Mythogenesis and Nanotechnology: Future Medical Directions

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Abstract

Nanotechnology promises an array of inventions and technological developments in the realm of medical science. Together with new bio-technologies, nanotechnology offers a formidable science of medical discovery. Atkinson ascribes nanotechnology to a nanocosm; a foreign world unlike anything the human mind can imagine, a finely structured cosmos or organised universe; a subworld with its own principles of organisation, ambiguous and wondrous. This paper provides some understanding of the future medical possibilities of nanotechnology.

Keywords: nanotechnology, nanocosm, medicine, future evolution

The realm of nanotechnology is in its pioneering stage, similar to what quantum science was in the 1920's and 1930's (Atkinson, 2005, p.34). Like our scientific discoveries of the atom, nuclear fission, DNA, space travel, and the human genome, science has extended human consciousness, enabling humans to ponder in new ways their relationship with the universe (Rainey, 1995, p.169). Science has provided the most potent mythos in the twentieth and twenty – first centuries, its dazzling technologies have evoked a sense of awe and confidence in human mastery over nature. Campbell suggests that science is entering the role of myth in breaking new grounds into understanding the mysteries of the universe (Rainey, 1995, p.188). He further states that science serves as myth by "instilling an awe and wonder of all existence" (Rainy, 1995, p.172). While still in its infancy nanotechnology is promising new technological developments. While Hall suggests that nanotechnology will not lead to psychic powers or antigravity automobiles it will make many things possible (2005, p.32). Future items may include transcontinental cars, food converted from sewerage, "all-senses virtual reality," permanent sharp knives, and spray on pants among other things (Hall, 2005, p.32). One of the key areas of future nanotechnology will be in medical interventions. Human biology will be a crucible of nanotechnology.

The discovery of the human genome and stem cell technology have prompted scientists to uncover the mysteries of the human body – cellular regeneration and the dynamics of brain and mind. The media has been a vociferous proponent of the new sciences, eagerly broadcasting their discoveries and progress. In addition, the hundreds of scientific medical journals and magazines are testament to the global fascination with human biology (Rainey, 1995, p.172). Overly succinctly illustrates science's hold on the human mind in terms of what I would call the 'holy grail syndrome.'

> *It is probably part of the human condition that cosmologists (or the shamans of any age) always think that they are knocking at eternity's door, that the final secret of the universe is in reach* (1991, p.27).

If there are any secrets to be uncovered, nanotechnology with its arsenal of atomic and molecular techniques may endeavour to do just that. At the same time nanotechnology will create new myths of human mastery which could rival ancient mythologies. For example, Ray Kurzweil (2000) contends that nanotechnology will drive a new age in which reality will be transformed. Kurzweil foresees that nanotechnology will tinker with human evolution to create enhanced human bodies and intelligence (2000, pp.140-141). In this way, nanotechnology may foster new possibilities and directions for human beings.

The purpose of this article is to provide some understanding of the future medical possibilities of nanotechnology. This is an area which shows much promise and deserves theoretical attention from futures practitioners. My own position as a futures practitioner concurs with Kurzweil et al that nanotechnology may spur an age of medical advances and life saving interventions. While I am optimistic of the benefits of medical nanotechnology, it will need to progress along with ethical and social values. My interest in medical nanotechnology stems from a concern with aging and diminishing abilities. Why do we age? What are the molecular and cellular processes of aging and can they be diminished or halted? Can our intellectual and sensory abilities be enhanced? These questions are particularly important since increased intellectual abilities may be needed in order to find solutions to global problems. On this note, the physicist Stephen Hawking claims that human beings will need to be smarter if they are to travel to the stars. Our present level of intellectual faculties are insufficient for traveling beyond Mars.

This article is intended for both futurists and the public. My use of technical language in parts of this article is intended to provide some insight into the complex nature of nanotechnology. Due to the impressive rate of nanotechnological work being currently undertaken, I can only provide an overview of nanotechnology. This paper locates nanotechnology in three areas: 1. nanotechnology as nanocosm, 2. nanotechnology and future medical technologies 3. nanotechnology and new understandings.

Nanotechnology as 'nanocosm'

Nanotechnology is a specific kind of technology which organises matter at an atomic and molecular level, or "at one atom at a time" (Kurzweil, 2000, p.137), below a tenth of a micron – 100 nanometers (Atkinson, 2005, p.31, or one thousandth the length of bacteria (Stix, 2002, p.6). The word 'nano' derives from the Greek word meaning 'dwarf.' Atkinson refers to the nano world as *"nanocosm"*, or one millionth of a millimetre (2005, p.3). The nanocosm is by any measure a foreign world unlike anything the human mind can imagine, a finely structured cosmos or organised universe; a subworld with its own principles of organisation, ambiguous and wondrous (Atkinson, 2005, p.3). Within the nanocosm matter acts as an autopoietic system, posited on self organisation and expressing unity (Atkinson, 2005, p.32). The nanocosm is a eutactic structure in which atoms and molecules are placed in prescribed places. Put in another way, the nanocosm will enable humans to further tinker with their own evolution.

The rudiments of nanoscience were expounded by the famous physicist and visionary Richard Feynman in December 1959. In his nascent lecture titled, "There's Plenty of Room at the Bottom," Feynman discussed how it was possible and practical to manipulate matter at a small size. His lecture anticipated atomic manipulation, fabrication, quantum-effect electronics and others (Roukes, 2002, p.19). Eric Drexler coined the word 'nanotechnology' while undertaking his doctorate at MIT in the 1980's. Drexler predicted molecular engineering and atom by atom nanoassemblers (Atkinson, 2005, p.6). In 1992, Drexler wrote his seminal work *Nanosystems: Molecular Machinery, Manufacturing, and Computation*, in which he expounded the direction of future nanotechnological innovation. Drexler's work caught the imagination of both scientists, companies and governments. Ironically, Feynman's and Drexler's theses did not generate much interest. In 1993, the first nanotechnology conference attracted little attention. In 1997, the fifth annual conference attracted 350 scientists (Kurzweil, 2000, p.138).

> *Growing recognition of nanotechnology came in the way of the National Nanotechnology Initiative (NNI), initiated by President Clinton which had $422 million funding by 2000, a 56% funding jump from the previous year* (Stix, 2002, p.7).

Worldwide nanotechnology research and development (R&D) investment has increased seven fold from 1997 to 2003. By 2004 the estimated funding in worldwide nanotechnology was $8.6 billion. The United States remains the largest country in terms of nanotechnological investment. In addition, the United States owns 64% of nanotechnology patents (Kanellos, 2004). The following table illustrates international nanotechnological funding levels.

Table 1

Public Sector Funding on Nanotechnology for the United States, Asia and Europe for 2003.

Public sector funding 2003	**Private sector funding 2003**
United States $1.6 billion	United States $1.7 billion
Asia $1.6 billion	Asia $1.4 billion
Europe $1.3 billion	Europe $650 million

Note: From "Nanotech funding to grow to $8.6 billion." By Michael Kanellos, 2004. Retrieved June 30, 2007, from http:// news.com.com/2100-1008_3-5310762/html

At least 30 countries are now working in nanoscientific fields (Rocco, 2001). Nanoscience has been incorporated in engineering, biological and physical sectors, estimated to exceed $1 trillion in 10-15 years, and utilising 2 million nanotechnology workers (Roco & Bainbridge, 2001).

Worldwide government funding for nanotechnology R&D (June, 2003). Rocco (2003).

Table 2

Worldwide Government Funding for Nanotechnology R&D (June, 2003)

Region	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004R**
W. Europe	126	151	179	200	~225	~400	~650	
Japan	120	135	157	245	~465	~720	~800	
USA	116	190	255	270	465	697	774	849
Other	70	83	96	110	~380	~550	~800	
Total (% of 1997)	**423** **100%**	**559** **129%**	**687** **159%**	**825** **191%**	**1,535** **355%**	**2,367** **543%**	**3,024** **700%**	

Note: From "Government Nanotechnology Funding: An International Outlook," by Mikhail C. Roco, 2003. Retrieved June 30, from http://www.nano.gov/html/res/IntlFundingRoco.htm

At present, there is a diversification of nanotechnological programs in different countries working on their own strengths. For example, Korea is working in the area of nanoelectronics memory chips, Australia in nanoscale photonics, and Russia and Ukraine in advanced materials synthesis and processing (Roco, 2003). There are wide scale international collaborative initiatives and interactions accelerating "in science, education and industrial R&D" (Rocco, 2003). Examples are the agreements are between NSF (US) and EC (EU), NSF (US) and Japan, APEC, Russia and China, the states of New York (US) and Quebec (Canada) (Rocco, 2003).

Mutual global strategies are now in force connecting international organisations, national governments, large and small industry, universities, and the scientific community (Rocco, 2003). The extent of global scientific interactions and funding in nanoscience testifies to its future promise.

However, accessing the secrets of the nanocosm will be more elusive than science would wish. The reason for this is due to its newness. Working at such an atomic level challenges our understandings of both physics and biology. In short, we need time to become adroit in understanding the organisational principles governing the nanocosm. Once its principles are better understood scientists can endeavour in advancing new technologies. Arguably, nowhere does the nanocosm hold so much anticipation than in the realm of medical science which will change our notion of the body and medical therapies.

Future Directions in Nanotechnology and Medicine

The 1966 movie called *Fantastic Voyage* applied the principles of nanotechnology. In the movie a team of medical specialists and their "high tech submarine" are shrunk to nano size and injected into the bloodstream of a noted leader (Alivisatos, 2002, p.56). Their mission is to enter the brain and remove a life threatening clot (Alivisatos, 2002, p.56). Their mission is hampered by menacing antibodies and the complexity of the biological landscape. Forty years on, the movie has presaged a novel medical intervention which may be available in the near future. The bio-technological nuance of the movie is synonymous with Foucault's notion of 'bio-technico-power' (Foucault, 1978); an augmented version of the human body by dint of "technologies and techniques" that "improve or prolong life" or increase "one's 'natural endowment' " (Jackson, 2005, p.120). However, not even Foucault could have imagined the extent of nanotechnological transformation to medicine. Here, I will outline nanotechnological medical interventions in five areas which may be available by the first half of the 21st century.

Diagnostic crystals

"Artificial magnetic crystals" in the form of nanoparticles could detect disease causing microorganisms. Such magnetic crystals mimic organic crystals which are used by bacterium as a compass (Alivisatos, 2002, p.58). These labeled particles would attach themselves to selected antibody molecules. Bound antibodies would then produce a detectable magnetic field. Therefore, this magnetic system would provide a more reliable approach in detecting foreign entities.

Nano imaging techniques

This technology is based on semiconductor nano crystals called quantum dots which would absorb light photons at various wavelengths. Quantum dots are selectively targeted to zones inside the body which would emit various colours, aiding in tracking cancerous cells at very early stages of potential tumours. Quantum dots will make it possible to tag various biological molecules, thus allowing for these molecules to be monitored at the same time (Alivisatos, 2002, p.62). Quantum dots could be used in selected organic beads which allow for numerous distinct labels; each of which could be attached to DNA molecular sequences. An investigator could ascertain the kinds of cellular tissue by reading the "spectral codes of the library DNA's that bind to sequences in the sample" (Alivisatos, 2002, p.63). Since the binding process is evident when genetic sequences complement each other, the results would disclose the "nature of the genetic material in the sample" (Alivisatos, 2002, p.63). This kind of imaging process is a poignant example of the medical potential of quantum dots and their ability to expose and detect DNA variations in the human genome. Apart from their ability to emit spectral bar codes quantum dots will increase medical knowledge in relation to understanding complex non-linear biological networks in the human body and for designing nano robots which could work in alignment with the autopoietic systems of the human body.

Respirocytes and microbovores

Respirocytes are artificial red blood cells about one cubic micron in volume, and consisting of a partition separating oxygen (O2) and carbon dioxide (CO2) (Hall, 2005, p.247). This cylindrical shaped nano robot would use O2 while pumping out CO2. The benefits of respiroctyes would be greater storage capacity of O2. Replacement of a quarter of red blood cells with respirocytes would increase the body's O2 capacity by 300% (Hall, 2005, p.247). Benefits of respirocytes would be in their ability to sustain people during physical trauma where greater reserves of O2 are needed. Secondly, increasing the ability for deep sea and rescue diving and eliminating the necessity of O2 tanks, due to respirocytes ability to provide O2 without breathing for up to an hour. Additionally, respirocytes would substantially diminish drowning accidents.

Similarly, nano robots called microbovores would act like white blood cells, patrolling, detecting and incapacitating pathogens. Microbovores could be programmed to detect specific pathogens such as influenza viruses, measles, malaria and other vector borne diseases and HIV infection. The advantage of injecting microbovores would be in augmenting cure rates of illnesses, thereby decreasing convalescence and morbidity and diminishing mortality of serous illness (Hall, 2005, p.247). An adjunct benefit would be in furthering medical science's knowledge of the auto immune and cellular systems.

Nano voyager

The nano voyager would be a high technological robot which would patrol, observe, analyse, detect, identify and collate molecular and cellular systems. The nano voyager would enhance our knowledge of the human body. Furthermore, nano voyagers could be programmed to specific bodily zones for more in depth analysis. Information gathered by the nano voyager would lead to the creation of new generation nano-bio-technological therapies and interventions. For example, neuronal nano voyagers would detail the enormous neuronal networks which will benefit medical understanding of cognitive processes. Kurzweil foresees that neural implant technologies will be universal in the second half of the twentieth century. Such technologies will be able to simulate virtual realities by providing direct sensory inputs into the brain (Kurzweil, 2000, p.144). These virtual worlds "would be highly realistic" and may either supplant or imbricate reality (Kurzweil, 2000, p.144).

Nanoshells

Nanoshells consist of a few million atoms, but are larger than DNA and proteins. They are made from small silica particles and are covered in gold since this element is biocompatible. Nanoshells capture light along the infrared spectrum which has various biological applications (Alivisatos, 2002, p.67).

Firstly, Nanoshells would possess high surface area which could effectively transport vital drug molecules to specific parts of the body (Alivisatos, 2002, p.68).

Secondly, nanoshells could in the near future be used in cancer treatment. Once injected into the bloodstream nanoshells would be taken up by the tumour site. Tumours create many defective blood vessels. However, nanoshells could enter and accumulate within these vessels. Once at the tumour site nanoshells would absorb light and convert it to heat destroying the cancer cells (Alivisatos, 2002, p.68).

Naomi Halas from Rice University invented this technique in the 1990's. In a test conducted in 2003, mice with tumours were injected with nanoshells. Within ten days there was complete remission of tumours with 100% survivability (Nova Science Now, 2005). The use of nanoshells are unlike conventional cancer treatments as they would be non toxic and would not effect adjacent healthy tissue (Nova Science Now, 2005). It is hoped that in the future nanoshells could be tailor made for different wave lengths of the light spectrum (Nova Science Now, 2005).

Conclusion: Nanotechnology and Evolutionary Algorithms

The fields in which present day nano-biotechnological scientists work in will shape future understandings of nanotechnlogical and the human body. The unique properties of the nanocosm which I have outlined need more time and research in order to comprehend its quantum principles. Roukes contends that in order to understand the principles governing atoms and molecules we need to be well versed in the principles governing the mesoscale (2002, p.19). The mesoscale is apparently a more familiar environment to explore atomic and molecular systems (Roukes, 2002, p.22). Future evolutionary algorithms will need to possess a knowledge of the nature of nanoscale interactivity with human cells. Molecular engineering will also have to open to complex cellular networks and their autopoietic organisation.

Drexler notes that in the future it will be important that critiques of nanotechnology are well founded due to their impact on human societies (Drexler, 2002, p.107). Saying this, we need to caution against the headiness of some futurists such as Kurzweil who confidently states that nanotechnology will make the body more versatile and durable (2000, p.140). Furthermore, he goes on to say that redesigning the human body by nanotechnology will offer future humans protection against nano pathogens (Kurzweil, 2000, p.140). Such aspirations do not take into consideration how psychological aspects in humans will adapt to nano engineered bodies or the kinds of societies which will have to be re-engineered in order to accommodate for nano designed humans. Futurists remain silent on these points. I would suggest the invention of evolutionary algorithms which take into account biologico-social aspects of human beings. Such algorithms would take into account the level of synergy interaction between biological, synthetic and social systems. For example, while nan-

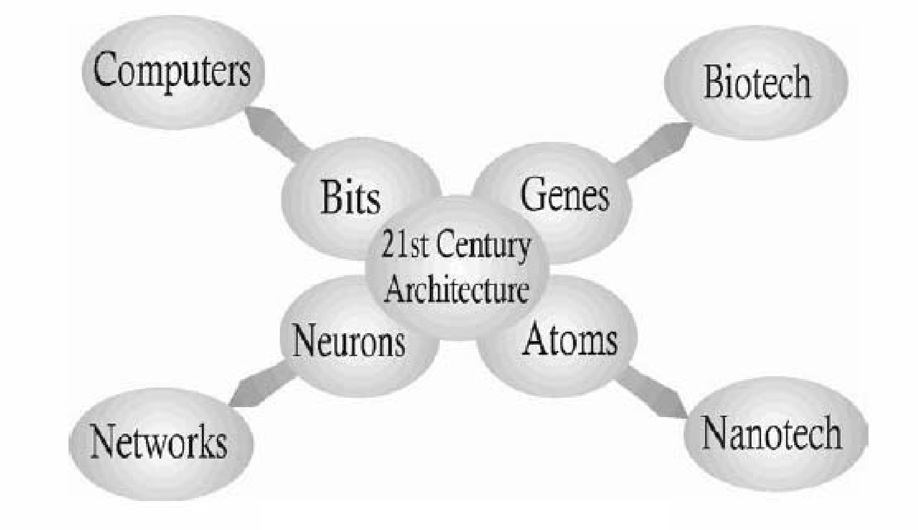

Figure 1. 21st Century Architecture

Source: Mikhail Roco, C. & W.S. Bainbridge. (Eds.). 2002. (p. 62).

otechnology may be able to take materiality to its extreme miniscule size, it is biology that will provide the paradigms for engineering nano-biotechnico hardware (Roco & Bainbridge, 2002, p.7). Furthermore, over time it is society that will inform the direction of this hardware, how it will be used and for whom?

The above diagram shows the synergy between various technologies and elements which conjoins nanotechnology, biotechnology and information technology. These three areas will probably stand at the vanguard of science in the 21st century. This new mythic age of human enhancement "via the deployment of convergent technologies requires new work to focus on the synergy of independent arenas of science" (Roco & Bainbridge, 2002, p.86). A co-ordinated and strategic approach will be necessary to create effective and beneficial medical technologies.

Another area which nano futurists have not delved into is divergent cultural notions of body constructions as found in Asian and other non-western medical traditions. How will nano-engineered bodies be understood or appropriated in Chinese or Indian medical systems which privilege the organicity of the body and its relationship with the environment? Would a nano body be viewed as a conduit of *'qi'* or *'prana'* in the same way as an organic body? Would such bodies follow a similar diagnosis and prognosis?

On a similar point will be the psychological impact of nano-biotech bodies. For example, paleo-anthropological records show that the human brain was well developed thousands of years before the advent of art and other kinds of intense abstract thought. This suggests "that the human mind was not merely the result of brain evolution but also required substantial evolution in culture and personality" (Roco & Bainbridge, 2002, p.112). The point here is that development of nano-biotechnological bodies must work on par with human personality and cultural evolution and our culturally programmed inheritance. At the same time, evidence indicates that "brains come prewired at the neural level for many more possibilities that actually get used" (Roco & Bainbridge, 2002, p.111). This may mean that human psychology may possess the appropriate cognitive tools to adapt to rapid nano-biotechnologies. Essentially nanotechnology and biotechnology are about the post-human or "techno-body" (Halberstam & Livingston, 1995, p.73). With the parameters crossed the human body may be replaced by a "mytho-body", a product of the post-human age (Fukuyama, 2002). Nanotech combined with biotech may further collapse the boundaries between human and mechanical so that we become cyborg entities (Ostry, 2004, p.224; Harraway, 1991).

Thacker discusses how human biology may be considered as a technology, a handiwork of evolutionary forces and natural selection (2003, p.48). The minifying of the human body to its molecular constituents brings us to Levi-Strauss' notion of miniaturisation as a way of investing existential control (Levi-Strauss, 1972). The miniature is easy to shape and is governable to the human will, thus, giving the individual a sense of control over it. Similarly, nanotechnology may be viewed along these lines of imbuing scientists with notions of control and dominance over nature. Caution must be taken here. With new knowledge comes new possibilities for either growth or entropy. The ancient myths speak of bifurcation periods as either times of crisis or illumination. For example, the Greek myth of Pandora's box or the myth of Eden foreground the advent of new knowledge which supplants the old world, from innocence to self knowledge and understanding of human limitations. Nanotechnology not only heralds new possibilities of human inventiveness but may be beneficial to our future evolution.

Glossary

Auto immune: Pertaining to auto immunity and the auto immune system which protects and fights against pathogens.

Autopoietic: Relating to the condition of autopoiesis (literally, "self-making") which views open systems as being self organising and able to communicate with other living systems.

Bifurcation: Relating to dividing into two parts. According to Ervin Laszlo during bifurcation periods a society can either progress or regress.

Biocompatible: The quality of being biologically compatible by not producing a toxic, injurious, or immunological response in living tissue.
http://www.reference.com/search?q=biocompatible&db=web

Cyborg: A living organism which is a composite of living tissue and electronic or mechanical devices.

Entropy: In thermodynamics, entropy is the measure of the state of disorder and chaos in physical systems.

Eutactic: Literally, "well ordered." Pertaining to a "molecular machine system" where atoms and molecules are moved to prescribed places or paths (Atkinson, 2005, p.318).

Evolutionary algorithms: "Computer based problem solving systems" that derive their design from evolutionary mechanisms (Kurzweil, 2000, p.302).
Genome: An organism's heredity information which is encoded in DNA.

Mesoscale: Pertaining to meteorological activity and processes which can be observed and measured.

Nano robot: Robot built by nanotechnology which has self replicating properties and which can manipulate its environment (Kurzweil, 2000, p.307).
Nanoassemblers: Nano robots used in assembling atoms and molecules in engineering and manufacturing products.

Nanotechnology: Refers to a body of technology which manipulates atoms and molecules at a *nano* (Greek: literally, "dwarf") scale or one billionth of a meter.

Neuronal: Pertaining to the neural system in the brain.

Organicity: Relating to or deriving from living organisms.

Photonics: The technology of light detection (photons), their transmission and control. Electronic magnetic energy is constituted on photons.

Post-human: Relating to future humanity which will be modified and enhanced using biotechnology and nanotechnology.

Quantum dots: Nano crystals used for various medical and non-medical uses.

Quantum mechanics: A theory of understanding how subatomic particles in matter and light work and its causal effects.

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