



CRN Task Force essays: a European commentary

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The foregoing essays raise serious issues concerning the future possible impact of nanotechnology on society. There is a tacit assumption that in 30 to 40 years time, or possibly sooner, nanotechnology will have given rise to affordable machines that will both dramatically advance our understanding of the natural world and be such that many of the repetitive functions necessary for humans to survive will be conducted by robots. The use of the word 'nanotechnology' here includes significant advances in software programming and the advent of true artificial intelligence. A prominent feature lurking in the background of all the essays is the certainty of existence of these affordable machines operating at the nanoscale, but themselves somewhat larger, as both domestic aids and as potential weapons. Putting nanomachines and artificial intelligence together gives robots for repetitive chores, nanofabricators to produce clothes and food, and microscale machines capable of battlefield surveillance or even delivery systems for single molecules of nerve agents (c.f. I. M. Banks¹).

These latter applications, as first expounded by Drexler, give rise to the doomsday scenario where new weapons of war and mass surveillance, as envisaged in Orwell's *1984*, become a reality. In order for civilized society to be able to handle such possibilities a number of questions are rightly addressed:

- Do we want a society modelled on a Big Brother state where every individual may be tracked and monitored through nano-surveillance machines?
- Do we want a society where lethal weapons are even more difficult to control and detect given the rise of global terrorism?

A negative answer to these two questions then raises further questions: Should nanotechnology be controlled? Should the information be freely available on say the internet, or should access be restricted by the state? If by the state, who controls it and how, and what is the response if information is leaked? History is replete with examples of states that have coveted information in the name of protecting the public, but have themselves been run by our

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¹ Iain M. Banks, "Use of Weapons", London: Orbit (1992). Iain M. Banks, "Excession", London: Orbit (1997) (the work of a science fiction writer describing advanced societies coping with AI, force field weapons and alien civilizations).

most notorious tyrants and despots. Can a state, in attempting to protect the public for its own good, remain a democracy?

If nanotechnology is to be open, how will the capitalist societies feed the basic research if no fortunes can be made on the back of the technology? How should intellectual property be handled to ensure economic growth but yet prevent technological monopolies which might lead to a totalitarian state?—the globalization problem.

The preceding essays address all these very valid questions with arguments both for and against some proposed solutions. However, one might be forgiven for thinking that this discussion is perhaps a little premature. The envisaged technology capability might not happen at all and will certainly not happen for probably two decades. A recent survey of European scientists' views of when some of the nanobiotechnology predictions might come to fruition² concluded that nanomachines for the human health application were probably 25 years away and that their benefit might be questionable.

Be that as it may, the Center for Responsible Nanotechnology (CRN) essays certainly raise the profile of the issues and this is very laudable. Most politicians and governments have problems looking one week ahead let alone 25 years, so that the chances of a real debate in the corridors of power is unlikely at this stage. More pressing for such people and bodies is likely to be their short-term future in terms of re-election, at least in the democratic states, and in the slightly longer term, the cost of energy and environmental issues. In the US, even President Bush has at last raised the latter as a major issue.³

It is worth examining the driving force behind the nanotechnology explosion in order to understand whether or not this technology will actually yield the capabilities predicted in the doomsday scenario. The most obvious example is in the electronics industry and the exponential increase in capacity of both microprocessor memory and processing power over the last 40 years. The Moore's law growth rate of doubling capacity every 18 months has become an axiom for companies like IBM and will probably hold true for at least the next decade. But what is actually driving this growth rate? In the 1960s and 1970s, the electronics industry was driven by funding from the US and European defence departments in their race for technological supremacy over the Soviet Union. However by comparison to today's commercial funding for electronics growth, this funding was but a drop in the ocean.

Western governments no longer control the electronics industry through their purchasing power. It is now driven by consumers who desire better personal processors, high fidelity video games and mobile telephones with internet access. It was the perception of the size of these desires by private companies that fuelled the 'dot-com' bubble and collapse of the equity markets in 2000. They now appear to have recovered, and 3G phones are on the market, albeit four years late, but one might ask whether this rate of technological advance will be sustained. Certainly more bandwidth is required for full real-time video, but having achieved that, what next? Will there still be a commercial impetus and the potential market to sustain and fund the research that underpins the Moore's law extrapolation?

The other major force that could drive the continued nanotechnology explosion is that of health. This is another huge market easily the equal in size of that of mobile phones, and

² "The future of nanobiotechnology", *Nanotechnology Perceptions*, in press (2006).

³ US President George W. Bush, State of the Union Address 29 January 2003.

increasingly with a growing customer base as people live longer. Recent advances in diagnosis and surgery using microtechnology and some nanotechnology, together with self-monitoring drug delivery systems, are already becoming available to the public. There is certainly a demand for better health care in terms of prevention of disease, diagnosis and remedial action through drugs, prosthetics or surgery. However, would most people be happy with the science-fiction scenario of nanomachines, the size of a grain of sand, wandering through one's arteries and veins repairing damaged cells and eradicating diseases as they went? Without the benefit of such a device being demonstrated as effective and safe, it is doubtful that funding would be made available by a commercially motivated company for some considerable time.

Western democracies such as the US and Europe no longer have the power through their governments to dictate the pace of technological progress. Commercialism driven by a huge consumer need has brought about both the exponential increase in capability and the corresponding linear decrease in the cost of modern electronics. It is this cost reduction that will be necessary for nanomachines to become a reality. For example, a recent attempt in the UK⁴ to build an integrated sensor with processor and energy source capable of communicating by short-range wireless to an analysis and control centre was not very successful. Such a device might be seen as a precursor to some of the nanomachines envisaged by Drexler, but using the latest off-the-shelf components, the smallest device was still only the size of a two pound coin.⁵ The latest electronic fabrication techniques could have reduced this to the size of a few millimetres but the cost would have been prohibitive, as the manufacturer required a market volume in excess of one million devices in order to recover some of its development costs. Perhaps the only way to sustain across-the-board progress in nanotechnology is thus in the less democratic commercially-driven states such as China, where government centralisation could still force the pace.

Returning to the political issues raised by the CRN essays, it is interesting to note that there is a tendency to favour a totally open approach to the promotion of nanotechnology and to rely upon a free press to expose any abuses. This seems to be in contrast to the US view of Iran and Iran's desire to generate cheap electricity from nuclear fission. That fission bomb technology is then only a small step away from a controlled reaction is an unfortunate consequence of having technology that is openly available. It is hypocrisy by the US to imagine that less favoured states should suddenly force themselves to become Luddite in their attitude while others, which enjoy warmer relations with the US, such as Israel, Pakistan and India, should not.

Will nanomachines become a reality? Apart from the questionable impetus from market forces, there is also the issue of how they will be powered. The domestic nanomachines capable of fabricating food and clothes envisaged by Freitas⁶ are powered by electricity and propane. How is the required electricity and propane to be produced in a world that is rapidly consuming all its hydrocarbon fossil fuels and engendering a major impact upon the environmental ecosystem in the process?

It is naïve to consider the development of nanomachines in isolation; unless the materials they use and the energy to power them are also cheaply available, then they are unlikely to

⁴ Steve Edwards, Whistonbrook Technologies, http://www.swig.org.uk/fdetail_19.htm.

⁵ About 25 mm in diameter.

⁶ R.A. Freitas Jr, "Economic Impact of the Personal Nanofactory", *Nanotechnology Perceptions* 2 (May 2006).

become a reality. In the Western democracies the quest for cheaper and greener energy sources is not driven by commercialization but by governments responding to public concerns. In this area governments can have real power in terms of legislation, which by prohibiting or restricting the use of fossil fuels by means of crippling taxation will force commercial institutions to seek alternative energy sources in order to remain competitive. Unfortunately, such policies will tend to result in the government not being re-elected unless the resulting tax revenue is used for something that the public desires as much as cheap transport and goods. The US at last seems to be contemplating such a policy, not so much from an environmental concern, but more to remove its economic dependence upon some of the Arab states. In Europe, a nascent form of this policy has been in place for some time, as evidenced by the high tax on petrol in comparison to the US, but it will need to be higher still to really force the pace of improving energy efficiency, carbon emission reduction and alternative energy sources. Has nanotechnology something to offer here? That is perhaps the more pertinent question.