 6% in 1986-1988 to 28%. Speculative articles remained constant at 30% with a small increase to 40% in 1999-2000.

Claims about the social implications of nanotechnology were entirely based on interpretive methods including speculative claims that derived from book reviews and science fiction. For example, David Einstein, writing in the *San Francisco Chronicle* claimed, "if you want insights into the technology of the next century or two, the place to go is science fiction."[30] Einstein writes specifically about nanotechnology, defining it as "microscopic machines made of biological material." He claims that "science fiction has had a field day with nanotech" and

30Einstein, D. 4 January, 1999. Stranger than fiction. *San Francisco Chronicle*. p. B1.

uses these sources to claim medical and industrial applications for the field. Similarly, David Lazarus (*San Francisco Chronicle*) provides a positive review of *The long boom: A vision for the coming age of prosperity* (the book's authors are from UC Berkeley and Atherton, CA which is near Silicon Valley).[31] Though Lazarus notes that the book is optimistic and "much-hyped" his review uncritically accepts and promotes the book's speculative claims about future technologies and its definition of nanotechnology as "atom-sized robots." In 1990 Fiction writer Michael Crichton published a column in *Newsweek* predicting advances in medical technology that "will revolutionize medicine with futuristic devices, ranging from biosensors that dispense drugs from under the skin to nanomachines, hardly larger than red blood cells, that course through our bloodstream scrubbing the insides of our arteries."[32] Crichton's claims were speculative and based on his interpretation of NST.

Theory/Agent

Four primary frames were constructed to interpret the naturalized (assumed) theories informing the reporting of nanoscale work. First, 15% of the articles assumed that nanoscale work was legitimate or necessary because the work created efficiencies, developed faster technology, enabled time savings, and created smaller parts. We labeled these claims "Theories of Efficiency."

Second, 51% of the articles assumed that nanotechnology was part of a positivist evolution of science. These articles assumed that nanoscale work was legitimate because it would eventually realize potential in different areas. These claims were categorized by their use of modality (will, could, should, might) which has been associated with hedging. We labeled these claims "Positivist evolutionary."

Third, 30% of the articles made extreme assumptions about the inevitability of nanoscale work. For example, these articles assumed that nanoscale devices were already in existence, that molecular manufacturing was inevitable, or that nanoscale medical applications were already being used. These claims were categorized by the

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31 Lazarus, D. 12 December 1999. The future's so bright, they have to wear shades. *San Francisco Chronicle*. Sunday Review p. 9.

32 Crichton, M. 24 September, 1990. Greater expectations. *Newsweek* p. 58.

use of the present or the past tense (e.g., "Nanotechnology is gaining mainstream respectability. . . . Science clearly has accepted the notion"[33]). We labeled these claims "Inevitability."

Fourth, 3% of the articles approached the field from a critically negative perspective. These articles assumed that nanoscience work was dangerous, risky, and would lead to future problems. Table 6 shows these four naturalized assumptions that informed nanotechnology reporting.

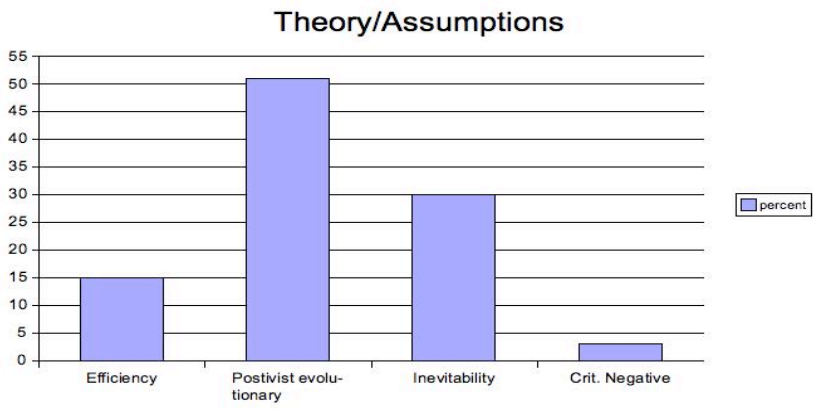

Figure 4. Theory / Naturalized assumptions informing NST reporting

This category is complicated by the operation of more than one theoretical framework within each article. While the researchers are working from their own assumptions, the reporter approaches the topic from a potentially different set of naturalized assumptions. For this study, we examined the assumptions presented by the article itself. The results suggest assumptions within the reporting of nanoscience work and not necessarily those held by the scientists and technologists conducting the research.

33Hall, C. 19 July, 1999. Brave new nano-world lies ahead. *San Francisco Chronicle.* p. A1.

Related Research

Following Zimmerman et al., we used the category "related research" to describe "information about whether the findings have been replicated or fit other results."[34] In other words, this category listed recognizable research topics and fields the reporter claimed were influenced by the primary research. These results were similar to those found in the pilot study. The topics cited most often were computing (35%), medical applications (32%), electronics (15%), social implications (14%), industrial products, including materials sciences (12%), and manufacturing processes (10%).

These categories correlated directly with the most often mentioned representations of NST in the pilot study. However, manufacturing processes did not rate as prominently in this study as in the pilot study. This is because our second study expanded the data set to include articles from the year 2000. Most of the mentions of manufacturing processes (especially molecular manufacturing) occurred early in the data set. We found fewer mentions of this category in 2000. Business research was mentioned by only 6% of the articles. Although social implications was a high-mentioned category, 48% of all mentions in this area occurred in 2000.

These research descriptions were positive, supportive of research and technological development in NST, and consisted of illustrating other areas which would benefit from nanoscale work. Negative accounts, societal impacts, or cautionary accounts were few and typically embedded within larger narratives.

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34 Zimmerman, C. , G. Bisanz, J. Bisanz, J. Klein, and P. Klein. 2001. Science at the supermarket: A comparison of what appears in the popular press, experts' advice to readers, and what students want to know. *Public Understanding of Science 10,* p. 40.

CONCLUSION: FORESHADOWING FUTURE PERSPECTIVES OF NST.

In these articles, nanotechnology is unproblematically represented as a symbol of technological progress and advancement. The social context built by these perceptions is one of elite activity and privilege. NST is an activity that holds key economic benefits for those fortunate enough to be included. However, these perceptions are based largely on speculative claims about the future and an underlying assumption that technology and efficiency necessarily result in social progress. Most surprisingly, as nanoscale work became institutionalized toward 1999 and 2000, the percentage of speculative and unfounded claims increased while actual descriptions of specific research processes remained stable at approximately 30% of articles.

NST was represented as relevant to the creation of future computer technologies, medical applications and procedures, electronics, and industrial products. However, these are large, different, and very broad fields and areas of application. We found no central field or concept that appeared able to best claim or conceptually define NST. By 2000, nanoscale work was only emerging as a business interest. Several reports claimed that the field could have economic benefits for specific regions and local communities. However, these benefits were not elaborated or defined. In addition, very few articles reported marketable inventions or new products derived from NST.

Although this study has only examined historical news articles, the conclusions are important for understanding current representations and understandings of the field. In their study of 3 national news papers and the Associated Press, which included reports to 2004, Gorss and Lewenstein also concluded that national media coverage of NST has been "overwhelmingly positive."[35] In comparing NST coverage to similar early coverage of biotechnology, Gorss and Lewenstein write that issues of public accountability have been more prominent in NST coverage. In other words, they claim that there have been proportionately more articles about the ethical, legal, and societal implications of NST than there were about biotechnology in its early public emergence. Yet,

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35 Gorss, J., and Lewenstein, B. (2005). The salience of small: Nanotechnology coverage in the American press 1986-2004. Paper presented at the 2005 conference of the International Communication Association,

as our research also found, Gorss and Lewenstein's data show that this topic of coverage remained relatively small when compared to reports of technical development, economic prospects, future applications of NST, and related research on NST.

Gorss and Lewenstein concluded that "the framing for nanotechnology is yet to be established,"[36] meaning that by 2004 no stable, defining image or narrative had yet emerged to fully describe or represent NST. This lack of a central defining concept can be traced through our historical data which shows NST emerging simultaneously in several fields and claiming a broad range of different applications from medicine, to computer technologies, to material sciences. Given the multiple sites, applications, methods, and academic fields staking a claim within the panorama of NST practice, both currently and historically, it would seem that a coherent frame for the field may still be far away. At the same time, with the decline of the category "manufacturing" toward 2000, it appears that more traditional disciplinary frames appeared to gain legitimacy at the expense of the more home-grown "molecular manufacturing" frame. This suggests that ultimately NST may not solidify as a separate field or frame but as a field of practice within already existing and dominant frameworks.

The lack of a dominant and defining public concept for NST was also noted by Cobb and Macoubrie in their report from the first representative national phone survey of American's perceptions about NST.[37] Conducted in March and April 2004, Cobb and Macoubrie's survey of 1536 adults found that 83.6% of respondents had heard "nothing" or "a little" about NST. Cobb and Macoubrie also concluded that Americans are "minimally knoweldgeable" about NST. Yet, despite these findings, most respondents reported a positive perspective about NST. Only 22% of their respondents claimed that the risks of NST outweigh its benefits. Respondents also claimed "new ways to detect and treat human diseases" as the majority choice of benefit associated with NST. These findings have strong historical precedent in the data presented above. If Americans are at all exposed to media reports about nanotechnology, these reports are more likely to be positive about the field and they are more likely to report medical applications for NST (Cobb and Macoubrie did not offer "better computers" as a

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36 Ibid, p. 24

37 Cobb, M. and Macoubrie, J. (2004). Public perceptions about nanotechnology. *Journal of Nanoparticle Research 6*: 395-404.

potential benefit).

Following Cobb and Macoubrie's findings, it is important to note that despite 18 years of media reports of NST in national and local media, the vast majority of Americans report no knowledge about the field. Even though Cobb and Macoubrie found a generally positive predisposition to NST we can assume that these attitudes may change if (or when) people encounter more information about the field. Currently, it appears that those who read media coverage of NST may already be predisposed to certain perceptions of science and technology. When reporting on the effect exposure to *Prey* had on respondents, Cobb and Macoubrie wrote, "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."[38] They note that people who choose to read *Prey* may be predisposed to having positive attitudes towards new developments in Science and Technology. However, they also note that this finding can not be generalized to people who like science fiction books, since there were hundreds of respondents who claimed to like science fiction but had not read *Prey*. Perhaps we can also suggest that an interest in Science Fiction is not drawing people to NST literature or media articles.

It is crucial that researchers and industry advocates find more appropriate venues to inform the public about NST. We can not assume that general media outlets or predispositions to science fiction will necessarily lead people to become interested in NST. Nor can we assume that these outlets will provide accurate or useful introductions to the field. In fact, our research shows that by 2000, science fiction and cultural phenomena (movies, literature) remained a small (though constant) part of the the NST context while social implications, medical applications, and business and financial issues were rapidly increasing. As Cobb and Macoubrie's data suggests, people do associate NST with medical applications, an area close to their own daily interests and needs. Perhaps more people will encounter NST as a methodology within other practices rather than as a stand alone science or technological application. If this occurs, it will become even more difficult to construct a single frame to conceptualize NST as a single field or technological pursuit.

38Cobb and Macoubrie, p. 401

We also are concerned that the media reports we examined were increasingly less likely to contain specifics about NST research, products, or implications. As most journalists are rarely practicing scientists, they require more detailed and specific information from the NST community. To an extent, it is surprising that early articles about NST are so positive given the lack of specification and detail available in the reports. At some point, this good will may subside as journalists begin to seek more credible and data-driven information for their reports. Media reports of science should be recognized as more than simple translations of scientific work. In an world of increasingly complex and specialized science, popular reports enable government and business leaders and scientists from other fields to understand and engage areas beyond their own immediate area of specialization.[39] Even though it seems that the general public has paid little attention to scientific reporting about NST, media reports do influence academic and industry recruitment, investor attitudes, and legislative activities. Thus, it is crucial that media reports be accurate, informative, and critical. Journalists writing about NST must be held to a high standard for the quality and credibility of their reporting. While some of this responsibility passes to the those providing source data for journalistic research, science writers must also recognize the role they play in explaining, critiquing, and legitimizing NST. Reporting should not elide the social issues and impacts of NST, nor should it take for granted the economic impacts, technological innovation, or scientific progress commonly associated with the field. Such reporting does not do a disservice to the field. Instead, it would present a more credible and critical field to an interested and as yet supportive external audience.

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39 Paul, D. (2004). Spreading chaos: The role of popularizations in the diffusion of scientific ideas. *Written Communication, 21,* 32-68.

Appendix A

News media referenced in this study

1. *The Washington Post*and *Los Angeles Times* as members of the national prestige press.
2. The *Houston Post, Miami Herald, Philadelphia Inquirer,* and *Boston Globe*, as representatives of large newspapers from balanced geographical regions of the United States.
3. The *Allentown (PA) Morning Call* and *Charlotte (N.C.) Observer*, as examples of medium-sized newspapers.
4. The *Albany (NY) Times-Union*, The *Albuquerque Journal, The Arizona Republic, Baltimore Sun, Chicago Tribune, Detroit Free Press, San Francisco Chronicle,* and *San Jose Mercury News* to cover geographical regions that have been indicated as the top 10 major nanotechnology development areas.
5. *NY Times*for its coverage of science and technology issues.
6. The *Wall Street Journal* for its role as a leading financial newspaper.
7. *Seattle Post-Intelligencer* for geographic distribution and coverage in a technology-intensive region.

In addition to these US-based papers, we added three Canadian newspapers: *The Globe and Mail*, as a member of the national (Canadian) prestige press, *Edmonton Journal,* representing geographical region, *Halifax Chronicle*, representing geographical region. These three papers were also included among the seven papers used in Einsiedel's (1992, p.92) content analysis of science coverage in major Canadian newspapers.

News magazine selection was based on Zimmerman et al. (2001) Media included: *Time, Newsweek,* and *Maclean's* (Canada). To this list we included *US News and World Report, Popular Science, Reader's Digest,*and *Discover*.