Scientific constructions of nanobiotechnology

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Introduction

The aim of this paper is to describe how nanobiotechnology is being constructed and presented by the scientific community to the general public. Like all areas of science, nanobiotechnology is a construction founded on a particular scientific discourse. The burgeoning growth of nanotechnology has been likened to a new renaissance. As an anthropologist researching nanobiotechnology I am particularly interested in the kinds of promises and visions that this technology has enunciated. Moreover, I am interested in how nanobiotechnology is being constructed. What is being said about nanobiotechnology and how is it being said? These are important questions in ascertaining the nature of nanobiotech culture. Like other cultures the nanobiotech culture is composed of its own specific rituals, symbols and rules of membership, and defines what is sanctioned and proscribed. The philosopher Thomas Kuhn views science as a culture prone to transitory models and approaches, which supplant each other over time. The advent of nanotechnology and the converging technologies of biotechnology and information technology are foreseen to steer humanity into the future (Roco & Bainbridge, 2003). Roco & Bainbridge and others nvisage that these converging technologies will create a plethora of medical interventions and human enhancements, which will change our present notions of the body and medicine.

Like other areas of science and technology, nanobiotechnology is about problem solving; in this instance, how to improve and enhance human cognitive and other bodily functions in novel ways. This is not new. The forte of science has for centuries hinged on novelty and creativity. Science as a creative exercise has sought to improve humanity's knowledge of the physical world. However, only in the twentieth century did science and technology become a leading paradigm in changing human life. Empiricism became the yardstick in measuring the properties of life and its complex processes. Concomitantly, the neo-enlightenment onus on rationality became embedded in understanding the life sciences and in defending their linchpins—evolution and natural selection. The recent advent of nanotechnology and biotechnology have taken the life sciences to a new stage. Arguably, this stage enables our species to tinker with its own evolution. The promise of new medical interventions is a key area in which nanobiotechnology is presently engaging itself in, throughout the world. At the same

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time, there are a number of scientists who are trying to mitigate the visionary euphoria by posing the real problems of nanobiotechnology. This being the case, this paper will locate nanobiotechnology in two opposing areas: discourses of existential control and human mastery, and the problems of nanobiotechnological medical interventions facing scientists.

Nanobiotechnology as existential control and human mastery

An in-depth reading of nanobiotechnology publications reveals a particular discourse that is concerned with controlling matter. Words such as “control” and “manipulation” appear frequently in scientific explanations of nanobiotechnology. This is not surprising due to the particular kind of technology that nanobiotechnology professes to be. Collins suggests that the “absolute control of matter by nanomachines is a variant of the dream of *Homo sapiens* who seeks to achieve complete mastery over nature and with utter freedom to shape his own destiny” (2007:82). Feynman’s seminal lecture “There’s plenty of room at the bottom”, given in December 1959, set the stage for human mastery over the atomic and molecular world. Feynman’s original vision of subatomic and molecular manipulation was an extension of science’s “dominator paradigm”, which views nature as an object for human domination.

Controlling matter at sub-atomic and molecular levels is the kernel of nanotechnology. Scientists explain that nanotechnology is a kind of molecular engineering in which atoms are assembled like “Lego” blocks. The metaphor of Lego blocks works within the ambit of a scientific mechanism in which A fits into B in order to create C. Interestingly, there are nanotechnological websites that attempt to create graphic images of nano assemblers. One of my favourite websites portraying the “Lego model” of nanotechnology is e-drexler.com’s Nanotechnology: Molecular Manufacturing, and Productive Nanosystems (http://e-drexler.com/). Here the viewer is allowed to be privy to a nanofactory movie that shows the atomic creation of a nano-processing computer superior to any ordinary microchip laptop computer. The short movie shows a nano assembly plant at the 10 nanometre scale—at which it looks not too dissimilar from an ordinary assembly factory. We are taken through an assortment of conveyor belts, wheels, coloured schematic blocks, nuts, cogs, and mechanical arms, all of which assemble atoms and molecules in various production stages leading towards the finished object. The mechanistic oeuvre of the movie typifies the general manner in which scientific explanations of nanotechnology are conveyed to the public. The visual use of factories and assembly lines is apparently supposed to make lay viewers think of nanotechnology as something that is both controllable and familiar.

The notion of existential control and nanotechnology reaches its zenith in nanobiotechnology, in which science fiction and science fact are blurred. The protagonists of this movement include Eric Drexler, Ray Kurzweil, Mihail Roco, and William Sims Bainbridge. All four authors can be placed in the transhumanist school. Transhumanism is a visionary movement that states that the new technologies will be able to dramatically enhance and improve health, cognitive abilities and delay aging (Drexler, 1986; Preston, 2004). For Drexler, nanobiotechnologies even hold the keys to immortality. The promises of nanobiotechnologies will ultimately change the ways of being human; Drexler points out that human beings have for too long been slaves of evolution, and that the tables have now been turned in our favour to enable our own evolution to be directed in the ways that we want

(Drexler, 1986; Preston, 2004). Nick Bostrom, a well known transhumanist who heads the Future of Humanity at Oxford University, points out that "Transhumanists view human nature as a work-in-progress, a half-baked beginning that we can learn to remould in desirable ways. Current humanity need not be the endpoint of evolution. Transhumanists hope that by responsible use of science, technology, and other rational means, we shall eventually manage to become posthuman, beings with vastly greater capacities than present human beings have."[1]

The term 'transhumanism' was first adopted by Julian Huxley in 1957 (Tirosh-Samuelson, 2007). Some of the ideas of transhumanism were generated in the 1920s at a time when eugenics was still in vogue in Europe and North America. However, the roots of transhumanism may be traced to the 18th century Enlightenment period and its attempt to merge science and technology to improve the human condition (Tirosh-Samuelson, 2007). The teleological orientation of nanotechnology with its visions of a radically different high technology world as proffered by Drexler, Kurzweil and various scientists and engineers has proliferated in the popular book market (Schummer, 2006:219). However, it is this futuristic discourse of nanobiotechnology that has influenced the U.S. administration's outlook towards "shaping the world atom by atom".[2] Roco and Bainbridge's futuristic assertions of technological convergence are of this ilk, as illustrated in the following: "Technological convergence could become the framework for human convergence. The twenty-first century could end in world peace, universal prosperity, and evolution to a higher level of compassion and accomplishment" (Roco & Bainbridge, 2003:6; Ostrum et al., 2002). Roco & Bainbridge's anthology of nanobiotechnologies gives the reader some ideas of the direction of foreseeable medical interventions and therapies. These include:

1. "nano-bio-info-cogno-socio" convergence for improving human performance. These include addressing a host of presently incurable diseases, manufacturing new drugs and new therapies (Spohrer, 2003:103). New therapies include gene therapy and identifying allelic variants for "relevant drug-metabolizing enzymes and drug targets" (Bonadio, 2003:195; Evans & Relling, 1999).
2. Advancements in cognitive science and neuroscience, which will lead to the development of neural-perceptual enhancements such as neuroprosthetic devices (Nicolelis, 2003:251).
3. The merging of diagnoses and treatments such as nanoshells and nanodots, which will remarkably enhance monitoring and detecting of diseases in their early stages (Lee, 2003:255). Other diagnostic therapies include the reconnexion of biological cell pathways via coupling biomolecular units (i.e. DNA, antibodies, receptors, enzymes) with microelectromechanical systems (MEMS) (Lee, 2003:256). This rewiring will be constituted in "artificially controlled platforms", which will enable the possibility of preclinical tests without resorting to animal or human experiments (Lee, 2003:256).
4. Biofeedback mechanisms such as nanoscale biosensors, which will provide a broad range of the functional characteristics of an organism (Pope, 2003:261).

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[1] Nick Bostrom, "The Transhumanism FAQ: A General Introduction," available on www.nickbostrom.com.

[2] *Nanotechnology: Shaping the World Atom by Atom*; 1999, Washington, DC: National Science Technology Council.

5. Brain-machine interfaces via neurovascular approaches, using catheters guided to the brain via the vascular system (Llindis & Makarov, 2003:245).

6. The manufacture of nanobodies that simulate antibodies. Nano-antibodies would in theory combine with each other to create proteins that could target killer cells in a patient's immune system (Nicholls, 2007:53). The inspiration for nano-antibodies has been provided by the unusual immune system of camels.

7. State sensory gating and the use of a nano-tech helmet that could non-invasively monitor frontal lobe blood flow measurement in ascertaining hypofrontality (decreased blood flow to the cortex), which is an evident symptom in mental and neuro-degenerative disorders such as clinical depression, PTSD, schizophrenia and Alzheimer's disease (Garcia-Rill, 2003:231).

Taming the dragons

Diverging from Drexlerian visions of a nano-utopia, many scientists working in nanobiotechnology are finding out that manipulating matter at such a miniscule scale isn't easy. The reason for this is that at the nanoscale scientists are confronted by new kinds of forces and effects (Rourkes, 2002:26). Working at a sub-atomic level brings about various levels of indeterminacy, exemplified by Heisenberg's Uncertainty Principle. Atomic uncertainty is intrinsic to quantum mechanics. The cosmologist Paul Davies (2000) notes that atoms may become excited and unexcited at the same time—a hybrid state in which both possibilities co-exist. While Davies foresees that the ability to exploit atomic superpositions might lead to the creation of quantum computers, Rourkes points out that any understanding of the nanoscale must be founded on an in-depth understanding of the principles governing the mesoscale. Measuring quantum effects at the mesoscale will prove to be invaluable. Moreover, our present capacity to move atoms on prepared surfaces is a long way from the ability to build complex molecular assemblies (Rourkes, 2002:20).

Atkinson's critique of Drexler's notion of nano assemblers is worth noting. For Atkinson (2005), the Drexlerian nano assembler is a logistical nightmare rather than a scientific miracle. Drexlerian nanobots would have to be capable of myriads of functions and control a huge number of other nanobots in order to create something several millimetres across (Atkinson, 2005:256). In addition, Atkinson states that Drexler's vision is antithetical to nature's designing principles, which are based on modular units—cells. If we take into account Maturana's and Varela's idea of cellular autopoiesis (Maturana & Varela, 1987) (cells as self-organizing and open systems) how does Drexler's nanobot interact with such cellular automata? Does the interface between nano-organisms and living cells compromise the integrity of the latter? This remains unclear. Also ambiguous is how nanobiotechnological innovations will interact with the human mind, given that the brain is a highly specialized organ of impressive parallel processing capabilities, which "has evolved to carry out specific tasks" (Tirosh-Samuelson, 2007). For this reason, evolutionary psychologists such as Cosmides and Tooby object to germline genetic or other kinds of cognitive engineering that will alter "what defines a human personality… [(because it)] affects the control system of the body and alters complex, exquisitely well-designed mental mechanisms that have been engineered by the evolutionary process to solve problems of survival and reproduction" (Tirosh-Samuelson, 2007; Cosmides, 2007). While human intervention may produce smarter people we do not know whether there will be unintended consequences for tinkering with evolution (Tirosh-Samuelson, 2007). Along this line, Schummer (2006:228) gives the following caveat:

> Moreover, an improvement in one aspect could be at the expense of other aspects. For instance, improving physical health to the extent of prolonging life by nanobiotechnology could simply increase the rate of mental disorder through the dementia of life-prolonged patients; it could also undermine traditional strategies for social well-being, from social relationships between generations to systems of social insurance. Or, improving intellectual performance through nanotechnological devices could be at the expense of other mental capacities. Thus, what might be considered an improvement in one culture could in another raise concerns and be perceived as an ethical issue of nanotechnology, because of different underlying concepts of a good life.

On a similar note, Garcia-Rill asks us what kind of hybrid structures should be developed in relation to cognitive interventions? One area, as mentioned earlier, is neural prostheses to enhance sensory perceptions and memory. Of course these kinds of foreseeable implants require an extensive knowledge of cognitive architecture and processes—how is neural architecture constituted? According to Garcia-Rill, advances in brain science correlate with computational improvement. According to Moore's "law", computational hardware capability doubles every eighteen months, although such progress is not emulated in software development (Garcia-Rill, 2003:228). Similarly, while brain research has proffered insight into the brain's hardware, including neuronal inter-connectivity and synaptic interactions, more knowledge is needed about how the brain processes information. Garcia-Rill advises us that any future nanobiotechnological innovations concerning the brain's software should be developed around analogue computational software, since brain processes work in analogue mode (Garcia-Rill, 2003:228).

Conclusion

The field of nanobiotechnology is in its formative stage. Consequently, there are various medical, social and ethical issues that such technology will raise in the future, which are beyond the scope of this article to address. The field of nanobiotechnology is both complex and fraught with various engineering considerations. Over the next fifteen years nano-bio-cognitive and information technologies can be expected to converge, enabling significant improvements in medicine (Batterson & Pope, 2003:416). New understandings of biological feedback and neuroscience sensors will emerge, generating alternative understandings of the human body and its capacities. These technologies will work in tandem with computer-based bioinformatic and rehabilitation technologies. Improvements in computer processing, and perhaps the genesis of quantum computers, may expedite nanobiotechnology towards approaching the visions of Drexler, Kurzweil and other transhumanists. Again, from my social scientific viewpoint, a major concern with nanobiotechnology is its ideological foundation. Wolbring (2003) asserts that bio-gene-nanomedicine is posited on a western bio-medical discourse about perceived bodily disabilities, impairments and defects. In other words, its discourse views human physical disabilities in a negative way as departures from the "healthy" norm. Such medical constructions influence the general public's views of what is normal and abnormal. Wolbring rightfully calls attention to the difficulty of deciding who judges what is normal and what is defective, or the manner of conducting medical intervention (Wolbring, 2003:232). That science and technology, like other areas of human social activity, are not immune from bias may limit the beneficial potential of nanobiotechnology. For example, scientific trends and social dynamics tend to encourage scientists and engineers to gravitate towards specific parts of science and technology, to the detriment of other areas that are deemed to be less important. Such "scientific apathy" is characterized by the comparatively poor research attention given to finding affordable medical care and treatments for Chagas disease, viral encephalitis, trypanosomiasis, lymphatic filariasis, river blindness (onchocerciasis), elephantiasis and other tropical diseases, which affect more than eight hundred million people worldwide. Policymakers and producers of nanobiotechnology will have to implement a range of transformative strategies so that this unique technology will be able to be truly beneficially integrated into future societies.

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