

Nanotechnology and the Environment: The Nano-Atomic Reconstruction of Nature

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Intro

Nanotechnology is a new set of techniques for engaging with and reconstructing nature at the level of atoms and molecules, or what I'll refer to as the *nano-atomic level*. Nanotechnology is not so much a distinctly new techno-scientific field, but a new platform and paradigm for enabling a range of existing techno-sciences to shift further down into the nano-atomic level, including chemistry, physics, biotechnology, information technology and engineering.

The applications and products of nanotechnology will range from breaking existing chemical compounds and materials into nano-particles and creating new types of nano-scale materials; enabling new ways of genetically modifying and reconstructing living organisms; and inventing new ways of manufacturing and putting together products from the ground-up. In some cases the end-products will be nano-scale in size, in others they will be larger-scale products manufactured using nano-scale techniques or by incorporating nano-scale materials. The range of applications and products will be enormous and span all sectors of the economy.

To address the question of the ecological implications of nanotechnology cannot just entail considering a narrow and defined set of new products and new problems. It also requires consideration of how nanotechnology might *re-frame* our relationship to nature, as well as how existing industries, economies and cultures — and the demands for commodities and resources across these fields — will be shaped and transformed by the development of nanotechnology.

However the current debate over nanotechnology's environmental "impacts" has largely failed to adequately grapple with these broader issues and processes.

On the one hand, nanotechnology is rather disingenuously presented by its proponents as an essentially 'green' technology that will improve the environmental performance of existing industries, reduce our consumption of resources and energy, and allow us to shift to an environmentally sustainable economy and way of life. In other words, nanotechnology will provide a panacea to existing resource constraints and environmental pollution — we will be able to continue a 'business as usual' path of economic expansion, they suggest, while minimising our ecological impacts.

Nanotech critics and regulatory institutions, on the other hand, have mostly emphasised the new forms of environmental hazards and risks from the release of nanoparticles — as well as other potential hazards — that mostly come under the banner of the 'unintended and unpredictable side-effects' of nanotechnology.

What have barely been explored, however, are the broader environmental implications of nanotechnology if its radical potential for taking apart and reconstructing nature is exploited

fully by the corporate-industrial global economy. For nanotechnology may ultimately facilitate the next wave of expansion of the global economy, and the transformation and integration of ever more parts of nature into our systems of production and consumption.

A Green and Sustainable Nano-Economy? The Ideology of Nano-Atomic Precision

Some of the specific environmentally-beneficial applications of nanotechnology being developed or promised by the nanotech industry include: more efficient energy production technologies, such as more efficient solar and renewable energy generation technologies, as well as the more efficient use of fossil fuels; improved water and air filtering technology for cleaner drinking water and for reducing air pollution emissions; ‘smarter’ energy-saving building materials; biosensors for the detection of pollutants and pathogens; and environmental remediation applications such as products for cleaning up contaminated water and soils.

Beyond these specific applications, it is claimed that nanotechnology will enable the more efficient use of resources and energy across all industrial and economic sectors due to the capabilities of new nanomaterials and production techniques. This includes the prospect of nanomaterials that are stronger, lighter, more durable and reliable than the conventional materials they replace, or that require less resources and energy to produce and create less wastage and pollution by-products. Lighter materials for transport technologies such as aeroplanes, for example, may reduce energy consumption.

If the more distant promise of ‘molecular manufacturing’ is realised, then it is claimed that products may eventually be able to be manufactured from the ground up — atom-by-atom — to fit our precise specifications. Molecular manufacturing may entail being able to use any number of cheap and interchangeable natural resources as raw materials.

In general, it is presented as a taken-for-granted certainty that nano-atomic precision will translate into the ability to precisely manufacture products with a minimum of resource inputs and waste outputs, and that these efficiency gains will in turn translate into a reduction in our current environmental impacts.

I refer to this way of framing nanotechnology as the *ideology of nano-atomic precision*, whereby the degree of precision and control over nature at the nano-atomic level — as well as the control over the products of nanotechnology — are to some extent exaggerated, as are the supposed environmental benefits that will flow from this precision. At the same time, concerns over the imprecision, unpredictability and uncertainties surrounding the techniques and products of nanotechnology are down-played.

For nanotech proponents, the combination of these environmentally beneficial applications, incremental efficiency gains, and precise manufacturing techniques all add up to the promise — or is it just the techno-capitalist fantasy? — that nanotechnology will enable us to “*decouple* resource consumption from economic growth through initiatives in the recovery, recycling and reuse of material products”, as expressed in a recent CSIRO report.

This promise/fantasy of decoupling goes hand-in-hand with the hope that nanotechnology will enable a purely *technical* solution to the global ecological crisis, sparing us the messy and painful business of having to reduce existing levels of production and consumption, or to otherwise tamper with existing political and economic structures.

Novel Environmental Hazards and the Threat of Nano-Pollution

However the ability to *more or less* precisely modify nature at the nano-atomic level is not matched at present by the ability to precisely predict or control the ecological impacts of the release of these nano-products into the environment.

Nanotechnology now threatens to introduce an entirely new form of pollution into our ecological lexicons and into the world: *nano-pollution*. In particular, nanoparticles and devices may constitute a whole new class of non-biodegradable pollutants. Like chemical pollution, the concerns over nano-pollution are based on the persistence, bioaccumulation and toxicity of nanoparticles and other nano-structures and products.

Nanoparticles and other nano-structures will be released into the air, soil and water in the form of environmental remediation products; through waste streams from factories and research laboratories; as fixed or unfixed nanoparticles in composite products and particularly after nanoproducts have been disposed of; in the form of nano-chemical pesticides and fertilisers; accidental releases during handling or transport; as components of military weapons; and through the explosion of nano-powders.

The ecotoxicological impacts of nanoparticles remain poorly researched and poorly understood. However preliminary studies suggest that the size and toxicity of nanoparticles pose a serious threat to animals, plants and micro-organisms. Early studies also suggest that micro-organisms and plants may be able to produce, modify and concentrate nanoparticles that can then bio-accumulate following ingestion by other organisms.

One of the few environmental studies carried out to date has shown that the carbon nanoparticles known as ‘buckyballs’ may cause brain damage in largemouth bass, a species accepted by regulatory agencies as a model for defining ecotoxicological effects. These carbon nanoparticles have also been found to kill water fleas and have bactericidal properties.

Nanoparticles may travel through soils and be taken up by plants, thereby providing an avenue for entering the food chains of humans and animals. Because of their size and bonding properties, it has also been suggested that nanomaterials may adsorb and provide an avenue for transport of other environmental contaminants already present, such as cadmium and petrochemicals. This tendency would make them a potential mechanism for long range and wide-spread transport of pollutants in groundwater.

The antimicrobial properties of nanoparticles have led to concerns that they may shift into microbial populations and disrupt signalling between nitrogen-fixing bacteria and their plant hosts. Any significant disruption of nitrogen fixing could have serious negative impacts for the functioning of entire ecosystems. High levels of exposure to engineered nanoparticles of aluminium (currently used in face powders and sunscreen) have been found to stunt root growth in five plant species.

Nanoparticles and devices which are non-biodegradable and are released on mass into the environment — such as nano-scale sensors or ‘smart-dust’, or nano iron oxide used already in the US for remediation — may also simply introduce their own set of environmental pollutants and hazards that cannot be cleaned up but clog up and pollute ecosystems.

Beyond the specific hazards of nanoparticles, the transformative power of nanotechnology also poses more far-reaching environmental threats and challenges. One of the inherent dangers associated with nano-biotechnologically modified organisms — such as modified viruses — is not only that they reproduce, but that they may also mutate and evolve in

unpredictable and uncontrollable ways. The ETC Group has referred to the dangers posed by the release of nano-biotechnologically engineered living organisms as ‘green goo’.

Adding to all of these concerns is the premature commercialisation of nano-products before adequate regulatory systems are in place and adequate safety testing and environmental assessments have been carried out.

The Deep Integration of Nature into the Economy

The range of environmental crises we now face are not caused by the inadequacies of existing technologies. They are instead a result of the extent to which we are willing to exploit, transform and manipulate nature in order to meet the ever expanding consumption levels and resource demands of over-developed and hyper-industrialized economies.

To suggest that any new production efficiencies and environmentally-beneficial applications made possible by nanotechnology will simply be translated into environmental ‘savings’ and a lessening of environmental impacts, is to assume that — after the introduction of a new technology — everything else essentially remains static and unchanged.

But new technologies do not only directly reshape nature and the material world, but also tend to shape and reconstitute the social structures and cultures of production and consumption. In particular, new technologies may facilitate the expansion of productive capabilities, changes in economic structures, and the creation of new types of commodity and material demands.

In the case of a new technological platform like nanotechnology, the ability to more precisely engineer living and non-living nature at the nano-atomic level offers an enhanced ability to reconstitute nature in order to meet the precise requirements of the dominant systems of production and consumption.

Nanomaterials and manufacturing processes may well introduce new efficiencies in the use of materials or energy consumption. But these very efficiencies *per unit of production* can also facilitate an overall *expansion* in the quantity and range of products manufactured. New production efficiencies often simply translate into cheaper materials and cheaper end-products. Improvements in the efficiency and endurance of batteries, for example, may simply enable the proliferation of a new range of portable electronic equipment.

Nanoparticles will be able to be manufactured from a wide range of materials, yielding new qualities from older materials, or finding new uses for previously unused or under-utilised natural resources. In this sense, natural resources may increasingly be encountered as *interchangeable* inputs for manufacturing systems. The new and improved properties of nanomaterials and other nano-structures will also enable the development of ever more novel products with new features and capabilities.

Nano-biotechnology will enable the integration of living and non-living materials, such that nano-bio modified organisms will be able to be constructed from a tool-box of interchangeable parts. The smallest units of nature — including cells and viruses — may be transformed into tiny production units — or *nano-factories* — for producing commercially useful materials.

Molecular manufacturing techniques for manufacturing products from the ground-up — atom-by-atom — may be developed precisely because they produce commodities more

quickly and efficiently than existing methods, and from a range of interchangeable raw materials, thereby accelerating and cheapening production processes.

In essence, nanotechnology represents the most powerful attempt to date to deconstruct the world into its most basic elements or units, and to then reconstruct them to meet our requirements. In contrast to the ‘green’ imagery promoted by the nanotech industry, this level of taking apart and reconstituting nature could be understood as one of the most radical interventions and even most violent assaults on nature to date.

In these various ways, nanotechnology opens up new avenues for the exploitation of the earth’s resources, as ever more parts of the earth become mere putty to be reconstructed and harnessed to the goals of commodity production. Rather than *decoupling* resource consumption from economic growth — or simply decoupling nature from the economy — nanotechnology represents the deepest *integration* of nature into the economy yet attained.

In terms of specific applications of nanotechnology, for every environmentally ‘beneficial’ application we could probably identify other more directly harmful or destructive environmental applications. For example, nanotechnology is already being used to develop a new range of military weapons, new forms of chemical pesticides, and new technologies to assist in the extraction and processing of fossil fuels and for producing nuclear power. While some nano-materials and nano-products may require less resources and energy for their manufacture, other nano-materials may be very energy intensive and polluting.

The fact that nanotechnologies, nano-materials and nano-products are likely to be patented and controlled primarily by large corporations — and given that nanotechnology is likely to facilitate the concentration of corporate control both within and across industrial sectors — also reinforces the likelihood that the nano-economy will be biased towards large-scale, globally-oriented, and corporately-controlled forms of production. It is these corporations that will determine what products are developed and commercialised, driven of course by commercial interests and the profit-motive rather than green principles *per se*.

In the absence of any challenges to the dominant political and economic structures, we can expect this power to reconstruct the natural world to primarily be used to feed the global economy’s insatiable appetite for resources and commodities.

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