Chapter 7
Nanotechnology and the Extension and Transformation of Inequity

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While the authors that have contributed to this book believe that furthering the cause of equity is a laudable goal, there are many people who benefit from existing unequal political arrangements. In this chapter, Georgia Miller and Gyorgy Scrinis argue that many of those currently directing the future of nanotechnology have a strong incentive to maintain these patterns of unequal distribution. They note that nanotechnology is arising from actions that align it with powerful economic and political interests in the Global North. Despite paying lip service to studying the "ethical, legal, and social implications" of nanotechnology, those who are driving the rapid expansion of nanotechnology have not shown any genuine commitment to reorienting the enterprise to human needs or a more equal society. Given the power disparities between nano advocates and critics, Miller and Scrinis find it improbable that there will be any fundamental realignment. In a sense Miller and Scrinis offer a challenge to all the authors in the volume to find ways to break through the barriers to equity.—eds.

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7.1 Introduction

Governments in the European Union, the United States, Australia, and elsewhere are acting slowly to address the new health and environment risks associated with nano-ingredients now used in hundreds of products world-wide. Non-governmental organizations (NGOs), social scientists, and members of the public involved in early stage engagement activities have emphasised that governments need also to address nanotechnology's social dimensions alongside its new safety risks. But governments have shown little interest in supporting critical reflection about the interactions between nanotechnology, science, and society, or in implementing measures to address equity concerns at an early stage of nanotechnology development.

Discussion of nanotechnology's societal dimensions remains largely divorced from questions of innovation policy, research funding, and governance. Where social, ethical, or equity issues are acknowledged, they tend to be peripheral to the "main game" of technical research and industry development. United Kingdom think tank Demos (Stilgoe 2007, 16) suggests that for many proponents: "Social and ethical concerns have become an obligatory footnote to nanotechnology's technological promise." However a number of NGOs have warned that based on their experiences with past technologies, and given nanotechnology's development trajectory to date, nanotechnological development is likely to widen existing inequalities between and within countries (e.g. ETC Group 2005a–2005c; Friends of the Earth Australia 2006; NanoAction 2007).

Nanotechnological innovation may further entrench or deepen a number of forms of existing inequalities. This includes inequalities of wealth and income; unequal access to employment, to the means of production, and to other social goods, such as health care (Invernizzi et al. 2008); the further concentration of economic and corporate power; the further loss of privacy and the aggregation of information collected on the citizenry (Cribb 2007); greater inequity in exposure to hazardous chemicals and wastes in the workplace and in the environment; and greater instability and insecurity for war-affected regions as a result of nano-weaponry and new means of destruction—casualties may increasingly be borne by the technologically inferior side (Woodhouse and Sarewitz 2007). Where nanotechnology is applied in the quest to "eliminate" disabilities or different biological realities, it could further marginalise disabled people (Cabrera 2009; Wolbring 2002). However, nanotechnology may not merely extend existing socio-economic relations and forms of inequality, but also re-shape and transform them, such that these inequalities and imbalances in wealth and power may take new and novel forms in the contemporary era. This may include new forms of exclusion, disadvantage, dispossession, exploitation, and control, and these may combine with or re-frame existing forms of inequalities and power imbalances. The emerging field of "human enhancement," for example, could even create new elite minorities of people whose cognitive or physical capacities have been extended beyond species-typical boundaries (Roco and Bainbridge 2002).

7.2 Acknowledging the Social and Economic Values Shaping Nanotechnology's Development Trajectory

Scientific practices and technological development are often viewed as existing outside of social processes. It is common scientific and public policy practice to frame social dimensions of technology development as external "risks" or "impacts"—something to be considered as *secondary effects* rather than as *core aspects* of technology development that require attention during each stage of the innovation cycle (Kearnes et al. 2006a,b; Macnaghten et al. 2005; Mohr 2007). Woodhouse and Sarewitz (2007, 140) observe that "unequal outcomes associated with science and technology are [not] usually interpreted as emerging from... the structure of the research and development (R&D) enterprise itself." The need to identify and interrogate the unacknowledged political, cultural and economic forces shaping development of new technologies has therefore been emphasised by social scientists (Irwin 2006; Mohr 2007; Rogers-Hayden et al. 2007; Wynne 1993, 2007).

Political and economic pressures, the assumptions and aspirations of researchers, industry groups and government decision makers, the membership of decision making bodies, institutional cultures, and the allocation of research and industry development funding have the potential to shape nanotechnology development. Growing financial pressures on scientists in universities and public research institutions mean that the innovation priorities of corporate sector research partners are increasingly influential (Woodhouse and Sarewitz 2007). Such factors influence the scope and direction of research, the regulatory context of nanotechnology commercialisation, and the extent of government support—financial and political—for industry development. They also affect the likelihood that the views of less privileged actors will be sought—and their interests incorporated or ignored—in nanotechnology oversight. These factors all influence the extent to which equity considerations will be perceived as legitimate and the priority which they will be accorded.

Nanotechnology's early development was strongly driven by public funding; as late as 2003 public money constituted half of nanotechnology research and development funding world-wide (Lawrence 2005), and in 2004 it was still a full third (Hullman 2006). Yet governments have largely failed to acknowledge that its developmental trajectory is mutable, and could—and should—be shaped to maximise social utility, and better reflect community preference (Sparrow 2007). To improve nanotechnology governance, to facilitate proper evaluation of nanotechnologies in society, and to reduce the likelihood that nanotechnology will deepen existing or create new forms of inequities, it is essential to: open up nanotechnology assumptions, institutions, funding, and governance to critical scrutiny and debate; to undertake early and mid-stage technology assessment to inform the allocation of research funding, development of innovation strategies, and governance; to investigate and implement measures that will prevent or mitigate a "nanotechnology divide" which magnifies existing global socio-economic inequities, including potential reform of existing intellectual property and patenting systems; and to support public participation in decision making in each of these areas, including of marginalised groups.

7.3 The Economic, Social and Political Context of Nanotechnology Development

Nanotechnology development has been aggressively funded and promoted by national governments; "governments everywhere grasp that they have already entered a nanotechnology race" (Whitman 2007, 277). However there are also interlocking non-government institutional interests that are deeply committed to supporting nanotechnology's rapid development. Business, academics, industrialists, the research community, and military interests all view nanotechnology as essential to maintaining economic, scientific and military competitiveness, and are therefore also strong proponents (Whitman 2007).

The strong network of financially and technologically interested groups committed to nanotechnology development has significant implications for equity. Those most closely engaged in techno-scientific policy deliberations tend to come from privileged classes and nations, and to have a particularly optimistic view of the social, economic, and environmental benefits of technological innovation (Woodhouse and Sarewitz 2007). It makes it likely that public concerns of a fundamental or precautionary nature will carry little political weight (Whitman 2007; Woodhouse and Sarewitz 2007). The ready access that financially and technologically interested groups have to the decision making process, and the central role of governments as nanotechnology proponents, public policy developers, regulators, educators, and facilitators of public engagement, is also an impediment to effective governance (FoEA 2009).

The quest for economic and military competitiveness that motivates nanotechnology development shapes research agendas and research cultures, and the kinds of knowledge that nanotechnology produces. Private sector investment in techno-scientific research is traditionally oriented towards delivering products for potential customers with wealth and access, rather than the needs of the poor and disenfranchised (Woodhouse and Sarewitz 2007). But even within public research institutions and universities, there is strong pressure on scientists to produce commercially useful research and to pursue intellectual copyright. Jamison (2009) argues that the links between researchers and industry have become so intimate that science has entered a new, market-oriented mode of knowledge-making, where profit-making is central. He suggests that this diminishes the possibility that nanotechnology will be developed for altruistic or public interest purposes, and results in willful neglect of its social, cultural, and environmental implications. Similarly, Invernizzi et al. (2008, 136) observe that the argument that nanotechnology products will help the poor is belied by its development trajectory to date: "Since nanotechnology's development is essentially guided by corporations' search for profits, a majority of innovations are directed to Northern, affluent societies."

At a time of unprecedented food, ecological, and climate crises, nanotechnology's most important equity issues arguably relate to whether or not it will: further concentrate Northern corporations' control of trade; magnify existing socio-economic inequities between and within countries; further jeopardise the livelihoods and resilience of poor people; add to their pollution burden; and further undermine the ability of communities to retain local control and ownership of food production (ETC Group 2005a,2005b; Invernizzi and Foladori 2005; Invernizzi et al. 2008; Mooney 2006; Nyéléni 2007; Scrinis and Lyons 2010).

There is ongoing debate about the role of technology in causing or deepening inequality at a global scale. Many observers suggest that technology deepens existing inequality, even where it is not the main force creating it; Woodhouse and Sarewitz (2007) caution that new technoscientific capacities introduced into a non-egalitarian society tend disproportionately to benefit already privileged people. Others point to the complex dynamics of inequality and suggest that in some contexts emerging technologies could reduce rather than increase inequalities (see Cozzens et al. 2006). Despite ongoing disagreement about technology's role in deepening inequity, our experience in recent decades demonstrates conclusively that technological innovation alone will not redress inequity. During the last 30 years, a period of significant technological progress and innovation in which microelectronics, information technologies, medical treatments, and telecommunications were developed, the gap between the global rich and the global poor has widened.[1] When global inequality has increased during the expansion of such powerful technologies over recent decades, the obvious question is "why would it be any different for nanotechnologies?" (Invernizzi et al. 2008).

7.4 Potential for Nanotechnology to Exacerbate Existing Inequity

Proponents predict that nanotechnology will deliver breakthroughs in medicine, energy, agriculture, and communications. Yet these breakthroughs—as with previous technical breakthroughs—may be inaccessible to poor or marginalised groups (Royal Society and Royal Academy of Engineering 2004). The availability of technologies does not guarantee access to those who have most need of them. In many instances, efficient and relatively cheap technologies already exist to address public health, sanitation, medical, energy, and agricultural needs of poor people and even these are often not accessible (Invernizzi et al. 2008). Furthermore, it is possible that by concentrating ownership and control of essential platform techniques, processes, and products, nanotechnology may exacerbate existing inequity (Shand and Wetter 2006).

The ETC Group's Shand and Wetter suggest that: "With applications spanning all industry sectors, technological convergence at the nanoscale is poised to become the strategic platform for global control of manufacturing, food, agriculture, and health in the immediate years ahead" (Shand and Wetter 2006, 80). Should predictions of nanotechnology's potential as a platform technology prove accurate, countries and companies which are making early investments, patenting aggressively, and can afford to defend patent claims, are likely to cement and expand their control of key industries and trade (Corporate Watch 2005; ETC Group 2001, 2005a,2005b, 2008; FoEA 2006). In an analysis of nanotechnology patent grants up to 2003, Hullman

(2006) found that Northern countries were well ahead of Southern countries in registering nano-patents; the United States was the most active nation in the world for registering patents, followed by Japan, Germany, the United Kingdom and France. There is a wide disparity among Southern countries in nanotechnology investment, development and patenting. In recent years patent grants have grown in high-growth emerging economies (Liu et al. 2009). In particular, the patent growth rate in China has been remarkable; since 2005 China has held the largest number of nanotechnology patents internationally (Preschitschek and Bresser 2010). Nonetheless, the majority of patents world-wide are still held by Northern countries, and the majority of Southern countries hold few nanotechnology patents. Patenting trends therefore reflect not only a North-South but also a South-South divide.

Nanotechnologies may enable corporations to extend their control over markets and other producers, via proprietary control of essential platform techniques and products of nanotechnology (ETC Group 2005a,b). Bowman (2007, 313) notes that: "Of particular concern is the progressive blurring of the invention/discovery interface under Article 27 [of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement)] that may produce uncertainty over the types of nano-products that can be patented... wide interpretation of Article 27(1) may result in the monopolisation of fundamental molecules and compounds." Forero-Pineda (2006) observes that strong protection of scientific and technological intellectual property, including the patenting of research tools, can constrain the capacity of scientists in Southern countries to carry out their own research and development. Without active international cooperation, Southern countries must exert considerable energy to access scientific results and information.

In addition to consolidating the domination of technological intellectual property by corporations and governments based largely in Northern or high-growth emerging countries, nanotechnology may disrupt markets on which many Southern countries' economies depend. Novel nanomaterials and nano-innovations may disrupt or displace the markets for existing products, commodities, services, and technologies. This could have a disproportionate impact on Southern economies which are heavily reliant on commodity trade, and which may lack the capacity for rapid transformation in the face of new economic circumstances (ETC Group 2005a,b; NanoAction 2007).

A range of nanotechnological innovations have the potential for displacing workers and the demand for labour in a range of industries. This would be consistent with previous technological innovations and revolutions, yet in the present techno-economic context, there is the potential for the displacement and redundancy of workers on an unprecedented scale. Examples here include the ability to further automate factory production, and the displacement of agricultural workers through innovations in agricultural mechanisation, chemical input applications or precision farming systems (Scrinis and Lyons 2007). Workers in both Northern and Southern countries will be vulnerable to displacement as a result of nano-automation and any gains in efficiencies, particularly manual labourers. Nonetheless, Southern workers may be most adversely affected, with limited capacity for government support and fewer alternative employment opportunities.

Nanotechnology may also exacerbate existing environmental injustices, such as the exposure of poorer communities to toxic substances and wastes in their workplaces or neighbourhoods. Again, this is likely to affect poor and marginalized communities in both Northern and Southern countries. Further, Southern countries may find themselves disproportionately shouldering nano-risks by becoming manufacturing centres for nano-products Northern workers would prefer not to handle, or else as dumping grounds for nano waste. Since Southern countries usually have weaker environmental regulations, it is possible that international companies will choose to locate plants and waste disposal sites in these countries, leaving local communities exposed to greater risks (Invernizzi et al. 2008).

Beyond the potential for exacerbation of economic inequity and environmental injustice, nanotechnology presents threats to privacy and to accepted human freedoms. Cribb (2007) suggests that the data storage, fusion, mining, and analytic capacity of quantum computing—advances that may be achieved within a generation—will enable round the clock surveillance of every aspect of a person's life. He suggests that this is "no less than the enabling technologies for the global police state, though no-one is admitting as much" (Cribb 2007, 4). Further, he suggests that this will have a key bearing on future human culture: "Like the *observer principle* in quantum physics where the mere act of observation changes the event being observed, people who know they are, or may be, under surveillance around the clock are bound to modify their natural behaviour" (Cribb 2007, 9). In addition to their role in political surveillance or law enforcement, nano-enabled remote sensing and surveillance technologies may also be used by corporations and governments to enforce proprietary rights and contract compliance on farmers and other users of nano-products (Shand 2005).

Next generation nanotechnology applications in the field of therapeutic or human "enhancement" are predicted to alter people's cognitive and physical capacities. NGOs and bioethicists have warned that nanotechnology "has the potential to challenge our understanding of what it means to be human, what it means to have impairments, to differ from the norm or to be different" (Cabrera 2009, 1) and to expand social inequalities (ETC Group 2004; FoEA 2006; Wolbring 2002, 2008). Human enhancement could create new elite minorities of wealthy citizens who have access to the technology, and a new majority of people who are seen as "impaired" or "disabled" because their "performance" has not been nanotechnologically "enhanced" (Wolbring 2002, 2008; Chapter 5).

7.5 Nanotechnology Decision Making and Policy Development Entrenches Existing Inequities

R.E. Sclove (1995), then director of the Loka Institute, argued that the extent to which democratic involvement should be sought in oversight of a given technology "should correspond roughly to the degree to which it promises, fundamentally or enduringly, to affect social life." Governments in Australia, the United States, and elsewhere have predicted that nanotechnology will transform every aspect of our lives (DITR 2006; NSTC 2000). The APEC Centre for Technology Foresight observes that major breakthroughs associated with nanoscale convergent technologies will inevitably be associated with large-scale social upheaval:

> If nanotechnology is going to revolutionise manufacturing, health care, energy supply, communications and probably defence, then it will transform labour and the workplace, the medical system, the transportation and power infrastructures and the military. None of these latter will be changed without significant social disruption. (APEC 2002)

Given the scale of anticipated global nanotechnology-driven social, economic, and ecological change, NGOs have argued for wide-ranging public involvement in decision making to ensure that nanotechnology is managed in the interests of wider publics, not just that of the emerging industry. The Loka Institute (2007) has argued that: "the general public of every nation, their children, and their children's children [are] the key stakeholders in this potential revolution." Friends of the Earth Australia (2006, 8) has urged that "It is essential that civil society has an informed debate about whether or not it actually wants the changes that nanotechnology will bring, and has the opportunity to be involved in decision making about public policy and regulatory development." Greenpeace UK's Doug Parr (cited in Regaldo 2003) has cautioned that: "What we want to avoid is the situation where a small group of financially and technologically interested people develop something and thrust it on the rest of the world." Yet it seems clear that "financially and technologically interested people" remain at the centre of nanotechnology decision making worldwide, while the rest of the global population is ignored, or at best given a tokenistic opportunity to take part in dialogue that has no capacity to affect outcomes.

Nanotechnology decision making is concentrated in the hands of the emerging industry, based largely in Northern countries, and in the hands of governments. Governments' principal international policy forum is the OECD, whose membership is exclusively Northern and dominated by European nations (for membership see OECD undated) although some Southern countries are invited to participate as observers.[2] The activities of the OECD's Working Party on Nanotechnology and Working Party on Manufactured Nanomaterials are conducted primarily in English, with French translation assistance offered for meetings. This is a clear barrier to wider participation of many countries. The OECD is not a decision making forum, but its joint research initiatives, policy forums, and workshops are extremely influential. The absence of Southern countries from OECD nanotechnology activities means that this central forum is guided by, is responsive to, and advocates for the interests of Northern countries. Other key international nanotechnology regulatory forums and conferences and even international consumer-interest meetings also tend to be trans-Atlantic (focusing on Europe and the United States), rather than transnational in character. A frequent assumption is that once a trans-Atlantic regulatory agreement is negotiated (presumably on terms acceptable to both the United States and Europe), it could be the blueprint for a future global agreement (e.g. Inside US Trade 2009)

The exclusion of Southern countries' interests from United Nations forums is also problematic. For example, in mid 2009 the United Nations Food and

Agriculture Organization (FAO) met jointly with the World Health Organization to consider nanotechnology's use in food and agriculture for the first time (WHO 2009). The meeting took place at the tail end of an unprecedented global food crisis. Nonetheless, the United Nations' key food policy institution restricted its agenda to consideration of safety issues (of key sensitivity in Northern countries) with no consideration for the broader implications for food sovereignty and food security (of vital importance for the South). The Nyéléni Forum for Food Sovereignty had earlier warned that nanotechnology's use in food and agriculture would further undermine the capacity of small-scale farmers to meet their own food needs (Nyéléni 2007). NGOs had also been critical of the large-scale, input and capital-intensive, export-oriented, and corporately-controlled paradigm of food production which nanotechnologies are primarily being used to support and extend (ETC Group 2004; FoE 2008). Yet despite the FAO being the United Nation's key forum for food policy, all socio-economic and equity aspects of nanotechnology's use in food and agriculture were excluded from discussion. Opportunities to present to the meeting were limited to scientific "experts" with expertise in the technical risks of nanotoxicology; small scale farmers and international farmers' advocacy networks such as La Via Campesina were excluded. In 2010 the FAO held a conference to identify and promote applications of nanotechnology in food and agriculture that could benefit Southern farmers. However even this meeting was overwhelmingly dominated by technical nano-scientists. In a field of 300+ participants there were one or two social scientists and only 3 people representing community NGOs; neither farmers nor farmers' representative groups were represented. Although held in Brazil, the meeting was conducted exclusively in English. There was little acknowledgement that nanotechnology may intensify economic or other pressures on small farmers.

"Financially and technologically interested people" also firmly control nanotechnology decision-making at a national level—even where efforts are made to give the impression that the outcomes of public engagement exercises will inform policy development. Friends of the Earth Australia (2009) has pointed out that economic pressures, and the unacknowledged role of governments as key technology proponents, can fatally constrain and compromise the capacity of public engagement to affect the decision making process. As Whitman (2007, 279) asks: "When set against the political, institutional and financial backing already driving nanotechnology and its projected growth, how much purchase is deliberative democracy likely to have?"

Nanotechnology marks one of the first instances where the need for "upstream engagement" has become part of the "master narratives of public policies" in many OECD countries (CIPAST 2008; Joly and Kaufmann 2008). However this does not reflect an acknowledgement by governments that wider publics have the right to be involved in decision making that will affect them, or recognition that public involvement will result in better decisions. There has yet to be a public dialogue with explicit links to decision making within government, industry, or the scientific community. Instead, governments' interest in "engaging" their publics on nanotechnology is largely explained by a wish to avoid a repeat of the backlash that greeted genetically engineered foods. The stated objective of many countries' public engagement programs is to build public acceptance of nanotechnology (CIPAST 2008). In its survey of seventy international public engagement initiatives on nanotechnology, CIPAST (2008) notes that many rate poorly on Arnstein's (1969) "ladder of citizen participation." That is, using Arnstein's ladder, nanotechnology engagement efforts are more accurately described as "manipulation," "therapy," or "informing." Rather than offering "citizen power," nanotechnology engagement generally constitutes "non-participation" or "tokenism." Evaluating recent public engagement activities in Australia, Lyons and Whelan (2009) conclude that: "industry interests have captured policy makers and regulators, dissenting voices have been excluded from engagement processes, and engagement processes have not connected with actual policy making activities."

7.6 Discordant Standards Between Innovation and Regulatory Policies Support Industry Development, While Leaving the Public Exposed to Risks/Costs

NGOs and social scientists have raised critical questions related to equity and nanotechnology development. They have questioned: the scope, direction, and purpose of nanotechnology research and commercial development; the assumptions of government, industry, and scientists; which groups, institutions, and individuals are entitled to participate in decision making; whose interests nanotechnology is managed in; the social distribution of benefits and costs; and the mutability and controllability of nanotechnology's development trajectory (Hepburn 2006; FoEA 2007, 2009; Kearnes et al. 2006a,b; Loka Institute 2003, 2007; Macnaghten et al. 2005; Mohr 2007; Sparrow 2007; Stilgoe 2007). Yet equity issues are excluded entirely from innovation and regulatory policy.

The fact that governments are both principal proponents and facilitators of nanotechnology, as well as principal agents for securing and framing governance arrangements, is a key obstacle to appropriate governance (FoEA 2009; Whitman 2007). Government and industry proponents have claimed wide-ranging economic, social and environmental benefits of nanotechnological innovations (e.g. DIISR 2009; DITR 2002; IFRI 2008). But they have largely failed to acknowledge and assess the potential for economic, social, and environmental "costs" or detrimental consequences of nanotechnology development, or to explore the more complicated issues associated with intellectual property and questions of ownership and access. Potential "downsides" of nanotechnology development are largely ignored, or narrowly defined—primarily as toxicological risks. Discordant evidentiary standards are also applied to nanotechnology innovation and regulatory policy.

Innovation policy, including generous government support for nanotechnology research, and industry development and promotion, is underpinned by widely claimed, but poorly scrutinized predictions of economic, social, and broader benefits. The perceived value of these benefits underpins practical and financial government support for rapid nanotechnology commercialization, and forestalls precautionary scientific risk management. Yet claimed benefits remain largely unexamined and outside the scope of any systematic assessment; the inevitability of these benefits is assumed.

Conversely, *regulation* is considered legitimate only to address proven examples of toxicological risk. Contrary to the lax evidentiary standards applied to claims of benefits, risks must be definitely proven and quantified before regulation will be enacted to protect public health and safety, and even before nano-specific safety assessment of new products will be required. In short, publicly funded support for industry development is assured, whereas basic precautions to ensure public safety are stalled.

This “benefits versus risks” framing of innovation and regulatory policy is extremely problematic (Miller and Scrinis, forthcoming). It ignores broader costs, challenges, social and equity dimensions of new technologies, and privileges narrowly defined technical risk as the only legitimate basis for new technologies’ regulation. This reinforces the tendency of scientists and decision-makers “to see themselves as purveyors of objective risk assessment, and… to view public concerns as subjective perceptions of risk that are thus marginal to the decision-making process” (Ross 2007, 215).

J. Clarence Davies, former United States (U.S.) Environmental Protection Agency official and fellow of the U.S. Woodrow Wilson Center’s Project on Emerging Nanotechnologies asserts that: “what is needed is a capability to consider the overall impacts of major new technologies and to do so while there is still time to deal with the impacts” (Davies 2009, 31). Yet governments have largely been unwilling—or unable—to undertake systematic technology forecasting and assessment of nanotechnology’s social dimensions as a part of the governance process. In some instances this is a reflection of the loss of technology assessment capabilities. The places where technology assessment was once carried out in countries such as Denmark and the United States have been significantly reduced in size and shape during the last 15 years (Jamison 2009).

7.7 Intrinsic Properties of Nanotechnology Make it More Likely to Expand Inequity

In evaluating the structural and systemic implications of nanotechnological development, in addition to acknowledging the realities of the socio-economic context in which nanotechnological innovations are being developed and deployed, it is important to consider some of the more or less intrinsic characteristics of this technological platform. The intrinsic characteristics of nanotechnology are in many cases common to other emerging technological systems of the twenty-first century. For example, nanotechnological instruments and systems are often capital-intensive, require highly specialised knowledge, will be controlled by patents, and will enable the closer integration of a range of technological systems. It is therefore well-resourced corporations that are better placed to control and even monopolise the development and commercialisation of nanotechnological systems.

Where nanotechnological innovations increase the productivity and efficiency of manufacturing or agricultural systems, they may similarly facilitate the growth and concentration of market share of large-scale producers, and thereby undermine the economic viability of smaller-scale producers (Foladori and Invernizzi 2008; Scrinis and Lyons 2007; FOE 2008). The surveillance and monitoring capabilities of nano-scale technologies are also likely to be utilised by, and of most benefit to, large and powerful corporations and governments, at the expense of the liberties and autonomy of workers and citizens. The control of the global market for genetically-modified seeds by a handful of agri-biotech corporations may represent the future pattern of nanotechnological development in a range of industries.

The potential benefits of nanotechnological innovation for poor or disadvantaged social groups, communities, or countries are often discussed in terms of identifying individual beneficial applications. For example, the development of cheap water filtration technologies, cheap pharmaceuticals or medical diagnostic kits, and decentralised energy generation systems, have been used to demonstrate the broad-based potential benefits of nanotechnological applications for poor communities (Salamanca-Buentello et al. 2005). Particular nano-applications may indeed offer benefits to their users - especially where existing technologies or management systems are inadequate or expensive. However nano-products and systems do not always offer more effective services or treatments than existing technologies, nor necessarily represent the best value-for-money investment for resource-poor communities and governments. Further, important questions regarding the extent to which nano-products establish a relationship of dependence are often ignored (Stilgoe 2007). It is questionable whether recipient communities will have control over the future manufacture, maintenance, and distribution of such nano-products, and at what cost. Due to their highly technical and capital-intensive nature, manufacturing or maintaining nano-products may be outside the skills base or economic affordability of recipient communities. Should nanotechnology create dependency on ongoing "technological charity" by foreign companies or governments, it may be of limited long-term benefit to recipient communities. Similarly, if communities become reliant on products manufactured far away, they may be vulnerable to fluctuations of nano-product price or availability. If nanotechnology applications displace alternative, community-controlled solutions there could be a loss of traditional knowledge that comes at a high social cost.

Importantly, individual beneficial nano-applications do not challenge or displace the broader socio-economic structures which create, entrench, and extend existing inequalities and power imbalances, and which frame the deployment and use of these individual applications (Invernizzi et al. 2008). At the same time, the public focus on individual applications ignores the ways in which nanotechnological systems may reinforce, extend, and transform broader socio-economic structures, and in ways that may deepen and create new forms of inequality, disadvantage, exclusion, dispossession, and power imbalances. Prominent promotion of examples of "technological charity" may disguise the extent to which nanotechnology perpetuates or exacerbates existing inequity, poor industry practice, environmental pollution, unjust intellectual property regimes, etc. It may also give the incorrect impression that public good applications for poor communities are a major focus of nanotechnology research and development. In fact, in the United States, the world's largest government funder of nanotechnology R&D, military applications receive the greatest proportion of public funding (U.S. National Nanotechnology Initiative 2005), while the private sector is focused on developing consumer items for wealthy and comparatively healthy people in the Global North. The structure and focus of the nanotechnology research and development enterprise itself therefore reflects and perpetuates broader social and economic inequities.

7.8 Conclusion

Governments and other nanotechnology proponents have shown little interest in supporting critical reflection about nanotechnology's social dimensions. Proponents have been keen to promote the potential for individual nanotechnology applications to meet social or environmental needs. However, they have largely avoided the question of whether or not nanotechnology innovation as a whole will exacerbate existing inequity. Whereas social and ethical concerns have to some extent become an "obligatory footnote to nanotechnology's technological promise," such issues remain marginal to the principal business of industry commercialisation. Nanotechnology research, development, and commercialization to date demonstrate clearly that it is driven by a quest for scientific, economic, and military competitiveness, rather than a desire to overcome inequity.

The potential for nanotechnology to reduce existing inequities, rather than exacerbate them, is limited on a number of fronts. Nanotechnology research is expensive and scientists face strong pressure to develop profitable products for a wealthy clientele. Addressing concerns relating to the potential for further concentration of corporate ownership of potential future platform technologies would pose significant direct challenges to intellectual property and patenting regimes internationally. Nanotechnology is a highly technical field and those with the greatest understanding of its risks and challenges have a professional or financial interest in its development. The members of specialist groups most closely involved in technoscientific policy development come from privileged backgrounds, and often hold an overly optimistic view of the potential for technological innovation to be of wider benefit. Participatory processes to seek input in policy and decision making processes from wider publics and marginalised groups remain tokenistic, and are sidelined from the main business of industry development. Regulatory systems are lagging well behind commercial research and development for practical as well as political reasons. There are inherent uncertainties in the technology and its applications, as well as significant knowledge gaps in its implications for human health and the environment. The capacity to detect and monitor particles is extremely low compared to their widespread use and environmental diffusion. Regimes to control military applications face enormous obstacles in the face of an unacknowledged emerging nano-arms race, and political pressure from technologically advanced nations to reduce their soldiers' exposure to conflict.

For these reasons, there may be limits to the extent to which—through better regulation and more democratic control—nanotechnological development can simply be directed towards equitable and just goals and applications, or can be used to redress existing forms of inequalities and power imbalances. This is not a reason not to pursue efforts to increase the levels of democratic participation in policy development, to delay action to protect public health and the environment, or to forestall measures to prevent or mitigate greater inequities. However given these limits, it is legitimate to question the societal benefits of nanotechnological innovation as a whole, and to expose the embedded interests of the broader technological and economic paradigms that will shape the development and deployment of this technological platform.

Notes

1. The gap between the global rich and the global poor is growing, although by some measures economic inequality between countries is decreasing. Milanovic (2005; cited in Cozzens et al. 2008) has examined global data, and concludes that inequality *between* countries' gross domestic product (GDP) per capita is rising. However, if GDP is weighted by population, inequality between countries is declining. Nonetheless, data analysed by Milanovic and others demonstrate that inequality *within* countries is increasing.
2. Interested NGOs and the nanotechnology industry may also send observers to meetings.

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