THE TREADMILL OF PRODUCTION: THE CASE OF NANOTECHNOLOGY

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Abstract

The socioenvironmental impacts of nanotechnology are rooted in the way in which power is distributed in the national and global treadmill of production. The future roles of nanotechnology are largely discernible through analysis of the interests of the public and private institutions that control the global technological trajectory. The technological innovation trajectory reflects the primary interests of these social institutions (transnational corporations and states), and the intended results of the technological innovation process are to further those institutional interests in consolidating economic and political power. Although the potential unintended consequences of nanotechnology present serious social and ecological threats, it is the intended consequences that reveal the anti-ecological nature of the technologies and the institutional arrangements that produce them. Nanotechnological innovation promises to greatly accelerate the treadmill of production, exacerbating existing socioenvironmental problems and generating new forms of ecological disruption. Within the context of the current political economy, the nanotechnology trajectory being pursued by powerful institutional actors is bound to generate greater levels of ecological disorganization, significant public health problems, and increased domestic and transnational socio-economic inequality.

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Technological Innovation and the Treadmill of Production

The emergence of nanotechnology with its promise of a myriad of new materials, production processes and military and commercial applications is bound to become an enormous accelerator of the Treadmill of Production (Schnaiberg 1980, Schnaiberg and Gould 1994, Gould, Pellow and Schnaiberg 2004). This treadmill, which increases corporate profitability at the expense of workers and the environment depends upon technological innovation to replace human labor with capital and to increase the capacity for the transformation of natural resources into commodities. In doing so the treadmill increases profits and environmental threats while reducing the generation of social benefits (employment, wages, etc.), ensuring constant increases in social and environmental inequality (Gould 2003).

The treadmill of production invests surplus capital in technological innovation (through states and firms) in pursuit of increased corporate profitability and state revenues, and thus, each round of capital accumulation serves to increase the capacity for further capital accumulation through further investment in technological research and development (Gould et al 2004). The economic benefits of nanotechnology are therefore likely to accrue to corporate owners, managers and investors (as well as states), while the social and ecological costs are disproportionately borne by non-elite citizen-workers. Treadmill elite control of the technological innovation process largely prevents the harnessing of the research and development infrastructure by democratic citizenries for the pursuit of non-treadmill goals such as improvements in social equity and ecological sustainability, as such goals are rarely profit enhancing.

Nanotechnology Politics and the Environment

The processes of scientific research and technological innovation have always been politically charged endeavors (Noble 1977, Wright 1992). Nanotechnology has been politicized by dominant social institutions that see this set of technological innovations as having great capacity to augment their narrow social goals of corporate profitability and state coercive capacity. These institutions choose to support specific forms and directions of nanotechnological research and development, and to shape the vision of technologists into a political campaign to gain widespread social acquiescence to this set of social changes. This is an intensely political agenda that, by emerging from and moving through the societal science and technology infrastructure, can largely make an end run around democratic politics to achieve broad realization.

Part of the political campaign is to market nanotechnology as utopian in meeting a multitude of preexisting and newly generated social needs. All new technologies are sold by institutions to publics as utopian (Nye 1996), with particular emphasis on medical benefits and attractive consumer goods. In line with this political strategy, nanotechnologists and their institutional supporters have emphasized the social benefits of innovation while minimizing social costs. Despite the potential for serious human health, livelihood, and ecological threats, social institutions have moved forward aggressively in promoting a new world vision based on nanotechnology, and have used their power to begin to impose this political vision on the global citizenry.

In addition to the usual utopian benefits promoted by technologists, nanotechnology promoters have emphasized a wide array of ecological benefits potentially stemming from the new technology, capitalizing on broad public concern for the deteriorating state of the global biosphere. Here the naïve and convenient notion that ecological problems are primarily technological in nature, and thus amenable to engineering solutions, rather than social structural in nature, and thus requiring political-economic solutions is reinforced. The failure of decades of technological fixes to reverse or even to slow the pace of ecological destruction is ignored in favor of the view that the next round of growth enhancing technological innovation emerging from institutions will resolve ecosystem-social system discontinuities. Faith in "ecological modernization" (Mol 1995) is useful to states and corporations seeking to avoid the difficult and threatening political and economic implications of the necessity of bringing social systems in line with ecological limits. In effect, nanotechnology promoters promise that social systems can escape ecological limits through technological innovation, in much the same way that early industrialists promised, and in much the same way that nuclear technology promoters promised, and in much the same way that biotechnologists continue to promise. In doing so they ignore both the realities of nature, and the realities of the political economy.

There are a number of specific nanotechnology products that are emphasized to promote the utopian ecological vision of the "nanotech revolution". For example, nanotechnology offers a new class of filters to purify contaminated water and air (Wood et al 2003). This is seen as a clear ecological benefit. However, the increased capacity to filter increasingly contaminated water supplies will likely reduce the imperative for preventing their contamination. Water contamination is a mechanism for increasing corporate profitability by using nature as a waste sink. We can expect that the structure of the political economy will promote the use of nanotechnology filters as a profit enhancing technological fix to preclude the need for the protection of water from contamination. Then, the provision of commodified filtered water to those whom can afford it will provide another mechanism for corporate profit enhancement. Similarly, nanotechnology water filters offer the potential to rapidly increase desalinization of seawater to make a technological end run around fresh water scarcity as the treadmill of production demands ever increasing use of fresh water reserves in the environmental context of a finite total supply. Here we see nanotechnology's environmental promise to increase human use of ecosystem elements, converting seawater into a saleable commodity. The long-term changes to local ecosystems and global sea levels stemming from such a development remain unaddressed, and the incorporation of new ecosystem elements into the production treadmill is spun as an ecological benefit rather than an ecological cost.

In addition, it's proponents have argued that nanotechnology will further improve agricultural yields through the use of "smart soil" in concert with genetically modified organisms, thus reducing the discontinuity between growing human populations and the limited capacity of ecosystem to provide food for humans (Roco and Bainbridge 2001, ETC Group 2004). As in the genetically modified crop campaigns of corporations, the problem of malnutrition is conceptualized as one of insufficient production rather than poor distribution. A brief review of recent public health campaigns in northern industrialized countries to reduce the rapidly growing problem of obesity should be sufficient to make clear that the political-economic problem of distribution is a more significant cause of regional food deficits than is total global production capacity limitations. Further, by making it possible to produce food, textile and luxury crops in a wider range of ecosystemic conditions, nanotechnology threatens to expand habitat destruction by facilitating the integration of new ecosystems into the global production treadmill.

Another set of ecological benefits of nanotechnology promoted by treadmill institutions is in the area of energy efficiency and expanding energy sources (Wood et al 2003). The institutional goal of increased energy efficiency is generally to increase total production output per unit of energy input. Thus efficiency goals tend to be treadmill accelerant goals. Despite decades of increases in energy efficiency, total human energy demand has continued to rise. Savings in energy demand per unit of production have been used to increased production rather than limit energy total energy use. Here again, the problem of increasing energy demand is not technological in nature but rather social structural. The growth requirement of the treadmill of production quickly absorbs and offsets any ecological savings from increased technological efficiency (Schnaiberg and Gould 1994). This process applies to non-fossil fuel based energy alternatives as well.

Nanotechnology offers potential improvements in the utilization of solar energy inputs through cheaper and new forms of photovoltaics. Clearly, significant reductions in fossil fuel use would have environmental benefits. However, the promise of this nanotechnological energy transition assumes a replacement of fossil fuels rather than an augmentation. Adding to total available energy stocks will simply increase production capacity and thus accelerate the conversion of ecosystem elements into goods and waste. Qualitative savings in natural resource demand in energy and materials will ultimately be outstripped by quantitative increases in total production unless the political economy is reoriented (Schnaiberg and Gould 1994). Note that oil did not replace coal, nor did nuclear replace oil. The notion of replacement of fossil fuels with nanotechnology-based alternatives also ignores the powerful political and economic interests vested is fossil fuel production. Viable alternatives to fossil fuel use already exist in many applications, and their failure to replace fossil fuels in those sectors is a result of political-economic factors, not lack of technical capacity. The lack of state investment in renewable energy options over the past quarter century is clearly illustrative of the power of private capital resistance to technological threats to continued profitability. The use of nanotechnology based filters to make even low grade fossil fuels economically viable for extraction and marketing by corporations, at great ecological cost, is a more politically realistic projection.

The notion that nanotechnology will allow the treadmill of production to escape ecological limits through the provision of infinite and cheap energy inputs simply replicates the utopian promises of coal in the emergence of “carboniferous capitalism” (Mumford 1934), and the promises of nuclear fission in the 1950s. The propaganda surrounding the vision of a nanotechnology based solar/hydrogen economy in which the environment benefits should be considered in light of the outcomes of these earlier campaigns. Each round of treadmill technological innovation has been accompanied by claims of the end of ecological scarcity, and the reduction of social inequality through the provision of cheap goods and energy. Claims that “material abundance” will eliminate poverty are historically just as common. Nanotechnology proponents have recycled these old political tools despite decades of empirical evidence of their lack of credibility. Increases in total “material abundance” in recent decades have been accompanied by dramatic increases in global inequality, ecological damage and poverty. Inequality, ecological disorganization and poverty are political-economic problems that cannot be solved through science and technology. Given the social structural basis of control of science and technology, it is more realistic to expect that each round of technological innovation will serve the interests of those who control the process and result in greater inequality, ecological disorganization and poverty.

The Quality and Quantity of Eco-Technological Threats

Threats to ecosystem integrity stemming from the introduction of new technologies come in two essential forms. One form of threat emanates from the quality of the technology itself (Schnaiberg 1980). Technologies have varying potential to cause ecological disorganization depending upon their natural resource input requirements, their production of specific types of waste material, their accident potential, and their capacity to transform ecosystem elements into new materials (Schnaiberg 1980). Designed into each technological innovation are the specific forms and scope of ecological harm that it will produce.

In addition to these anti-ecological qualities of technologies are the quantitative impacts stemming from the manner and scope of their implementation. Even qualitatively high-risk technologies may have relatively small total negative ecological impacts if the scale of implementation is kept modest (Schnaiberg 1980).

From a global ecological standpoint, the riskiest and potentially most threatening technologies are those that have high qualitative and high quantitative risks (Schnaiberg 1980). The transformative power of nanotechnologies, the scope of their likely implementation, and their potential for catastrophic accident make them particularly risky to the environment both qualitatively and quantitatively.

Nanotechnology offers the capacity to transform ecosystem elements on the atomic and molecular scale at a highly accelerated rate. Nanotechnology is sold as a vehicle for environmental improvement due to its potential to manufacture practically anything from practically any ecosystem element, thus skirting the depletion problems associated with relying on specific non-renewable ecosystem elements for specific forms of production (Wood et al 2003). However, by generating a new accessible ecosystem elements surplus it threatens to vastly expand the volume of manufacturing and thus the conversion of ecosystem elements into manufactured goods. The rapid increase of the sheer volume of conversion of ecosystem elements into commodities, as required by the political-economic arrangements of the treadmill of production, poses significant potential ecological threat (Schnaiberg and Gould 1994). Simultaneously with the rapid expansion of production, nanotechnology promises a rapid reduction of human labor input (Wood et al 2003), thus reducing the provision of social benefits (jobs) per unit of ecological disorganization.

The Socioenvironmental Threats of Nanotechnology

The overriding goals of the modern science and technology project are increased state military capacity and increased corporate profitability. The two key drivers for corporate profitability through technological innovation are 1) the conversion of ecosystem elements into commodities, and 2) the replacement of labor with capital (Schnaiberg 1980, Schnaiberg and Gould 1994). The former represents a primary nanotechnological environmental threat, while the latter presents a primary nanotechnological social threat. That is, nanotechnological innovation presents major social and ecological threats based on their designed intent to rapidly eliminate sources of human livelihood, and accelerate the conversion of ecosystems into commodities (McKibben 2003). These socioenvironmental threats are generated by nanotechnology as a means of hyper accelerating socially regressive and ecologically destructive institutional treadmill goals, regardless of the specific qualities of nanotechnology itself.

In addition to the above threats, nanotechnologies posses specific qualities that present new, and exacerbate old, ecological threats. Nanotechnology has and will continue to be used to create new materials (nanates) that represent ecological additions which natural systems have not evolved to deal with. The qualitative threat specific to nanotechnology in this regard is its potential to generate a seemingly infinite variety of new ecological additions in a relatively short span of time. While the relative toxicity and ecosystemic impacts of an infinite variety of new ecological additions cannot be assessed, the fact that nanotechnology will greatly expand the existing stock of synthetic additions to ecosystems indicates that nanotechnology will certainly exacerbate the familiar problem of synthetic chemical and material contamination stemming from the explosion in chemical engineering in the 20th Century. In this respect, nanates do not pose a new ecological threat (aside from the specific qualities that any particular nanate may have), but nanates will greatly expand an existing threat (Suchman 2002) which to date has not been effectively addressed.

The societal track record in terms of assessing, controlling, and mitigating the negative ecological and human health impacts of the products of non-nanotechnology based chemical engineering is abysmal. Due to treadmill institutions' prioritization of science funding, we know relatively little of the health and ecosystemic impacts of the tens of thousands of synthetic chemical compounds produced by states and corporations in the 20th Century. Rapidly increasing the number of ecological additions will also rapidly increase our ignorance of the health and ecological impacts of chemical and material additions. As we lack the institutional will to assess our current ecological impacts, nanotechnology promises to increase the gap between the potential threat and our understanding of that threat.

Nanoparticles do pose serious human health threats and threats to other living organisms, and thus to ecosystem integrity as a whole. Again, the specific toxicity of any of an infinite possible range of nanoparticles cannot be assessed here, but the ecological and health problems associated with nanates noted above of course apply to nanates as individual nanoparticles as well as nanomaterials. However, the very qualities of nanoparticles in general appear to pose serious risks stemming from their size, their mobility, their social invisibility, and the inability of biological organisms to effectively address them (European Commission 2004). Although all nanoparticles are not a result of nanotechnology, the technology does, by its very nature, threaten to greatly increase environmental exposure to a wide range of new nanoparticles. Much of this exposure is anticipated to be experienced by production workers in fabricating plants, indicating that such environmental health risks will be borne primarily by workers rather than owners, managers and investors who reap the primary economic benefits in the familiar pattern of environmental injustice that is inherent to the distributional logic of the treadmill of production (Gould 2003).

Again, our capacity to limit this exposure should be judged against the track records of treadmill firms in protecting worker exposure to production-related environmental hazards. Similarly, the capacity to contain such hazards within production facilities should also be judged against the track records of firms in preventing the escape of pernicious additions into the larger environment. Given this poor record of containment, the ability of nanoparticles to enter humans and other living organisms through inhalation, ingestion and through the skin, the social invisibility and hence, difficulty of detecting exposure, and the lack of understanding of the health impacts of exposure, the mass production of a wide range of nanoparticles is problematic from the perspective of human health, ecological integrity and environmental justice. Additional exposure to nanoparticles through the use of consumer goods poses unknown and unnecessary risks as well. Rushing such goods to market in a competition to secure market share without understanding the risks posed to consumers reproduces the 20th

Century experience of rushing toxic chemical substances to market, and discovering the health and ecological impacts too late to reverse them.

Nanotechnology, especially nanites (nano-machines), are particularly vulnerable to catastrophic “normal accidents” (Perrow 1984) that pose additional and irrecoverable ecological threats (McKibben 2003). The ecological risks stemming from nanites are qualitatively different from previous social system-ecosystem interactions. Nanites, as a new class of ecological additions and as a new form of ecological withdrawal capacity, pose perhaps the greatest and least knowable environmental threats. As a broad class of technologies, it is difficult to assess the ecological threats that any specific nanite might pose. However, the quality that raises the most concern is the potential for the creation of self-replicating nanomachines. Self-replicating nanites would be necessary in order to make wide scale, high volume molecular manufacturing possible, and thus fulfill the promise of the nanotechnology revolution envisioned by its proponents. It is the self-replicating quality that has raised the greatest ecological concern, since such a quality of human technology has never before entered the social system-ecosystem interaction equation. Combined with the quality of social invisibility, which reduces human capacity to monitor and respond to ecological threats (Gould 1993), and the designed intent to transform ecosystem elements into synthetic goods, the introduction of self-replicating nanites into the environment presents the potential for uncontrolled invasion and devastation of ecosystems, and potentially, the entire biosphere. This has been termed the “grey-goo” problem in which self-replicating nanites proliferate uncontrolled in nature and reduce the biosphere to a stock of molecularly manufactured end products. Clearly, such nanites represent extraordinarily high-risk technologies due to both their qualities (transformative capacity, self-replication, invisibility, self-locomotion) and their quantity (self-reproduction indicates the potential for infinite quantity). The actual feasibility of the creation of self-replicating nanobots remains contested, but the social investment in the pursuit of their realization is significant and growing. That line of investment poses ecological and social threats that most citizens would likely find unacceptable, however the insularity of the science and technology research process from democratic input, combined with the competitive pressure on states and firms stemming from the structure of the global political economy, fuel the pursuit of this socially and ecologically disorganizing end goal.

Technological controls have been proposed to be designed into self-replicating nanites to prevent uncontrolled proliferation and transformation of ecosystem elements. The programming of termination dates and the design of nanites unable to self-replicate in all but controlled environments offer some hope that the technology will not trigger an ecophagic apocalypse (Wood et al 2003). But these safeguards would have to be 100% failsafe, as one uncontrollable release could potentially terminate the biosphere in a worst-case scenario. As no technology can deliver on such requirements, total social and ecological dependence on the capacity to deliver a technological impossibility is problematic. Further, the history of other high-risk technologies indicates that the competitive pressure on firms and states lead to overconfidence in safety control mechanisms and underestimation of risks. The lack of a viable global governance system with effective enforcement mechanisms makes the universal application of even risky control technologies unlikely. The competitive pressures of the treadmill of production have also lead to extensive corporate fraud in terms of safety compliance with regulating agencies. The same competitive pressures have lead states to reduce safety and environmental regulation, reduce monitoring of environmental hazards, and reduce enforcement and inspection. And the tight relationship between corporate and state treadmill elites has produced sets of regulations largely designed by those who will receive maximum economic benefit from slack regulatory controls (Gonzalez 2001). In a political-economic context that structurally prioritizes profitability over social and ecological protection, and competitive advantage over appropriate caution, the generation of a new class of high-risk technologies with potentially devastating ecological consequences is socially irresponsible.

Conclusion: Nanotechnology and the Radical Democratization of Innovation.

The scientific research and technological innovation processes must be made subject to democratic controls in which their potential social and ecological impacts can be assessed by informed publics, and under conditions in which democratic citizenries are empowered to determine the goals of research and development, the prioritization and funding of that research, and the manner in which technologies shall be implemented or prohibited. This input must occur at the earliest stages of the research and development process, determining the purpose and trajectory of the most basic lines of scientific inquiry in order to harness the human scientific and technological capacity for the maximization of democratically established social benefits. Although nanotechnological innovation remains at a relatively early stage, and public input into its form and efficacy is beginning to emerge, that input is emerging at a stage that is still too late to preclude significant lines of research, and only after powerful institutional proponents have staked out interests and developed campaigns to ensure that such interests are achieved. Further, the channels through which such public input is considered have been designed specifically to thwart opposition to the political-economic vision of the nanotechnology proponents. After-the-fact protests and control efforts will no doubt emerge, but they will be difficult battles between citizens and powerful treadmill institutions. That is certainly a less then optimal scenario for democratic governance and the creation of a technological trajectory that serves the majority human interest.

Given the context of the current global political economy (which promotes corporate profitability as a central value, economic growth as the overriding social goal, and competitive advantage over appropriate caution), and the lack of understanding of (and thus, ability to mitigate) the ecological consequences of nanotechnological developments, the social and environmental costs of such developments are likely to outweigh the benefits promised by the individuals and institutions involved in their production.

REFERENCES

ETC Group. (2004). *Down on the Farm: The Impact of Nano-scale Technologies on Food and Agriculture*. Ottawa.
European Commission Community Health and Consumer Protection. (2004). *Nanotechnologies: A Preliminary Risk Analysis on the Basis of a Workshop Organized in Brussels on 1-2 March 2004 by the Health and Consumer Protection Directorate General of the European Commission*. European Communities.

Gould, K. A. (1993). "Pollution and Perception: Social Visibility and Local Environmental Political Mobilization". In *Qualitative Sociology*. Vol. 16, No. 2.

Gould, K. A. (1994). "Legitimacy and growth in the balance: The role of the state in environmental remediation". In *Industrial and Environmental Crisis Quarterly*. 8, 237-256.

Gould, K. A. (2003). *"Classe Social, Justiça Ambiental e Conflito Politico"* In *Justiça Ambiental e Cidadania*, Edited by José Augusto Pádua, Henri Acselrad and Selene Herculano. Relume Dumara: Rio de Janeiro.

Gould, K. A., D. N. Pellow and A. Schnaiberg. (2004). "Interrogating the Treadmill of Production: Everything You Wanted to Know About the Treadmill But Were Afraid to Ask." In *Organization and Environment*. 17 (3), 296-316.

Gonzalez, G. (2001). *Corporate Power and the Environment*. New York: Rowman and Littlefield.

McKibben, B. (2003). *Enough: Staying Human in an Engineered Age*. New York: Holt.

Mol, A.P.J. (1995). *The Refinement of Production: Ecological Modernization Theory and the Dutch Chemical Industry*. Ultrecht: Jan van Arkel/International Books.

Mumford, L. (1934). *Technics and Civilization*. New York: Harcourt Brace Jovanovich.

Noble, D. F. (1977). *America by Design: Science, Technology, and the Rise of Corporate Capitalism*. New York: Alfred A. Knopf.

Nye, D. E. (1996). *American Technological Sublime.* Cambridge, MA.: The MIT Press.

Perrow, C. (1984). *Normal Accidents: Living with High-Risk Technologies.* New York: Basic Books.

Roco, M. C. and W. S. Bainbridge. (Eds.). (2001). *Societal Implications of Nanoscience and Nanotechnology: NSET Workshop Report*. Arlington, VA.: National Science Foundation.

Schnaiberg, A. (1980). *The Environment: From Surplus to Scarcity.* New York: Oxford University Press.

Schnaiberg, A. & Gould, K. A.. (1994 [2000]). *Environment and Society: The Enduring Conflict*. New York: Cambridge University Press.[West Caldwell, NJ: Blackburn Press]

Schumacher, E.F. (1973). *Small Is Beautiful: Economics as if People Mattered.* New York: Harper & Row.

Suchman, M. C. (2002). "Social Science and Nanotechnology". Unpublished paper. University of Wisconsin-Madison.

Wood, S., R. Jones and A. Geldart. (2003). *The Social and Economic Challenges of Nanotechnology*. UK: Economic and Social Research Council.

Wright, W. (1992). *Wild Knowledge: Science, Language, and Social Life in a Fragile Environment. Minneapolis: University of Minnesota Press.*