Molecular Manufacturing and the Developing World: Looking to Nanotechnology for Answers

Don Maclurcan*

Institute for Nanoscale Technology, University of Technology, Sydney, Australia

Despite limited literature discussing the global implications of molecular manufacturing (MM), the seeds for certain key debates are starting to be sown. They essentially mirror those presented for current and near-term nanotechnology:[1] for what purposes will the technology be developed and used, by whom will it be created and owned, what is the nature of the risks it will bring, and what kind of impact will it have upon the global economy and developing world?

The realisation of MM's central goals[2] would undoubtedly lead to the most concentrated technological tsunami ever witnessed. The unpredictable nature of such a revolution makes answering the previous questions all the more difficult. However, just as biotechnology is commonly used as a yardstick for nanotechnology evaluations (given the continuity of many social concerns and the relationship between existing biotechnology capabilities and the potential to develop nanotechnology[3]), I argue here that the best way to set up the MM debate, in terms of its impact on developing countries, may be to look at developments and trends in nanotechnology. Central to such analysis is addressing the ways in which nanotechnology creates new possibilities for developing countries in terms of access to technology, potential benefits, risks, and shifting views of science and technology, as well as the imposing of new demands in terms of infrastructure and approaches to science.

While many of the issues MM faces may be similar to those presently developing with nanotechnology, MM offers a revolution of a starkly different magnitude. However, MM still faces an 'identity crisis' in the developed world, and an 'identity absence' in the developing world. This has been further hampered by authors and academics who, in writing articles and papers concerning nanotechnology's impact upon the developing world, mix the two terms and

* E-mail: donald.maclurcan@uts.edu.au.

[1] Hereafter referred to as 'nanotechnology'.

[2] The development of a 'nanofactory' and the resultant capability of "efficient, low-cost production of high quality goods" [see Ref. 7 infra].

[3] South African Nanotechnology Initiative, "National Nanotechnology Strategy: Nanowonders—Endless Possibilities, Volume 1, Draft 1.5", South African Nanotechnology Initiative and the Department of Science and Technology, Pretoria, 2003.

Nanotechnology Perceptions **2** (2006) 137–141
Received 24 April 2006

confuse references to the relevant potential impacts.[4] Coupled with hype surrounding 'grey goo', a poor foundation has evolved for international discussions in which to include MM. There need to be consistent efforts by those writing in the area to distinguish the kind of nanotechnology to which they are referring.

However, while the scope of potential impact differs greatly between nanotechnology and MM, history suggests there will be universal patterns in terms of its distribution. Whether MM is developed to either a limited or a full capacity, it is more than likely the majority of the world will never reap its benefits and perhaps even fewer will know or understand its potential.

The location of MM's initial development will play a key role in the resolution of suggestions that MM will increase global corporate control,[5] eradicate natural resource markets to the detriment of developing countries[5,6] or reduce global inequalities and allow countries to 'leap-frog' the industrial revolution.[7] Some suggest that industrialized countries are more fertile ground for its development,[8] while others believe China and India are in a more likely position than the United States of America and European Union to be the initial producers.[9,10] However, as McCarthy notes, "just possessing the technology does not mean that a given state will be able to use it to full advantage".[8] Countries will require an ability to integrate and respond to MM in order to exploit its potential.

In more recent times, debates have extended to consider MM's initial development by both small and big research groups, within private and public spheres, by structured and unstructured research groups, as well as by 'rogue' and 'peaceful' nations.

Assessing nanotechnology, we notice an increasing 'nano-divide' in terms of national research levels and funding, as much amongst the developing countries themselves as between the developed and the developing world.[11] This highlights the limitations of discussing the developing world as if it were a homogeneous grouping. Emerging technology affects regions, countries, populations and communities in vastly disparate ways. Already, 62 countries are engaging with nanotechnology on a national level. Nineteen of them are classified as 'developing' but none of these are from the group of countries classified as 'least developed'. However, via nanotechnology we may be witness to a new form of inexpensive access to niche R&D markets, as demonstrated by development of national nanotechnology programs in countries such as Costa Rica.

Furthermore, when spending is adjusted for purchasing-power parity, Chinese government

---

[4] Maclurcan D. C., 2005, "Nanotechnology and Developing Countries: Part 1 - What Possibilities". Accessed on: October 30, 2005. Available: http://www.azonano.com/Details.asp?ArticleID=1428.

[5] ETC Group, "The Big Down: From Genomes To Atoms", ETC Group, Winnipeg, 2003.

[6] Cascio J., 2005, "WorldChanging Nanotechnology". Accessed on: September 30, 2005. Available: http://www.worldchanging.com/archives/003445.html.

[7] Drexler K. E., Peterson C. and Pergamit G., *Unbounding the Future, The Nanotechnology Revolution,* William Morrow and Company, Inc., New York, 1991.

[8] McCarthy T., 2004, "Molecular Nanotechnology and the World System". Available: http://www.mccarthy.cx/WorldSystem/intro.htm.

[9] Based on economic, education, research focus and political support data.

[10] Treder M. (Private Communication).

[11] Maclurcan D. C., 2005, "Nanotechnology and Developing Countries: Part 2 - What Realities". Accessed on: October 30, 2005. Available: http://www.azonano.com/Details.asp?ArticleID=1429.

nanotechnology funding ranks second, internationally, behind the United States of America.[12] Nonetheless, funding (on an absolute basis) remains heavily focused towards programs in industrialized countries of the European Union, the United States of America and Japan.

It appears that smaller national programs will require clear, specific strategic roadmaps that target niche research and consider significant international collaboration if they wish to be part of the 'nanotechnology revolution'.

Initial applications in nanotechnology, such as in cosmetics, sporting apparatus and clothing, have exposed early indicators as to the nature of research orientation. Increasing levels of private sector patent concentration within the developed world,[13] promoting 'broadbrush' patents, have added to developing country concerns. By the time MM arrives, corporate control in areas such as the life sciences will be so strong and patents and other forms of technological control[14] so all-encompassing, that the ability to replicate a multi-functional theranostic kit cheaply and rapidly may have little or no bearing on its ability to reach those in greatest need.

Some have suggested that 'economic abundance' resulting from the realisation of MM will negate such a trend. MacGillivray disagrees, believing that with MM "the economics of production will change... human nature won't".[15] History also disagrees. While economic theory is based on scarcity, the current world *is* already one of abundance. We 'solved' the 'production issue' long ago. Given the world's current population, we do not need greater production to feed such a number. Rather, we require more equitable distribution of resources, reductions in consumption and the recognition that true 'equality' (at Western standards of living) is not sustainable. As the 2002 United Nations' Human Development report notes, if the per capita energy consumption of developing countries were to rise to even half of that of the advanced industrial economies, the energy reserves of this finite planet soon would be exhausted.[16]

Despite the orientation of early applications, a number of groups remain hopeful that nanotechnology can be 'appropriate' and used to fulfil the Millennium Development Goals.[17-19] Similarly, 'nanofactories' have been touted as 'appropriate technology' on the basis of their potential to reduce skilled labour and supporting infrastructure requirements.[20] However, it

[12] Lux Research, "Ranking the Nations: Nanotech's Shifting Global Leaders", Lux Research Inc., New York, 2005.

[13] Shand H., "New Enclosures: Why Civil Societies and Governments Need to Look Beyond Life Patenting", The New Centennial Review, 3 (2), pp. 187-204, 2003.

[14] See Shand's comments on terminator technologies [Ref. 13 supra].

[15] Regis E., *Nano: the Emerging Science of Nanotechnology: Remaking the World—Molecule by Molecule,* Little Brown, Boston, 1st Edn,1995.

[16] UNDP, *Human Development Report: Deepening Democracy in a Fragmented World,* Oxford University Press, New York, 2002.

[17] Court E., Daar A. S., Martin E., Acharya T. and Singer P. A., 2004, "Will Prince Charles et al. Diminish the Opportunities of Developing Countries in Nanotechnology?" Accessed on: February 20, 2004. Available: http://www.nanotechweb.org/articles/society/3/1/1/1.

[18] Barker T. et al., 2005, "Nanotechnology and the Poor: Opportunities and Risks". Accessed on: January 26, 2005. Available: http://nanotech.dialoguebydesign.net/rp/NanoandPoor2.pdf.

[19] UNCTAD, 2004, "Interactive Dialogue on Harnessing Emerging Technologies to Meet the Millennium Development Goals". Accessed on: September 3, 2004. Available: http://stdev.unctad.org/unsystem/emerging.htm.

[20] Center for Responsible Nanotechnology, 2002, "Benefits of Molecular Manufacturing". Accessed on: October 20, 2003. Available: http://www.crnano.org/benefits.htm.

depends whether a nanofactory would reduce skilled or basic labour. If the latter, then it fails Schumacher's criteria for an appropriate technology.[21]

Furthermore, assessments of appropriateness must include assessments of risk. As with nanotechnology, suggestions have been made that MM could promote world peace,[11] while others have cautioned that it may, initially, prove quite dangerous.[22] Consistently, reports are finding that research into nanotechnology risk is inadequate and under-funded. With MM offering less chance to both predict and react to issues of risk, the key must be to focus on global capacity building in areas of risk assessment and risk management.

The problem with developed country discussions of nanotechnology for the developing world is that they often don't progress beyond the identification of so-called 'appropriate' applications. Very few people have even arrived at an acceptance that there *are* 'appropriate applications', full stop. MM continues to struggle for mainstream acceptance and it is, perhaps, more likely that its fruition will come via a gradual extension of nanoscale capabilities, rather than an immediate jump to MM.

In terms of capacity requirements, nanotechnology is changing both the way science is conducted within research teams and promoted to the public. As we move to a scale unable to be viewed by a standard microscope, and less likely to be comprehended, environmental and human health risk become increasingly important issues with which to engage the public. Early commentators have suggested that nanotechnology will reinforce the lessons from the GM-debate: that public participation is crucial to acceptance but 'engineering consent' is not a sustainable means for widespread acceptance and development. In my experience with researchers in Thailand, India and Australia there is a strong recognition that capacity development in nanotechnology must incorporate ethicists and legal experts in terms of analysing national regulatory frameworks, maximizing competitive advantage and contributing to public dialogue.

Finally, nanotechnology is demanding and creating a more interdisciplinary view of science at the research level. Since MM will most probably enter in a climate shaped by nanotechnology's legacy in these areas, it is important that such considerations extend to MM debates.

All these considerations lead me to make two suggestions.

The first suggestion is that we work towards a *truly* international nanotechnology conference some time around 2010. Such a conference would ideally occur within the United Nations framework and involve official country representatives. It would be of great benefit to the conference, in terms of productivity, if countries submitted 'white papers' prior to the commencement of the proceedings, outlining national capacities, strategies and proposed niche markets in nanotechnology. Such a meeting could also incorporate discussion on the proposed International Convention for the Evaluation of New Technologies[23] and gauge reception of, and progress towards, MM. The Global Nanotechnology Network[24] as well as the Asia Nano Forum[25]

[21] Schumacher E. F., *Small is Beautiful: a Study of Economics as if People Mattered*, Blond & Briggs, London, 1973.
[22] Center for Responsible Nanotechnology, "By Whom?" C-R-Newsletter, no. 19, 2004 (http://crnano.typepad.com/crnblog/2004/05/by_whom.html).
[23] Suggested by researchers from the Action Group on Erosion, Technology and Change and University of Toronto Joint Centre for Bioethics.
[24] More at: www.globalnanotechnologynetwork.org.
[25] More at: http://www.asia-nano.org/index.php.

provide good examples and existing infrastructure for any efforts to develop international cooperation and consensus.

The second suggestion is that, replicating a method such as the United Kingdom's Royal Academy of Engineering 'upstreaming' approach,[26] civil society groups should seek to increase nanotechnology and MM exposure at international grassroots events such as the World Social Forum. Such efforts hopefully would pave the way for greater developing country engagement in academic writing and scholarship pertaining to these areas.

Despite significant differences in the potential capabilities of nanotechnology and MM, nanotechnology may offer the greatest insights and means by which to influence the future impact of MM with respect to the developing world. Initially, a clear distinction must be made between nanotechnology and MM. Current nanotechnology indicators point towards increasing concern for the developing world in terms of barriers to technology access, inadequate research into environmental and human health risks, and significant demands in terms of the capacity to respond to and develop nanotechnology. Any study of MM and its potential impacts upon the developing world will gain from an appreciation of the relevant context and developments surrounding nanotechnology.

About the author:

Don Maclurcan is a PhD candidate with the Institute for Nanoscale Technology at the University of Technology, Sydney, Australia. His research investigates the extent to which nanotechnology creates new possibilities or imposes new demands for developing countries.

[26] See The Royal Society and Royal Academy of Engineering's 2004 report titled, "Nanoscience and Nanotechnologies: Opportunities and Uncertainties" for greater explanation.