The social impacts of nanotechnology: an ethical and political analysis

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Abstract

This paper attempts some predictions about the social consequences of nanotechnology and the ethical issues they raise. I set out four features of nanotechnology that are likely to be important in determining its impact and argue that will have significant social impacts in—at least—the areas of health and medicine, the balance of power between citizens and governments, and the balance of power between citizens and corporations. More importantly, responding to the challenge of nanotechnology will require confronting "philosophical" questions about the sort of society we wish to create and the role that technology might play in creating it. This in turn will require developing institutions and processes that allow the public to wield real power in relation to technological trajectories. My ultimate contention is that the immediate task established by the social impacts of nanotechnology is not so much to develop an ethics of nanotechnology as to facilitate an ethical *conversation about* nanotechnology.

Introduction

There is a lot of "buzz" about nanotechnology at the moment; the science of the small is making a big splash (Berube 2006). According to some pundits, the development of nanotechnology heralds a technological revolution as powerful as the invention of the transistor or the silicon chip (Gringrich cited in Roco and Bainbridge 2001, 270; National Science and Technology Council 1999, 1). If this is true then one would expect the ethical issues raised by this technology to be correspondingly profound (Sparrow 2007a).

A full evaluation of the perils and promise of nanotechnology would involve answering questions about its implications in—at least—the following six areas of concern: health and safety; environmental impact; law and regulation; social consequences; science and technology policy; and broader "philosophical" issues. However, reasons of space prevent me from addressing all of these in this context.

Fortunately, the health and safety issues associated with nanotechnology have been subject to a thorough initial survey by the Swiss Re insurance company (Swiss Re 2004) and are also being hotly debated by toxicologists and others with expertise more suited to this task than philosophers such as myself (Dreher 2004; Nordan and Holman 2005; Service 2005). Similarly, the environmental impacts of nanotechnology have also been subject to a comprehensive review by Swiss Re (2004) and (more controversially) examined by the United States' Environmental Protection Agency (2007) and are also being vigorously debated and contested by ecologists, biologists, and environmentalists elsewhere in the literature (Brumfiel 2003; ETC Group 2004; Friends of the Earth 2006; Hood 2004) . It is, perhaps, more unusual to choose not to discuss legal and regulatory issues in the context of the discussion of ethics—after all, one would normally hope that a consideration of the ethics would inform the law. However, at this stage it appears that the most pressing need for regulation arises out of environmental and health and safety concerns, which are beyond the scope of my purview here. Moreover, the legal and regulatory issues associated with nanotechnology have recently been a topic of investigation by a number of authorities (amongst them a team of academics at Monash University that includes one of the other contributors to this symposium) and I feel confident in referring the reader with a particular interest in this topic to their work (Bowman and Hodge 2008; Hansen et al. 2008; Helmus 2007; Hodge, Bowman, and Ludlow 2007; Matsuura 2008).

Thus I will concentrate here on the remaining three sorts of issues, which are in any case where the expertise available to a scholar in the humanities may be put to best use. In particular, I will try to provide some predictions about the social consequences of nanotechnology and the ethical issues they raise, matters which are particularly poorly treated in a literature that tends to be dominated by writers whose expertise is in the

physical rather than the social sciences.[1] My answers will necessarily be somewhat tentative simply because the impacts of individual technologies—let alone a whole new technological revolution—are notoriously hard to predict and also because the shape and potential of future nanotechnologies remain themselves somewhat unclear. My ultimate contention is that the immediate task established by the social impacts of nanotechnology is not so much to develop an ethics of nanotechnology—or "Nanoethics", as the title of a prominent philosophical journal would have it—as to facilitate an ethical *conversation about* nanotechnology.

Nanotechnology or nanotechnolog*ies*?

An important terminological question, which highlights an issue of methodology, arises in relation to discussions of nanotechnology and consequently must be addressed before proceeding further. Should we be talking about "nanotechnology" or "nanotechnologies"?[2] "Nanotechnology" is inevitably to some degree a misnomer, as there is not just one, but multiple technologies that involve manipulation of matter at the nanoscale. Scientists in the fields of physics, chemistry, biology, computer science, electronics, manufacturing, and materials sciences, as well as others, are all involved in developing technologies to engineer nanoscale structures. There are many different technologies that have emerged, are emerging, or are likely to emerge, from their efforts. It might therefore be argued that it would be more accurate to refer only to nanotechnolog*ies* and to avoid generalising about technologies which may have little in common other than the scale of the structures they produce or manipulate.

However, it is too late to insist that there is no such thing as "nanotechnology". The term has come into common usage, not least because it was taken up by advocates of engineering at the nanoscale to advertise the benefits of the coming technological revolution and to argue for increased funding for research in the area (Berube 2006; National Science and Technology Council 1999; Roco 2005). Moreover, as I will argue below, it is in fact possible to discern some common features shared by all these different nanotechnologies, at a high level of abstraction at least. In what follows then, I will continue to talk of "nanotechnology" to refer to technologies which manipulate matter at the nanoscale, whilst keeping in mind the range of technological innovations that may be referred to under that umbrella term.

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[1] Notable exceptions to this rule include: UNESCO (2006); and, Hodge, Bowman, and Ludlow (2007).

[2] As I note below, equivocation on this question is often used as a method to forestall criticism of nanotechnology.

I must also clarify that I do not intend to discuss some of the more far-fetched and speculative claims that have been made about nanotechnology, such as the idea that self replicating nano bots might threaten the world with an explosion of "grey goo" or that the development of nanoscale assemblers will lead to a "post-scarcity" world (Drexler 1986; Drexler 1991; Crandal 1997). These claims are science-fiction rather than science forecasting; there are simply too many technical barriers in the way at the moment for nanobots to be anything other than speculative possibilities (Smalley 2001; Stix 1996). I will focus my analysis on nanotechnology that either exists, is in development, or that can be foreseen without postulating too many revolutionary leaps in our technological know-how.

Four features of nanotechnology

In order to be able to speak sensibly about the impact of "nanotechnology", it is necessary to say something about what—if anything—the various products of nanotechnologies, which are grouped together under the rubric of nanotechnology, have in common. By examining the properties of these materials at an appropriate level of abstraction, it is possible to discern four features of "nanotechnology" that will be important in shaping its social (and other) impacts.

The single most important characteristic of nanotechnology, which we need to keep in mind when thinking about its implications, derives from the fact that the properties of a material can no longer be straightforwardly extrapolated from its chemical makeup once we have begin engineering at the nano-scale. The properties of nano-engineered materials are partially a function of their physical structure at the nanoscale and apparently minor differences in structure at this small-scale can result in large variations in properties of the material. As a result, there is another level of description—beyond those required of contemporary materials—necessary before we can begin to assess the properties of a product or material which contains nanotechnology. We need to know not just its physics and its chemistry but how its physics affects its chemistry. This is essential to the power of the nanotechnological revolution. This basic fact about nanotechnology is also the cause of some of its most disruptive implications for policy and regulation in a number of areas. In particular, it means that each new product involving nanotechnology may need to be assessed independently in relation to its possible environmental and health hazards. It also means that the science needed to evaluate the risks associated with any new product is extremely demanding (Donaldson et al 2004).

The products of nanotechnologies also have—or can be expected to have in the not-too-distant future—three further general characteristics that are likely to be crucial in determining their impact. Nanotechnology will soon be ubiquitous, invisible, and "slippery".

If the predictions of nanotechnology enthusiasts and industry pundits are to be believed, over the coming decades more and more products will come to contain nanotechnology (Mulhall 2002; Wood, Jones, and Geldart 2003; Royal Society and Royal Academy of Engineering 2004). It will be in our clothes, our electronics, our cars, our lounge rooms, our medicine chests, and our hospitals. Nanotechnology will become ubiquitous. One implication of this fact is that whatever issues are raised by nanotechnology are likely to be important simply by virtue of the number of people who will be affected by them. Moreover, when a technology becomes ubiquitous, qualitative as well as quantitative shifts in its impact may occur. The mere fact that a technology is used widely in many different applications means that it will be used in unexpected and problematic applications and its social impacts consequently become larger and harder to predict.

Nanotechnology will also tend to be invisible to ordinary citizens. By "invisible" I mean not only that the "nano" aspect of nanotechnology will be quite literally invisible but also that the fact that a product has the properties that it does because of nanotechnology will often not be discernible to the person using it. Consumers, and others who come into contact with a product over its life cycle, will not necessarily be aware that it relies on, or contains, nanotechnology. Of course, many forms of modern technology are "invisible" in this fashion, in that those using them generally don't know how they work. However, this phenomenon is likely to be especially pronounced in relation to nanotechnology for three reasons. Firstly, insofar as nanotechnology becomes ubiquitous, products containing nanotechnology will no longer necessarily stand out, or be advertised as such. Secondly, unless a product is labeled as containing nanotechnology it will be difficult for a consumer or other interested party to check whether it does or not. Thirdly, because the properties of nanotechnological elements will vary so much depending upon their precise physical, as well as molecular, structure it is likely to be extremely difficult to label products in ways which can communicate meaningful information to product users. The combined impact of these facts is likely to mean that consumers will seldom, if ever, fully understand whether and the extent to which products rely upon nanotechnological features. Nanotechnology's tendency to be invisible to consumers means that it will often not be possible to rely upon notions of individual choice or consumer sovereignty to resolve ethical issues associated with nanotechnology.

Finally, nanotechnology will be what I call "slippery". It will be difficult to regulate and control. It will be copied, pirated, and traded illegally. It will be used in unexpected applications and contexts. Again, this is a feature of technology more generally which will be especially prominent in relation to nanotechnology, especially as it becomes ubiquitous, because of the very novelty and promise of nanotechnology. As a result, there will be a tendency for nanotechnology to "escape" and to appear in areas other than those for which it was originally developed. This feature means that utopian visions wherein nanotechnology must be used

carefully or in a controlled fashion are unlikely to be realised.

Social impacts:

The social impacts of new technologies are notoriously hard to predict. One only has to remember the large number of pundits who heralded the dawn of the "paperless office" after the invention of electronic mail to realise the difficulties involved in predicting the social impact of a single technology, let alone an entire technological revolution. We must treat with equal scepticism the claims of some critics that nanotechnology will usher in a post-scarcity utopia (Drexler 1986; Drexler 1991; Crandal 1997) and the claims of others that it will create a dystopian world of rampant terrorist and robotic threats (Joy 2000).

Nonetheless, it would be wrong to let the difficulties involved in predicting the ultimate impact of a new technology prevent us from at least considering the likely impacts of foreseeable nanotechnology in the short-to-medium term. The effects of technologies on our quality and way of life are, after all, usually offered as the reason why we should accept technological change, so it would be extremely disturbing if we could not anticipate these at all. Moreover, if enthusiasts for nanotechnology can tout its benefits in terms of new consumer products, improvements to quality of life, and expanded lifestyle possibilities, social critics must be equally able to consider how likely it is that these possibilities will be realised and the possibility of alternative, perhaps less attractive, scenarios.

We can, in fact, be reasonably confident that nanotechnology will have significant social impacts in—at least—the areas of health and medicine, the balance of power between citizens and governments, and the balance of power between citizens and corporations. Furthermore, I believe that, if we extrapolate from the experience of previous technologies, we can have some idea of what these are likely to be.

Medicine

Medicine is an area of applied science where nanotechnology is likely to achieve some of its most immediate and impressive applications. New drug delivery systems, diagnostic devices, and medical implants based upon or containing nanotechnology have recently been developed or are about to enter widespread use (Zuo et al. 2007). The result of these developments will be improved health and expanded lifespan, at least for those who can access this technology. These are clearly important goods and constitute a compelling reason to pursue at least some applications of nanotechnology.

However, as is the case with most goods, the realisation of these goods is unlikely to be possible without costs and unanticipated consequences. The latter are obviously difficult to discuss sensibly; we can only do our best to become aware of such consequences as soon as they start to occur and analyze and address them

then. However, it *is* possible to say something now about what the costs of progress in the area of medical nanotechnology are likely to be.

One set of costs arises from the fact that the benefits of nanotech in healthcare are likely be unevenly distributed both within and between nations. At least initially, medical therapies involving nanotechnology are likely to be expensive and available only in wealthy industrialised nations. This is likely to change over time as nanotechnology becomes cheaper and manufacturing techniques "trickle down" to nations at the periphery of the global economic order. However, despite claims that the development of nanotechnology can be expected to increase the rate at which such technology transfer occurs, we can expect that the benefits of medical nanotechnology will be largely concentrated in the wealthy northern industrialised nations in the short-to-medium term at least. In this context, it is worth remembering the large percentage of the world's population who does not yet have access to clean drinking water, let alone the Internet, despite the fact that the technology to provide access to such has been around for centuries (Sparrow 2007b).

If the distribution of the benefits of nanotechnology is uneven enough, we may feel equivocal about the goods being distributed. Large inequalities in the distribution of healthcare may impose costs beyond the fact that many people do not have access to healthcare. If, for instance (to use a deliberately far-fetched scenario for the sake of having the issues writ large) the very wealthy come to have a life expectancy of 200 years when the average life expectancy is 85 years (let alone 35 years as it currently is in some parts of North Africa) this might be expected to generate a range of further, largely negative, social impacts, including concentration of political power, envy, and possibly social unrest. The obvious way to try to minimise these costs then, is to pay attention to distributional issues when pursuing the benefits of medical nanotechnology and to ensure that large inequalities do not arise.

Another set of costs is the net impact of nanotechnology on healthcare budgets, which will be to increase them rather than decrease them as might first appear. This is counterintuitive as we tend to think that improvements in medical technology should save money in the area of healthcare. Yet a moment's thought will reveal that, while some therapies may be cheaper than other therapies, money spent on healthcare ultimately succeeds only in shifting the expenses involved in keeping individuals alive to a later date. The longer people live, the more expensive it is to keep them alive to that age. Moreover, years added to the end of life are likely to each be more expensive than the last. For the foreseeable future, nanotechnology is unlikely to alter this dynamic, which means that it too will contribute to the increase of the expense imposed on each generation by the demands of keeping the previous generation alive. Of course, the fact that particular improvements in medical care are expensive says little about their ultimate value; it may well be that we should be prepared to bear higher social costs to extend the lives of existing generations. However, we should not delude ourselves that nanotechnology will allow us to escape the moral issues associated with

medical care and the resource allocation dilemmas the cost of such care raises.

Military applications

Two further social impacts I wish to draw attention to concern nanotechnology's implications for the balance of power between citizens and governments and between citizens and corporations. Nanotechnology can be expected to impact on social power relations because of its potential military applications and its potential in surveillance technologies.

A depressingly high percentage of nanotechnology research is funded by the military and is directed towards military applications. In the short term, nanotechnology is likely to be employed by the military in the form of advanced materials, with improved fire and impact resistance. In the longer term, nanotechnology may appear in new weapons systems such as "swarms" of miniaturised UCAVs or other advanced guided munitions (Altmann 2004; Altmann 2006; Ratner and Ratner 2003).

In so far as arms races are a zero-sum game, military applications of nanotechnology have no social benefits.[3] They may constitute a temporary benefit for the nation which develops them but this will eventually be negated when other nations to develop the same technology and/or appropriate countermeasures. They may, however, have social costs. One obvious and substantial cost is that resources devoted to researching and developing military nanotechnology are not available to researchers attempting to develop products that meet genuine human needs. When so many basic human needs remain un-met around the planet, this is a substantial cost indeed.

Another important cost is that developments in military technology may have implications for social and political relations within society. Modern militaries are immune from civilian threats today in a way that have they have never been before. Nanotechnology seems likely to further widen the gap between the means of political violence available to the military and those available to civilian populations. Insofar as nanotechnology empowers the military, an institution the function of which is at least in part to defend governments against their own populations, it may make governments harder to overthrow and less subject to popular demands.

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[3] This is not to deny that technology developed by and/or for the military may not have civilian uses. However, defence of military R&D in terms of its "spinoffs" neglects the fact that the purported benefits of this research could almost always have been secured more efficiently and quickly by civilian research had the funding for such research been available. To count such spinoffs as "benefits" of military research is therefore misleading unless it can be shown that these products could not have been made available by a comparable civilian research effort.

We must be careful here. Military or technological power is not itself political power. Ruling elite still need armies to wield their weapons and these armies are inevitably drawn from the body of the population. A loss of political legitimacy in the eyes of this population therefore may threaten the ability of even the most sophisticated military to defend a particular political order. Moreover, no society—and especially no modern technological society—can function in the face of the loss of support of the vast majority of the populace whose labour is necessary to maintain it. The withdrawal of this support will inevitably lead to the collapse of a regime. That being said, however, technology may reduce the possibility of successful political action by forces short of this majority and also affect the capacity of dissenting social forces to bring about the withdrawal of this support. To the extent that this turns out to be the case, we can expect military nanotechnology to empower the already powerful.

Some critics have raised precisely the opposite concern, that nanotechnology might allow subversives, criminals, or terrorists to wield power beyond the control of governments (Altmann and Gubrud 2004). Yet these concerns are probably exaggerated. Although, as I observed above, nanotechnology will tend to be "slippery", military nanotechnology is likely to be the most tightly regulated and controlled nanotechnology and the technologies required to manufacture it will be jealously guarded by governments. There is also little suggestion at this stage that nanotechnology will produce easily transportable or concealable area weapons that would be expected to generate multiple casualties. Nanotechnology is therefore unlikely to have greater potential for terrorist attack than existing biological or radiological agents.

A more likely route by which the development of nanotechnology might contribute to terrorism is that it may exacerbate existing trends towards asymmetric warfare. If the military forces of the industrialised world become more powerful difficult to attack and defeat due to nanotechnology this may force those involved in conflict with them to adopt new tactics, including sabotage and attacks on civilian and other "soft" targets (Boot 2006; Dunlap 1999). The development of military nanotechnology may thus indirectly increase the prevalence of terrorist attacks in the future.

Citizens and governments

There is another mechanism whereby nanotechnology can be expected to concentrate political power in the hands of governments. Nanotechnology can be expected to be applied to further miniaturise and improve surveillance technologies such as cameras, listening devices, tracking devices, and face and pattern recognition technologies. The improvements in electronics and computer memory that nanotechnology makes possible also facilitate the capacity of organisations to share, collect, store, and analyze data. Developments in nanotechnology can therefore be expected to greatly increase the ability of governments to keep track of their citizens (Nature Nanotechnology 2007). This in turn is likely to assist authoritarian

governments maintain their power and stifle social dissent.

Citizens and corporations

Surveillance by governments is a familiar phenomenon. If nanotechnology provides governments with new ways to extend surveillance, at least we can hope that liberal democratic polities will be moved to resist extension of such surveillance out of familiar concerns about what happens when governments abuse this power. A less obvious, but arguably more pressing danger, is the possibility of extensive surveillance of individuals by non-government organisations, including corporations, by means of nanotechnology. The same technologies which allow modern governments to collect information about the citizens allow large non-government organisations to do so also. Banks, insurance agencies, and other finance corporations already maintain large databases on consumers. The improvements in computing technology which can be expected to flow from nanotechnology will facilitate this.

Admittedly, the contribution of nanotechnology in this regard is not especially distinct from those of more familiar technologies in computing and chip manufacture. A more novel possibility is that nanotechnology might allow individual consumer goods to be uniquely identified and tracked. “Radio frequency identification devices” (RFIDs) are an existing technology which allows items to be tagged with a chip or label which is uniquely identifying and which can be read at a distance. It is likely that improvements in nanoscale manufacturing will eventually lead to such devices becoming cheap and ubiquitous such that almost everything manufactured contains one. This technology is likely to have a dramatic impact on the ability of corporations and governments to gather information about individuals. This information will be used both to allow corporations to better manage their services to potential customers and also to keep a close eye on “terrorists” and other political dissidents. By hastening the arrival of ubiquitous RFIDs nanotechnology may play a significant role in the development of what might be called a “surveillance society” in which citizens are not only watched and tracked to a greater extent than ever before, but expect to be so (Mehta 2002; Van Den Hoven 2006).

Familiar issues in new forms?

Of course, there may well be social transformations wrought by nanotechnology beyond those I have discussed here. As I noted above, it is difficult to be confident in making predictions about the impact of technology that is still in the very early stages of its development. It does seem likely, for instance, that there will be “winners and losers”, particularly in industry, from the introduction of nanotechnology and thus some shifts in social power. However, this is the case with technological change in general and I see no reason to think that such disruption will be especially rapid or profound when caused by nanotechnology.

Indeed, it is hard to avoid the conclusion that, in the short-to-medium term at least, the implications of nanotechnology for the nature and quality of life of citizens in prosperous societies are likely to be indistinguishable from those of ongoing developments in other areas of technology—in particular, medical and information technology. Information technology is also increasingly ubiquitous, slippery, and invisible. Moreover, much nanotechnology will find its application in improving computers and communications technologies. It is little wonder then that the implications of nanotechnology are hard to distinguish from those of computing and information technology. Similarly, the impact and ethical issues associated with medical technology arise out of its consequences for human health regardless of whether or not it involves engineering at the nanoscale. Making existing technology smaller does not in itself generate any *new* ethical issues.

The fact that social impacts and/or ethical issues are not new does not mean that they are thereby any less important; it may, however, affect our assessment of the extent to which responding to them requires a distinct programme of philosophical or bioethical research.

Philosophical Questions:

In the longer term, the prospect of continuous and relentless technological change raises some large—and, to a certain extent, abstract but not any the less important because of that—questions about what we are aiming for in technological development, which I have chosen here to label "philosophical". In a sense, of course, all of the issues I have been discussing thus far involve philosophical questions, about the relative value of different goods and the sorts of risks we are prepared to take in pursuit of them. However, it would be a mistake to confine ourselves to considerations of costs and benefits when thinking about the prospect of a high-technology future; we must also ask questions about the kind of world we want to live in and the role technology might play both in that world and in bringing it about. Because nanotechnology is a powerful and potentially transformative technology, which is currently being heavily funded by governments and corporations across the globe, questions about the purpose and goals of technology development are correspondingly foregrounded in the debate about nanotechnology.

Thus, some of the questions that we will need to think about if we are to make the most of the potential of nanotechnology, include: What is the goal of technology? How do we evaluate when a technology is worth pursuing? What would a society that adopted nanotechnology look like and is that the sort of society that we would wish to live in? Who benefits and who loses when new technologies are introduced and how should decisions about technological trajectories be made? How likely are technologies to contribute to central human goods such as happiness and a sense of meaning in life? The arrival of a powerful new set of

technologies offers us a rare opportunity—and a compelling reason—to consider these "big picture" questions seriously.

It might seem that insisting upon the importance of these philosophical questions is the predictable response of a philosopher writing about nanotechnology. However, we can already see, I think, the importance of these questions in shaping contemporary responses to nanotechnology. The real causes of contention between those who look forward to a nanotechnological future with enthusiasm and those who look forward to it with dread are ultimately philosophical. That is, they turn not on empirical facts about what material benefits the technology offers or the risks it involves but rather on ideas about what sort of society we should aspire to (Hepburn 2006; Miller and Senjen 2006; Senjen 2006a; Senjen 2006b).

In particular, an important grounds for cynicism about some of the purported benefits of nanotechnology begins with the observation that the contribution of technology to human happiness varies in relation to the needs it satisfies. Technologies that contribute to the satisfaction of unmet human needs for food, clean water, shelter, warmth, and health, etc, make an enormous difference to human happiness. Technologies that allow people to travel, communicate with each other, and access cultural goods also make a significant contribution to human happiness. Beyond this, however, technologies that satisfy consumer preferences for "things" make much less difference to how satisfied people are with their lives. The point here is not that people will not want or applaud these technologies but that the ultimate contribution they make to the happiness of those who use them is likely to be much smaller than we anticipate. Empirical studies of the origins of happiness suggest that once basic human needs are met the real sources of happiness are our relationships with other people and a sense that our lives have meaning (Hamiliton 2004, 46-54; Lane 2000).

In isolation, this observation would not seem to count against the prospect that nanotechnology might result in massive benefits in terms of human welfare and happiness. After all, some of the most exciting potential applications of nanotechnology involve water treatment technologies, medical technologies, and new materials, which could be used to provide basic goods to the large percentage of the world's population that is currently denied them (Hassan 2005; Meridian Institute 2005, 5-7; Salamanca-Buentello et al. 2005). However, when combined with the observation that previous technologies that were touted as having similar potential to meet the needs of the poor have often failed to do so for familiar reasons concerned with the operations of wealth and power in a divided world, the implications of this observation are more radical.

Unless a sufficiently powerful political campaign can be mobilised to contest them, decisions about the development and application of nanotechnology are likely to be made in the interests of the wealthy and powerful rather than the poor (Sparrow 2007b, 94-103). The markets for nanotechnology are where the money is—and the money, of course, is not in the hands of the poor. Thus any benefits that might accrue to the poor and dispossessed from nanotechnology will most likely have to "trickle down" after the

technology has first been applied to satisfy the desires of the wealthy. Moreover, while nanotechnology undoubtedly holds great potential for improving consumer electronics and other communications devices that may serve to link people with each other and allow them to access cultural goods, most of those who are likely to be able to access such devices already have access to goods that serve the same purpose.

These two observations together, then, suggest that the benefits of nanotechnology in terms of human welfare are likely to be less than is sometimes advertised and consequently that the risk it makes sense to take on in pursuit of nanotechnology is much smaller. This is one reason why, I believe, enthusiasts for, and critics of, nanotechnology so often seem to be talking past each other. Environmentalists and other critics of technological utopianism focus on well-being and are cynical about the capacity of nanotechnology to deliver improvements to the human condition that are worth the risks involved in pursuing it (Friends of the Earth 2006). Enthusiasts for nanotechnology, on the other hand emphasise, the economic opportunities it offers and especially the opportunities for economic growth, which are indeed enormous and consequently would seem to be worth pursuing even if there are risks involved (DeFrancesco 2003). Because they are working in different metrics it is hard for either side to reach the other with their arguments.[4]

Obviously there is a lot more that might be said about the philosophical issues briefly sketched above. Ultimately, I suspect that we cannot fully evaluate the implications of any new technology without confronting these larger questions about our values. However, while ethicists and philosophers undoubtedly have a role to play in debates about these matters, because the impacts of nanotechnology will affect the whole community it is not enough for a few experts to assess them and decide whether or not they are in accordance with their values. Instead, this essential debate about technology, progress, values and ethics must involve the whole community.

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[4] Economic growth is a very poor indicator of human happiness. Notoriously, current indicators of economic growth such as GDP register any and all economic activity as "growth", regardless of whether this activity is building schools to educate people or prisons to incarcerate them. Earthquakes and tsunamis can be substantial contributors to economic growth according to this measure as long as a society has the resources to rebuild afterwards. As a result of this phenomenon, it is possible for a society to become much richer—at least as measured by GDP, or even per capita GDP—with very few people being any better off because of it (Hamilton 2004). Pundits who advertise nanotechnology on the basis of the contribution it might make to GDP or the size of the industry in any given year, may therefore be missing the point when it comes to convincing critics of nanotechnology of its benefits. Conversely, happiness or well-being may not result in any economic activity that can be measured and thus discussing the impact of a technology on happiness may seem irrelevant to those who wish to measure progress via more orthodox indicators.

Technology and democracy

Thus the final—and arguably most important—set of issue set of issues that nanotechnology raises concerns the role of the public in making decisions about the use and development of technologies. It is not unusual to hear scientists and technologists suggest that the public should provide "guidance" about how science should be applied or how the ethical issues it raises should be resolved. Governments around the world are busily developing or carrying out consultative processes designed to work out what the public thinks about nanotechnology. Yet this project falls well short of what is required by way of respecting the democratic rights of citizens. Insofar as any technology is likely to reshape society, citizens have a right to be involved in the choice as to how—and whether—we should make use of it. If nanotechnology is revolutionary, then it is especially important that we should ensure that any nanotechnological revolution is a democratic one (Sparrow 2007a).

An important priority for those concerned about the issues raised by nanotechnology, then, is to investigate, develop, and support institutions and processes that would allow the public to wield real power in relation to technological trajectories. An obvious question that should be investigated in this context concerns the relative merits of various forms of "deliberative" processes, such as citizens' juries, deliberative polling, consensus councils, etc, as means whereby ordinary citizens might make informed choices about complex scientific and social problems. Importantly, any such institutions or processes should involve the real possibility of rejecting particular applications of nanotechnology and perhaps even the project of transforming the world via nanotechnology itself.

Towards an ethical conversation about nanotechnology

However, there is, I would submit, another important task for policymakers and scientists—and especially for social scientists—beyond this task of political philosophy. Public deliberation about nanotechnology, both formal and informal, will inevitably be shaped by the quality of the information presented in formal processes and in the public sphere about nanotechnology, its potential, risks, and implications. I have written elsewhere about the ways in which different and contradictory rhetorics are currently often used in debates about nanotechnology (Sparrow 2007a) and also about the extent to which these debates are characterised by widespread hypocrisy (Sparrow 2008). The very existence of "nanotechnology" is often elided in favour of "nanotechnologies" (which are much more difficult to characterise and thus criticise), as soon as critics start to make use of the term. Nanotechnology is "revolutionary" when enthusiasts want funding or media coverage; it is "familiar" when they wish to hose down public fears. The introduction and development of nanotechnology is "inevitable" when industry wants to brush aside critics but is "precarious" when enthusiasts for nanotechnology want to drum up funding or procure changes in government policy or public

opinion (Sparrow 2007a). Even claims about the science of nanotechnology and its potential often appear to be shaped to elicit particular reactions from their audience.

As a number of other writers have noted, there is a tendency in the halls of government and in industry to see the social sciences as a means of convincing the public to accept technology (Ebbesen 2008; Wood, Jones, and Geldart 2003, 35). If this is the task at hand, the presence of hypocritical claims and instrumental attitudes in discussions of nanotechnology need not loom so large. However, if we understand the role of social (and other) scientists to be more critical than this, then the combination of the need for an inclusive democratic process and the dubious quality of much of the existing popular debate about nanotechnology establishes an urgent case for critical intervention into these debates.

Before we can resolve the ethics of nanotechnology in the way I have argued it should be approached—through an open and participatory deliberative process that extends to consider the sort of society we wish to live in and the contributions technology might make to bring it about—we need to work towards an ethical *conversation about* nanotechnology. Such a conversation would begin with the faith that ordinary citizens are capable of participating in it and would require all participants to approach each other as equals and to treat each other as "ends in themselves". It would exclude conversational gambits that were intended solely to secure a particular outcome without regard to the autonomous choice of the other participants. Those with expertise relevant to nanotechnology—and especially social scientists and other scholars in the humanities who might claim to be especially well-placed to engage in criticism and social critique—may make an important contribution to such a conversation by identifying hyperbole and hypocrisy wherever it appears and by working to set out the values and consequences involved in the different choices we might make about nanotechnology with the maximum accuracy and clarity. Until an ethical conversation is well underway—to the point that it can sustain itself without such deliberate efforts to facilitate it—or until one or more nanotechnologies develops to such a point that it establishes distinctive ethical issues that require concerted philosophical investigation, the need for a more genuine, inclusive, and open conversation about our shared technological trajectory is the most urgent ethical imperative established by nanotechnology.

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