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What Counts as a 'Social and Ethical Issue' in Nanotechnology?

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Abstract: As 'social and ethical issues' becomes a recurring phrase in the community paying attention to nanotechnology research, a crucial question becomes: what counts as a social and ethical issue? A typical list includes privacy, environmental health and safety, media hype, and other apparently unrelated issues. This article surveys those issues and suggests that concerns about fundamental concepts of ethics, such as fairness, justice, equity, and especially power, unite the various issues identified as 'social and ethical issues' in nanotechnology.

Keywords: *nanotechnology, social issues, ethical issues, equity, justice, power*.

1. Introduction

As 'social and ethical issues' becomes a recurring phrase in the community paying attention to nanotechnology research, a crucial question becomes: what counts as a social and ethical issue?[1] Even the field in which the question occurs is in dispute: is it 'nanotechnology', 'nanoscience and nanotechnology', 'nanoscale science and technology', or 'nanoscale science, engineering, and technology'? Each of these labels implies something different about the relationship between inquiry, research, development, and application. If we set aside these differences, which are likely to be examined in other papers contributed to these special issues, and constitute a single 'nano' field, we are still faced with boundary issues. For example, questions about the ethical implications of creating and deploying nano-sized particles, which might or might not have deleterious health effects on humans or animals who inhale them, have been taken up by the technical research community as 'safety' questions.[2] Is a safety question an ethical question? Who decides? This brief paper is an attempt to begin to ask these questions in a deeper way, to identify what underlying principle(s) might define 'social and ethical issues' in nanotechnology.

2. Overview

Much of the excitement about nanotechnology exists because it offers the possibility of many societal benefits, such as reduced energy use, better medical treatment, and lower costs for computing and other common technologies (Amato 1999). Many observers have also expressed concerns about risks associated with nanotechnology – environmental risks, privacy risks, social and political risks (Arnall 2003, ETC Group 2003, Joy 2000). In that context, they have called for studies on 'social and ethical issues' in nanotechnology. But there is a danger in using the label for studies associated with risk, for it might imply that social and ethical issues are associated only with potential dangers of nanotechnology, or that the risks of nanotechnology will outweigh the benefits.

To say that there are 'social and ethical issues' (SEI) in nanotechnology assumes no position on the question of risks and benefits. Indeed, it is not even clear that talking in terms of 'risks versus benefits' is a useful way to approach nanotechnology. Rather, to say that there are social and ethical issues is to say that science and technology exist only in a social context, and that we cannot understand how science and technology develop without understanding both the social conditions that produce them and the simultaneous scientific and technological conditions that produce society. Better understanding of the interaction of science, technology, and society at many levels of the polity leads, I assert, to more informed decisions about how to invest in science and technology, when and how to regulate – or not regulate – technological development, how to address inevitable ethical challenges, and so on. Note that this perspective, of mutual interdependence of science, technology, and society, is why I prefer the term 'social and ethical issues' to the phrase used by some nanotechnology funders, most notably the U.S. National Science Foundation, which is 'societal and ethical implications' of nanotechnology. The latter phrase implies that science and technology come first, followed by 'implications'. The history of science and technology does not support such a perspective.

Much of the promise of nanotechnology, and the early identification of social issues associated with nanotechnology, appears in documents associated with the U.S. National Nanotechnology Initiative (Roco *et al*. 2001, Roco & Bainbridge 2005). In the remainder of this paper, I will adopt this necessarily American perspective, while acknowledging that similar discussions are being held in other countries.[3] Some of the major categories of social and ethical issues identified in the American documents include the following.

Economic and political implications of potential technology

These issues include the economic value of new materials and new industries created through nanotechnology, as well as economic dislocations caused by shifts in investment and the decline of industries and companies tied to displaced technologies. Other implications might include increased lifespans made possible through nano-based medicines or diagnostic techniques, leading to greater numbers of active senior citizens seeking employment and active participation in the political process.

Science and education implications

Nanotechnology is perceived by many as an interdisciplinary field, requiring knowledge of chemistry, physics, engineering, and, for many applications, biology.[4] But although American science education reforms of the 1990s led to recommendations for more interdisciplinary science studies in primary and secondary schools (National Research Council 1996), countervailing political pressures for instruction in basic topics and for accountability have stymied many reformers in their attempts to change curricula. Nanotechnology proponents therefore perceive a need for changes in educational systems in order to prepare students for careers in nanotechnology, whether as technicians with only minimal post-secondary training or as cutting-edge doctoral-level researchers.

Medical, environmental, space exploration, and national security implications

That nanotechnology will have impact in a great many areas of application is assumed by most participants in the field. A listing of 'medicine, environment, space, and national security' is in some ways only a listing of areas where the political imperatives for funding mean that applications are likely to appear sooner rather than later. Put another way, acknowledging that public funding is available precisely because these are areas important to society means that society expects developments in science and technology to contribute to improved medical care, environmental quality, space exploration, and national security – and supporters of nanotechnology expect to produce those developments. Thus, any advance in nanotechnology necessarily has societal implications.

Social, ethical, legal, and cultural implications

The list of social, ethical, legal, and cultural implications includes such issues as privacy, avoiding a ‘nano-divide’, unintended consequences, university/industry relationships and potential conflicts of interest, research ethics, and so on. It is widely acknowledged that, precisely because the applications of nanotechnology are not yet clear, neither are the ethical issues clear. And yet, many argue, the nano community must begin to address these issues now, before they overwhelm nanotechnology and derail potential benefits.

The NSF and other funding agencies are to be congratulated for recognizing and actively promoting discussion of SEI, which required the active work of a small group of socially-concerned scientists working in research centers, federal agencies, and legislative offices (Radin 2003). Yet the categories they have produced and that appear in other reports (including, for example, the June 2004 British report cited in note 3, which contains separate chapters on regulatory, environmental, and ‘social and ethical’ issues) require exploration. An odd element of the categorization is that it separates ‘social, ethical, legal, and cultural implications’ from economic, national security, workplace, and other issues that are also fundamentally social, legal, and cultural in their construction and implications. This, then, is the problem to be addressed: What are the implications of setting boundaries that separate ‘social and ethical’ issues from other inherently social and ethical issues? To address the problem, we need to determine if there is any principle that can distinguish among these topics, or if there is some underlying principle that can better be used to characterize what counts as a social and ethical issue.

3. Building from the bottom

A recurring metaphor in nanotechnology research is between ‘top-down’, *i.e.* defining a nanostructure and then etching away material until only the nanostructure is left, and ‘bottom-up’, *i.e.* building nanostructures atom-by-atom or molecule-by-molecule. In the spirit of that metaphor, and without taking sides in the technical debate about whether ‘top-down’ or ‘bottom-up’ is a superior approach to ‘real’ nano, I suggest that the confusion of categories and labels described above comes from an attempt to pre-define what counts as a social or ethical issue. Whether deliberate or not, the attempt to set boundaries is necessarily an exercise of power that precludes our ability to understand the properties inherent in issues that make them social or ethical. Instead, I will try in what follows to avoid boundaries, to survey many of the issues identified by others in ways that allow them to be seen in the same space – and so show what the connecting principle is. From the bottom up, I will try to build a principle for identifying social and ethical issues in nanotechnology.

The following list of issues and questions comes from perusing many of the reports and discussions about SEI of the last few years.[5] The list is not intended to be comprehensive, but I believe it covers the main issues identified by others.

Environmental issues

Environmental issues associated with nanotechnology are currently, in winter 2005, the most prominent in the news, and ‘environmental and safety issues’ is becoming a standard discussion among the nanotechnology community. The public notice of these issues was most noticeably drawn by a *Washington Post* article in February 2004 (Weiss 2004) but other news has continued to keep the topic current. To some people, these are ‘technical’ issues, separate from social and ethical issues. To others, the inherently social process of identifying what constitutes a risk and what constitutes safety make these issues ‘social and ethical’ ones. Generally, nanotechnology proponents argue that making things much smaller will make them more energy efficient, thus reducing energy demands. Others argue that the presence of very tiny manufactured nano-particles in the environment may cause health problems associated with inhalation. Some people associated with nanotechnology have also expressed concern about the environmental impacts of nano-manufacturing processes, particularly those involving large amounts of water. Will nano-manufacturing face some of the same environmental challenges regarding toxic waste streams as semi-conductor manufacturing currently does? Still others, including prominent nanotechnology researchers, have called attention to the difficulties in stating with any confidence what the environmental issues might be, because too little data is available (Colvin 2003). In this state of uncertainty about *implications*, the *issues* remain: Who is likely to bear the risks of any environmental challenges – investors, workers, or communities near the manufacturing plants? Who will reap the benefits of environmentally-friendly materials – producers, consumers, or anyone who breathes the air and drinks the water? How will decisions about risks and benefits be made, and by whom? What influences will shape those decisions?

Workforce issues

As noted above, the need for people ready to work in a nanotechnology-enabled world leads to a variety of needs. Some are specific: training programs for technicians, undergraduate and master's level programs for engineers and managers of nanotechnology companies, and advanced research training for doctoral and post-doctoral students. Others are more general, such as the suggestion from the Royal Academy of Engineering and the Royal Society that all research students be required to study social and ethical issues (Royal Academy of Engineering and Royal Society 2004). Most far-reachingly, people concerned about the workforce argue that, at least, American education must change to make students capable of working in interdisciplinary advanced technology arenas. But a key element of American education is the commitment to local control. Unlike most countries, the United States has no mandatory national curriculum; in addition, funding for education varies dramatically by state and locale. Some locales will invest in new curricula or new approaches to education that foster technological innovation, while others – even if community leaders wish to try new methods – may be stymied by lack of access to money or technological expertise. Given competing priorities for educational resources, including time, how will decisions about preparing students be made? How will the best techniques for training students be identified? Will some students find easier access to new ideas, techniques, and information than others? To what extent will issues of financing, ideology, local politics, and local industrial base shape these decisions?

Privacy issues

Nanotechnology is likely to lead to smaller, faster, cheaper computers. The notion of 'ubiquitous computing' with all the benefits it promises becomes much easier to develop with nano-based processors and memory. The proliferation of powerful computers, however, will make it even easier to compile and process databases of personal information. Current privacy regulations may serve to regulate the large databases maintained by credit companies and consumer manufacturing companies, although even this claim is questioned. What happens when, for example, any individual can use a tiny video camera to record people passing into a particular store, face-recognition software to identify those people, publicly-available databases to find those people's addresses and personal data, and then create marketing pitches based on the stores they have entered? Who will control access to information? In the field of genetics, many laws have been introduced, but not always implemented, to protect the privacy of medical records so that, for example, insurance companies will not be privy to individual health profiles. But is that fair to the investors in insurance companies, whose business model is based on the assumption that risks can be fairly identified and apportioned across groups? How can the claims and needs of individuals, corporations, other groups, and the state be adjudicated?

National and international political issues

Much of the U.S. government's investment in nanotechnology is driven in part by global economic concerns, a perceived need to maintain technological leadership. What obligations does a nation have to share technological developments with other countries, especially economic allies? In what ways is the development of technological leadership a force in global politics? The relationship between the developed world and developing countries is a particular concern, as a recent Canadian study suggests (Court *et al*. 2004). Even within a country such as the United States, what obligations are there for sharing technological development across the country? Several states, for example, are creating ‘nano centers’ in the hope that nano-based businesses will locate there, with attendant economic benefits. Questions of benefit and obligation, of resource allocation, are fundamentally political questions, in the ‘good’ sense of politics as a tool for balancing competing interests, values, needs, and responsibilities in ways that yield the best outcome for both individuals and the community at large.

Intellectual property issues

Like other ‘emerging technologies’ that are tightly linked to basic scientific research, nanotechnology generates intellectual property that is perceived as valuable and thus protected by patents. Various laws, regulations, and treaties govern the relationship between ‘the public good’ and the protections offered by patents. These rules vary across nations, and even within any one country there is not necessarily agreement on what should be patentable and how the benefits of protected intellectual property should be shared. In the United States, where much nanotechnology research is funded by government grants, the 1980 Bayh-Dole Act encourages universities to seek patents, on the grounds that such protection will ultimately encourage universities to transfer technology into the commercial sector, yielding economic, *i.e*. social, return as well as intellectual return on the government investment. Research studies on the effects of Bayh-Dole, however, have illustrated the potential unintended consequences, such as restricted dissemination of faculty research, delays in publication, deleted information, and – most ominous to those who believe academic research should be ‘pure’ in its motivations – a change in direction of faculty research toward projects with commercial potential (Thursby & Thursby 2003, Jensen *et al*. 2003). New questions arise: Do existing rules and regulations function in the nano-oriented economy? Are there differences between nanotechnology and, say, genomics research that should be explored? Does the close association of entrepreneurial companies with particular university-based researchers compromise the ‘public’ mission of research universities, or does it enhance the ability of students to explore technological developments that can contribute to the public good? Is a different language needed for discussing the interaction of funding, ownership, development, and returns? How can the interests of public and private be balanced?

Human enhancement

Among the applications of nanotechnology that some researchers consider ‘science fiction’, while others are actively attempting to implement, are enhancements to human memory, physical strength, and other characteristics. Though usually framed as attempts to monitor or repair ailments or disabilities such as Parkinson’s disease or genetic abnormalities, some of these technologies can simultaneously be used to control or enhance particular human characteristics in ‘normal’ humans as well. These possibilities raise many of the same issues as stem cell research and other aspects of biotechnology: defining the boundary between treatment and change, establishing common understandings of what counts as ‘human’ and ‘natural’, the rights and needs of the ailing and their families versus broad social interests in establishing clear guidelines that a broad mainstream of society can support, the role of religion and morality in public life and in the governance of science, and so on. As with so many of the issues listed above, the ‘right’ answer is not clear, and neither is the way forward. How might social consensus be achieved on such issues? Who should determine what research and what applications can or should be developed? On the issue of implants that might relieve symptoms of Parkinson’s disease, for example, I have heard researchers arguing that they should continue their research because ‘ultimately, it is a decision between the patient and his or her surgeon’. Others have argued, as the atomic scientists of World War II did, that research scientists have a moral obligation to guard against misuse of their research. How can such issues be resolved?

4. The common frame

What holds each of the issues above together, the principle that links the individual items into a common frame, is that all involve questions of fairness, equity, justice, and especially power in social relationships. That is what makes them 'ethical' issues. In each case, not only are legitimate questions possible about how nanotechnology research and application should develop, but even more fundamental questions exist about how to make decisions and who should control those decisions. These fundamental questions are asking about the source of power in societies with unequal social distributions of power.

Yet, precisely because the 'top-down' approach to defining social and ethical issues has separated 'social and ethical issues' from economic, political, national security, and other issues, the exercise of power has been hidden even in the definition of what is legitimate to study. Consider the interaction of economics, workforce, and safety issues, for example. Addressing the need to create safe working environments for manufacturing nanomaterials will require social negotiations for setting standards and levels of acceptable risk, a political process in which manufacturers and their workers will bring different levels of power. If economic, workforce, and safety issues have been excluded from the definition of 'social and ethical issues', then the place of power in the negotiations can be hidden, with rhetoric focusing more on technical safety or national competitiveness – both important issues, but ones clearly different than allocations of power.

Though scientists often complain about what they perceive as a lack of social power, they are in fact one of the most respected social groups in society and their judgments are highly regarded (National Science Board 2004). In the United States, in particular, 'expertise' is a valuable social resource, and in times of political conflict, such as in debates about stem cells, nuclear power, or global warming, competing groups fight to claim the mantle of 'science'. When individual scientists or scientific groups argue that because *they* interpret available evidence to say that a particular technology is possible or not possible, and that therefore development should proceed or be abandoned, they are claiming the social power granted to them by society. The difficulty comes when, as necessarily happens in areas of emerging technology, the scientific community itself is unsure of what is possible or not possible. Then power becomes a liability, an invocation or imperative to take action without consultation when the group in fact needs other perspectives. Defining such technical issues as *not* part of 'social and ethical issues' prevents us from seeing the interdependence of science, technology, and society with which I began my argument.

I do not want in any way to be read as saying that scientists have power illegitimately or inappropriately; I want only to emphasize the importance of recognizing the linkage among social groups and social power. For other groups also have social power, such as large corporations, organized ethnic enclaves, labor, and the elderly. The ethical challenge is to find ways for these groups to manage their competing interests, making clear what obligations and opportunities they perceive, exercising their power in responsible ways – including acknowledging the power held by others and the flexible boundaries between their interests.

At this point, other issues that are frequently listed as 'social and ethical issues' in nanotechnology enter the discussion. These include studies of public opinion about, media coverage of, rhetoric in, and history of nanotechnology. Do the principles of equity, fairness, justice, and power allow us to include these issues in a carefully defined 'social and ethical issues' category? Or must we start listing them in some new grouping?

Consider first the *media and public opinion issues*. Many people in the nanotechnology community worry that media coverage of nanotechnology focuses too much on risks and not enough on benefits. They believe that the risks have been overstated, and they worry that media coverage may affect public opinion, making it difficult to achieve the promise that they see for nanotechnology.[6] They point frequently to the example of genetically modified organisms, which many, but by no means all, scientists believe was unfairly tarnished with safety concerns. The nano community does not want nanotechnology to be what they perceive to be prematurely prevented from development. This seems clearly to be a question of power: the nanotechnology research community wants to be able to define what constitutes appropriate development of the field, without fear that some other social group – for example, a politically-savvy coalition of nanotechnology opponents or advocates of a particular direction in nanotechnology research – might exercise its power to direct nanotechnology.

Tied to questions about media coverage are *rhetorical issues*, including analysis of the images, both textual and visual, associated with nanotechnology. Again, many proponents of nanotechnology worry that images of 'grey goo' or of self-replicating nanobots that could take over the world, as in Michael Crichton's *Prey*, misrepresent the risks of nanotechnology and could affect public opinion. Clearly, such concerns raise the same issues of power as the concerns about media coverage. But, like issues such as intellectual property or workforce preparation, rhetorical issues can also be addressed in ways that do not directly deal with ethical concerns. Rhetorical analysis can show, for example, how the use of particular phrases, such as 'more changes in the next 30 years than we saw in all of the last century', can set expectations for inventors and investors.[7] It can also show how images of 'revolution' can be used both to promote a technology by highlighting the new and exciting opportunities and to criticize it by emphasizing its disruptive elements. If, through some exercise of power, we were to use some arbitrary definition of 'ethical issues' that included some rhetorical issues, but excluded others, we would miss the inherent interweaving of social and technical.

The final set of issues often labeled as 'social and ethical' are *historical and philosophical issues*, of the sort addressed in this journal. Such issues clearly raise questions of fairness, equity, and power – indeed, it is often through historical and philosophical research that such questions are most clearly identified and presented. History and philosophy also make clear the complexity of scientific development, in ways that show the interweaving of social, ethical, and technical issues. Historians and philosophers have demonstrated clearly that science and technology do not develop entirely through a pure internal logic, but exist only in a social matrix of funding, institutions, personnel, politics, and culture. Studying the history and philosophy of nanotechnology as it emerges is likely both to confirm previous understandings of how science, technology, and society interact, and simultaneously to pose new questions about the interactions, as the social matrix shapes the development of nanotechnology and is as well shaped by the new technology. Though such studies may challenge the power of science to maintain its boundaries separate from society, they represent our deepest understanding of the integration of 'social and ethical issues' throughout the nano – and indeed all of the technical – world.

5. Conclusion

The ability to see principles of fairness, equity, justice, and especially power – in short, the key social interactions that shape the co-existence of science and society – in so many aspects of nanotechnology suggests they can provide the frame on which to build a broader definition of 'social and ethical issues'. Indeed, the attempts to define 'social and ethical issues' narrowly is itself an exercise of power that can prevent us from understanding how central social issues are to the development of scientific knowledge and its implementation through technology in the modern world.

Thus at the same time that we congratulate the nano community for embracing studies of 'social and ethical issues', we should be wary of the attempt to draw boundaries between those issues and 'technical' ones. As I have tried to show in this paper, the 'top-down' attempt to separate some social issues from others hides from us the degree to which power operates as a unifying principle across many issues. Even more so, the attempt to separate social and ethical issues from other areas of nanotechnology research shields us from understanding the ways that equity, justice, and power are inherent elements of science and technology. We must allow 'social and ethical issues' to emerge from the bottom up, through the nano community, wherever they appear.

I will conclude by noting that nanotechnology may not be any different than any other area of emerging science and technology. Virtually every argument of this paper would hold if the words 'biotechnology' or 'information science' or 'cognitive science' were substituted for 'nanotechnology'. Social and ethical issues permeate science and technology. Only the exercise of power prevents us from seeing that.

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Notes

[1] See, for example, *21st Century Nanotechnology Research and Development Act* 2003.

[2] For example, a workshop on 'safety and environmental issues' was held in December 2004 in Atlanta, Georgia, organized by the National Nanotechnology Infrastructure Network (NNIN); the organizers represented a separate branch of the NNIN management than the 'social and ethical issues' branch.

[3] See, for example, a recent British report jointly produced by the Royal Academy of Engineering and the Royal Society (2004) and a report from the Büro für Technikfolgen-Abschätzung of the German Bundestag (TAB 2004).

[4] The question of whether nanotechnology is 'inter-', 'multi-', or 'trans-' disciplinary is in fact one of the first questions posed in the Call for Papers for the joint special issue of *Hyle* and *Techne* on 'Nanotech Challenges'. I leave that debate to others, but note merely that the question of how to describe cutting-edge research is a recurring one in American science. See, for example, Kohlstedt *et al*. (1999, pp. 104ff, 163-165).

[5] Except where I have drawn a particular issue from a particular source, or where some canonical reference seems useful, I have not attempted to identify the sources for the ideas listed here. I believe they are sufficiently widespread or easy to imagine (think of a mathematical text's injunction that 'it is left to the reader to show…') that no references are needed.

[6] There is little substantive data to support these claims. Both general data on media coverage of science and public opinion and specific data on other controversial subjects such as biotechnology and stem cells show that media coverage and public opinion are overwhelmingly positive (National Science Board 2004, Nisbet & Lewenstein 2002, Nisbet *et al*. 2003). Preliminary studies support the belief that the situation will be the same in nanotechnology (Lewenstein *et al*. 2005; Cobb *et al*. 2004).

[7] The quote is from Mihail Roco, director of the National Nanotechnology Initiative, and appeared in the *Houston Business Journal* on 16 January 2004.

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