NANOTECHNOLOGY AND THE HOPE FOR A MORE EQUITABLE WORLD: A MIXED METHODS STUDY

by

Donald C. Maclurcan

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CERTIFICATE OF AUTHORSHIP AND ORIGINALITY

I certify that the work in this dissertation has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

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Signature of Student

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"Anyone who believes exponential growth

can go on forever in a finite world

is either a madman or an economist"

Kenneth Boulding

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PREFACE

This journey began with an upturned brochure in a park. I found it walking home one afternoon, spread open to a page about undergraduate courses in nanotechnology - an area 'set to revolutionise industrial processes' - offered at the University of Technology, Sydney. It was at this university that I was finishing a degree in Human Movement Studies. Whilst the brochure's content made for an interesting read, I remained disinterested in studying science and, once binned, I moved on. Two weeks later, at the end of another fruitless meeting with the University's careers advisor, I casually asked if they knew anything about nanotechnology. "No, but I think there are people on level 16 doing that stuff", came the reply. Sure enough, I easily found the newly formed 'Institute for Nanoscale Technology' and, upon entering, was greeted by the Associate Director, Mike Ford. I deferentially explained that my background was not in science and that I was merely looking for more information, given my surprise at finding a brochure about the Institute in a park ten kilometres away. I had been in the room less than five minutes when Dr Ford proposed that, given the Institute was looking to 'branch out', I write a dissertation looking at nanotechnology's social implications. I sat stunned. Mike and I had never met, I had little idea what a research degree entailed and I still did not have a clue as to what nanotechnology was, let alone the nature of its social implications! Revisiting the basic research proposal I submitted a week later still brings me a laugh, but the novelty of having an 'outsider' in a scientific institute must have blinded everyone to my lack of research experience because, three months later and not yet 21, I sat down in an office vacated by a visiting professor and started to think about nanotechnology.

At this time, I was particularly interested in deepening my academic knowledge of how the world worked so that, one day, I could take my place as a respected leader, addressing global audiences about necessary reforms and how we all must change… As part of my thirst for knowledge, I had been working with The Fred Hollows Foundation, a non-governmental organization whose work in reducing avoidable blindness in the global South had pioneered new technologies and approaches to capacity building. I thus leapt forward with my research, having decided to explore nanotechnology's potential implications for the South.

Through the PhD journey, I have been able to look, in a broad, exploratory manner, at a largely uncharted area that remains surprisingly understudied. Of real privilege has been the chance to ride at 'the boundaries', engaging with the very different approaches of a sociologist and a physicist as my supervisors. Working across faculties, whilst exploring the interdisciplinary field of nanotechnology, has only added to the excitement. Furthermore, the chance to publish a good deal of my work has led to engagement in a number of regional and international policy meetings, deeply enriching the PhD process.

What I have learnt through this experience is the value of 'process' and re-formulating thought. My lengthy candidature has been constantly filled with a reflexive building of knowledge, across a very broad base. Similarly, as my understanding and critique of development has deepened, it has became clearer to me that nanotechnology is, at its sociological best, a medium to assess the processes and possible trajectories accompanying technological futures. In an unjust world, where struggles to avoid the co-option and mainstreaming of ideals are ever-present, there would seem to be value in bold creativity, grounded in existing wisdom.

As this phase of the journey ends, I realise I have transformed from someone looking to 'change the world' to someone looking to change the way I, and others, view it. I have uncovered a passion for exploring alternatives to the 'growth' paradigm and a particular interest in collaborative junctures between feminist, indigenous, peasant, Marxist and ecological thought. I now see 'the boundaries' as exciting spaces for new reflexivity, and finally recognise that the greatest resilience to avoiding co-option lies, as it always has, at the periphery.

Donnie Maclurcan

Inana, 2010

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COMMONLY USED ACRONYMS

AFM – atomic force microscope

AMO – atomically modified organism

APEC - Asia Pacific Economic Co-operation

BIOTEC – National Centre for Genetic Engineering and Biotechnology (Thailand)

DNA - deoxyribonucleic acid

ELSI - ethical, legal and social implications

EPO – European Patent Office

ETC Group - Action Group on Erosion, Technology and Concentration

EPO – European Patent Office

E.U. – European Union

FDA – Food and Drug Administration

GDP – gross domestic product

GM - genetically modified

GMO – genetically modified organism

IP - intellectual property

IPRs – intellectual property rights

JPO – Japanese Patent Office

LDC – least developed country

MDG – millennium development goal

MM – molecular manufacturing

MTEC – National Metal and Materials Technology Centre (Thailand)

NANOTEC – National Nanotechnology Centre (Thailand)

NECTEC - National Electronics and Computer Technology Centre (Thailand)

NGO – non-governmental organisation

NNI – National Nanotechnology Initiative (United States of America)

NSF – National Science Foundation (United States of America)

NSTDA – National Science and Technology Development Agency (Thailand)

OECD – Organisation for Economic Cooperation and Development

OTOP – One Tambon One Product

RS&RAE – Royal Society and Royal Academy of Engineering

R&D – research and development

STM – scanning tunnelling microscope

TRIPs – Agreement on Trade Related Aspects of Intellectual Property Rights

U.K. – United Kingdom

U.N. - United Nations

UNCTAD – United Nations Conference on Trade and Development

UNDP – United Nations Development Program

UNESCO - United Nations Educational, Scientific and Cultural Organization

U.S. – United States of America

USPTO – United States Patent and Trademark Office

UTJCB – University of Toronto Joint Centre for Bioethics

WHO – World Health Organisation

WTO – World Trade Organisation

SCIENTIFIC GLOSSARY

Molecular Manufacturing – An anticipated technology based on Richard Feynman's vision of factories using nanoscale machines to build complex products, including additional nanoscale machines.

Nanometre - One billionth of a meter or 10^{-9} metres.

Nanoparticle - A particle having one or more dimensions of the order of 100 nanometres or less.

Nanoscale - A length scale between 1-100 nanometres and the level of most atoms and some molecules.

Nanotechnology - The understanding and control of matter at dimensions between 1 and 100 nanometers, where unique phenomena enable novel applications.

Nanotube – A structure comprising atoms that form a hollow, nanoscale cylinder.

Quantum Dot - Semiconducting nanocrystals that differ in their ability to absorb and emit energy, based on the size of the crystal.

Quantum Mechanics - A set of scientific principles describing the known behavior of energy and matter that predominate at the atomic and subatomic scales.

Quantum Physics - The branch of physics which studies matter and energy at the level of atoms and other elementary particles, and substitutes probabilistic mechanisms for classical Newtonian ones.

Self-assembly – A method by which atoms or molecules arrange themselves into ordered nanoscale structures by physical or chemical interactions between the units.

LIST OF RELEVANT PUBLICATIONS AND RELATED CHAPTERS

Publication	Related Chapter(s)
Maclurcan, D. (2006), "Molecular Manufacturing and the Developing World: Looking to Nanotechnology for Answers", *Nanotechnology Perceptions*, vol. 2, no. 1b, pp. 137-41.	1
Maclurcan, D., Ford, M. and Cortie, M. (2004), "The Confusion Surrounding Nanotechnology", *Materials Australia*, vol. 37, no. 2, pp. 24-25.	1
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Maclurcan, D. (2010 - reprint), "Southern Roles in Global Nanotechnology Innovation: Perspectives from Thailand and Australia", in S. E. Cozzens and J. M. Whetmore (eds), *The Yearbook of Nanotechnology in Society II: The Challenges of Equity, Equality and Development*, Springer, Berlin, pp. 349-378	7

LIST OF RELEVANT PRESENTATIONS

Presentation	Date
"Make prosperity global: A holistic approach beyond quantitative growth" Second Conference on Economic Degrowth, Barcelona, Spain	Mar. 2010
"Nanotechnology and creativity at the edge" Asia-Pacific Science, Technology and Society Network Conference, Queensland Conservatorium, Brisbane, Australia	Nov. 2009
"Design for development" Symposium on Capabilities, Freedoms and Policy Making in the Pacific Region, University of NSW, Sydney, Australia	Nov. 2009
"Nanotechnology and the South: Moving beyond the divides" The Convergence of Conventional Microelectronics and Nanotechnology (Workshop), MINATEC, Grenoble, France	Sept. 2009
"Southern roles in global nanotechnology innovation" 3rd Workshop on Nanoethics, Aarhus, Denmark	Nov. 2008
"Regulating nanotechnology in the global South" NanoRisk™ 08, Paris, France	Oct. 2008
"Nanotechnology from a systems perspective" Global Youth Futures Festival, Sydney, Australia	Aug. 2008
"Nanotechnology and the South: frameworks, risks and concerns" Managing the Uncertainty of Nanotechnologies, University of Padua, Italy	May 2008
"Nanotechnology and the future" Breakfast Club, St Aloysius College, Sydney, Australia	May 2007

Presentation	Date
“Nanotechnology and the global South” Postgraduate Student's Conference, University of Technology, Sydney, Australia	Sept. 2006
“Nanotechnology and health: a comparative study” Second International Workshop on Nano and Healthcare, SASTRA, Thanjavur, India	May 2005
“Global equity in nanotechnology?” Expert Group Meeting, International Centre for Science-United Nations Industrial Development Organization, Trieste, Italy	Feb. 2005
“Nanotechnology at the border” Medicine at the Border, University of Sydney, Australia	Jul. 2004
“Nanotechnology and the health of developing nations” Asia Pacific Nanotechnology Forum 2003, Cairns, Australia	Nov. 2003
“Medical nanotechnology” UTS 5th Annual Postgraduate Conference, University of Technology, Sydney, Australia	Aug. 2003
“Nanotechnology in low income nations” Junior Common Room Research Presentations, St Andrew's College, Sydney, Australia	Aug. 2003
“Social issues in nanotechnology” Future Problem Solving Day, Loreto Normanhurst, Sydney, Australia	Jul. 2003

ABSTRACT

In this dissertation I explore nanotechnology's foreseen implications for the global South by asking: to what extent does nanotechnology offer hope for a more equitable world? Overall, I find that nanotechnology presently offers little hope, based on its failure to demonstrate a reflexive response to the legitimate requirements of equitable development.

My original contribution to knowledge is in placing nanotechnology's emergence within a broad historical and contemporary global context whilst developing and testing an interpretive framework through which to assess relevant claims. Furthermore, I establish greater clarity about the nature of global engagement with nanotechnology research and development and explore a range of perspectives, from within both the South and North, regarding nanotechnology's foreseen implications for global inequity.

Through a review of the secondary literature I identify four key themes around which to question nanotechnology's implications for a more equitable world, namely: understandings, innovative capacity, technological appropriateness and approaches to technological governance. To consider nanotechnology in relation to these themes, I use an exploratory mixed methods approach, consisting of two sequential phases. In order to establish the 'state of play', I first assess quantitative data surrounding national engagement, research participation and nanotechnology patenting. To explore matters more deeply, in the second, largely qualitative phase, I analyse the perspectives of 31 Thai and Australian 'key informants', supported by surveys of 24 Thai nanotechnology practitioners.

Through my research I find that there is agreement about nanotechnology's common characteristics but that, simultaneously, there are substantially different ways in which it is conceptualised. The result is a large variation in opinion surrounding various issues such as the expected entry costs and infrastructural requirements of nanotechnology research and development. Whilst there is evidence of widespread engagement and feasible entry points for some Southern countries into the budding fields of research and development, innovative capacity is shown to be increasingly centralised and

disengaged from ‘the local’, although the emerging gaps are as much South-South as North-South. In terms of appropriateness, nanotechnologies are seen as offering numerous technical advantages, but any associated benefits are set against numerous imponderables relating to risks and implications, as well as economic imperatives that can mean nanotechnologies are oriented away from Southern needs. In terms of governance, Southern approaches are found to largely focus on supporting innovation and managing risk at the expense of meaningful public engagement.

Overall, an increasing concentration of capacity and influence, simplistic hype that obfuscates key criteria of appropriateness and a largely ‘managed’ process of public engagement with predetermined desirable outcomes suggest that nanotechnology is likely to maintain and possibly amplify the inequities stemming from existing forms of technological innovation, such as biotechnology. Furthermore, debates surrounding nanotechnology and development remain so polarised that mainstream reflexive engagement seems unlikely.

However, whilst nanotechnology presently offers little hope for a more equitable world, I conclude that there is interesting new ground to explore at ‘the edge’, such as through ‘open source nanotechnology’ and other equity-driven practices. I argue that such boundary areas may allow nanotechnology to embody a process of ‘reflexive pluralisation’, leading to a more equitable world by revealing paths for innovation that are autonomous yet responsive to external change and opportunities for mutually beneficial cooperation - de-linked from national economic growth yet meaningful to people’s lives. The field could then, as Schumacher proposed in 1973, blossom ‘a new orientation of science and technology towards the organic, the gentle, the non-violent, the elegant and the beautiful’.