Nanotechnology and the Global South: Exploratory views on characteristics, perceptions and paradigms

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Abstract

Abstract. In the Global North, confusion, hype and disagreement plague nanotechnology debates. In the meantime, the debate about the Global South's engagement with nanotechnology has forged ahead, assuming common understandings about what nanotechnology is and what it is not, as well as the general irrelevance of definitional debates. This despite evidence that nanotechnology is being presented in a conflicting manner in the literature, through mixed terminology and imagery, and that little has been documented about Southern understandings. Given the importance of understandings in the genetically-modified foods debate, the way nanotechnology is understood holds serious repercussions for the framing of its ethical, legal and social implications. This chapter reports on the perspectives of Thai and Australian key informants, from a broad range of fields. It seeks to explore and clarify how nanotechnology might be defined, perceived and framed in terms of the South. The results suggest that nanotechnology may be conceptualized in similar ways, focussing on near-term nanotechnology that is defined by a common set of characteristics. Yet, when it comes to the way these conceptualisations translate into applications, there may be large differences in nanotechnology's perceived scope, sophistication and complexity. This holds interesting ramifications for global nanotechnology discourse, particularly in terms of the assumed costs and infrastructure required to conduct nanotechnology research and development and the more general role the South will play in the global nanotechnology picture.

Keywords. Nanotechnology, Global South, developing countries, understanding, conceptualisation, ethical, legal, social implications

Introduction

Nanotechnology's potential implications for the Global South are hotly contested in a polarised debate between those who see nanotechnology as part of the 'development solution' [1-4] and others who see it as part of the 'development problem' [5-8]. Concurrently, a surprisingly high number of Southern countries are actively engaging

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in nanotechnology Research and Development (R&D), although Southern input in international debates about the technology's trajectory remains limited [9].

In biotechnology's wake, debates, at both the national and international level are often targeted towards nanotechnology's ethical, legal and social implications (ELSI). Amongst biotechnology's many lessons for nanotechnology is that, in order for open, productive dialogue to occur, hype must be distinguished from reality and clarity must result in some form of common platform for debate. Without this, we risk a modern day rift, such as that surrounding the use of genetically-modified (GM) crops in the South, where parties on both sides of the argument accuse each other of misleading the public on fundamental matters of understanding [see, for example, 10, 11-13]. For nanotechnology, different understandings can be highly influential in shaping the ways in which it is assessed [14]. Internationally, the development of relevant regulations relies on some kind of common understanding [15]. Domestically, common definitions are needed to ensure the proper assessment of nanotechnology's scientific, legal, environmental, regulatory and ethical implications [14, 16], with the risk of applying inappropriate understandings potentially disastrous for an area such as regulation [17].

Given the early concentration of nanotechnology R&D in the North [9], it is useful to briefly explore the precedence set by Northern discussions, in terms of how nanotechnology is understood. For some, the United States National Nanotechnology Initiative's (NNI) definition of nanotechnology is believed to be most common [18, 19]. The NNI's latest[ii] definition states:

> Nanoscience involves research to discover new behaviors and properties of materials with dimensions at the nanoscale which ranges roughly from 1 to 100 nanometers (nm). Nanotechnology is the way discoveries made at the nanoscale are put to work. Nanotechnology is more than throwing together a batch of nanoscale materials—it requires the ability to manipulate and control those materials in a useful way [20].

However, as highlighted by research in 2006, nanotechnology is defined in a myriad of ways by those engaged in Northern nanotechnology debates; a veneer for residual confusion, hype and disagreement about how nanotechnology is understood [21]. At the foundation of nanotechnology confusion is the fundamental clash of paradigms between, as Peterson explains it:

1. Advanced nanotechnology: focussed on Feynman's original vision of broad control at the level of individual atoms, utilising nanomachines; and
2. Near-term nanotechnology: focussed on an expanded NNI vision that includes anything smaller than microtechnology [22].

Yet, despite the meaning of the word 'nanotechnology' shifting away from Feynman's vision [23], the current discussion of near-term nanotechnology is "conducted in the parameters set by the initial utopian and dystopian extremes" [24]. In

[ii] As of September, 2008.

this light, high-level reports, such as the 2002 National Science Foundation's *Converging Technologies for Improving Human Performance*, have been criticised for failing to distinguish between "…science and science fiction, hype and reality" [25].

According to some, the ambiguity and flexibility of understandings is intentional [23, 26]. Drexler believes that the framing of contemporary nanotechnology is institutionally influenced, with some researchers defining 'nanotechnology' in a way that suits the 'funding coalition' [23]. Drexler explains that this generally results in definitions that include any technology with nanoscale features, thereby allowing "specialists from diverse fields to infuse unrelated research with the Feynman mystique" [23]. Selin agrees, arguing that the constructs of the nanotechnology debate in the North have been created with a false sense of certainty by those seeking to gain the most:

> The story of the rhetorical development of nanotechnology reveals how speculative claims are powerful constructions that create legitimacy in this emerging technological domain [26].

In the meantime, the debate about Southern engagement with nanotechnology has forged ahead, assuming common understandings about what nanotechnology is and what it is not, as well as the general irrelevance of definitional debates. This is potentially problematic, given the conflicting way that nanotechnology is framed in the literature relating to the technology's impact on, and in, the South. At different times, Southern nanotechnology debates have consciously drawn on understandings that correlate with both 'near-term' and 'advanced' nanotechnology. Whilst most writing presents near-term nanotechnology as the mainstream, there are instances where advanced nanotechnology has also been presented as 'the reality' for the South. Bruns, for example, sees answers for global poverty through a future of accessible abundance based on the application of advanced nanotechnology [27]. Al'Afghani, on the other hand, focuses on the need for future environmental laws in the South to incorporate "mechanisms for licensing, supervision and control of emissions and disposal methods for both MNT [molecular nanotechnology] products and nanofactories" [28]. Furthermore, a 2003 briefing document for a United Nations Industrial Development Organisation Expert Group Meeting, predominantly attended by representatives from the Global South, refers to the ability for advanced nanotechnology to address medical, energy and environmental challenges via "…factories operating at the nanometer level, including nanoscale conveyor belts and robotic arms bringing molecular parts together precisely…" [29].

Perhaps a greater disservice to clarity comes from those in the North who draw on the hype of advanced nanotechnology's terminology and imagery when describing the benefits of near-term nanotechnology, without distinguishing between the two paradigms. One common way is by talking about recent innovation in areas of social development whilst referring to nanotechnology as a manufacturing revolution that will result in material abundance [see, for example, 2, 30, 31, 32]. The Association for

Women's Rights in Development, for example, highlight nanotechnology's current consumer benefits, talk about near-term developments for water purification, cheap energy, and accessible medical treatments, but also interweave, with distinct certainty, information about the long-term benefits of 'nanobots', whilst envisaging a world where "many of the material dreams of humanity can be fulfilled" [32].

If greater clarity is to be forthcoming, debates about nanotechnology's Southern impacts must include Southern perspectives. Few have recognised or explored how nanotechnology is defined, perceived or framed in relation to the South and by people from the South. Given the importance of clarity for shaping domestic ELSI and international regulatory debates, in this chapter I seek to provide an introductory study of these matters.

1. Methods

This chapter reports on a 2004 qualitative study undertaken in Thailand and Australia. A group of key informants[iii], sixteen from Thailand and fifteen from Australia, were interviewed about their understandings and perspectives relating to nanotechnology, as part of a wider study on nanotechnology and the South.

Whilst the study sought exploratory, rather than representative, perspectives on how nanotechnology might be understood in the South[iv], a key informant process was used to ensure a range of perspectives were considered [34]. Given the argument that studies assessing nanotechnology's impacts relating to the South must go beyond consultations based purely on scientific perspectives [7], this study included interviewees with expertise in ethics, law, social science, science policy and development studies. Effort was made to ensure the involvement of people with experience across the 'development process', from grassroots activism through to government policymaking and industry leadership, with interviewees coming from academia, as well as private, government and non-government (NGO) sectors. Nineteen of the key informants, slightly more than a half of my sample, were engaged in work that involved nanotechnology. All key informants from Thailand were Thai citizens. Key informants were identified through web and literature searches as well as a simplified process of co-nomination [35].

Linguistic, financial and temporal limitations, as well as nanotechnology's nascent stage at the time of the study, restricted the ability for wider public engagement, particularly outside of Bangkok, Thailand. Despite every effort to ensure diversity, the

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[iii] Key informants, or experts, are defined as "...those who can provide relevant input to the process, have the highest authority possible and are committed and interested" [33].

[iv] Each key informant's responses in this research are views held by themselves and do not necessarily represent those of the organizations with whom it is noted that they were affiliated. Where mentioned, each key informant's title and affiliation has been used to add credibility to their statements and allow for cross-sectoral analysis. Stated titles and affiliations are those held at the time of each interview.

majority of Thai key informants spoke fluent English and had, at some stage, received educational training abroad. The results of this study must be interpreted with these limitations in mind.

A study of a small number of key informants in Thailand can in no way be seen as indicative of attitudes across the non-homogenous South, particularly given Thailand's lack of a colonial history. However, Thai perspectives can be useful for exploring and considering nanotechnology and the South, given the situation Thailand faces in terms of both development and nanotechnology.

Thailand is classified by the United Nations Development Program as a "middle income country" [36] and is ranked 74th out of 175 countries on the Human Development Index[v] [37]. In recent decades it has experienced remarkable progress in human development [36]. However, Thailand's greater population continues to face significant challenges. As of 2004, 21 per cent of the Thai population earned less than $2 a day [38], whilst financial inequality had increased over the past 40 years, particularly between urban and rural areas [39]. Stark inequities are also evident in the distributed burden of the HIV/AIDS epidemic and general access to health services [36]. Various populations still suffer from very high levels of child malnutrition and maternal mortality, whilst overuse of pesticides is a threat to many in rural areas [36]. Despite the fact that the vast majority of Thais live in rural locations, the country is experiencing rapid urbanisation as well as an ageing population [37].

In terms of its engagement with emerging technology, Thailand has supportive infrastructure and strong hopes for biotechnology R&D [40]. In an early study of Southern nanotechnology capabilities, Thailand was identified as a "middle ground" Southern country [41]. This analysis is supported by early evidence of nanotechnology R&D [42-46], including the establishment of a national centre [47] and development of a national nanotechnology strategy [48]. Just as Thailand faces significant challenges with biotechnology innovation [43], so too do people claim Thailand faces significant challenges for nanotechnology innovation [44, 49]. From the perspective of ELSI, Thailand has a history of controversy in biotechnology, ranging from issues of morality [50] and environmental concerns [51], through to issues of intellectual property such as 'biopiracy' [52, 53] and compulsory licensing [54]. Yet already, the ELSI of Thai nanotechnology has created controversy around the issue of 'atomically modified organisms' [55].

Given the role of the North in shaping and driving debates about nanotechnology in the South, the value of simultaneously considering Northern perspectives must not be underestimated. Australian perspectives can act as a useful reference point given the country has been firmly entrenched in international nanotechnology debates having developed the world's first 'nanomachine' in 1997 [56]. However, as of 2004, Australia also lacked a formal national nanotechnology initiative and its global output

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[v] An index combining normalized measures of life expectancy, literacy, educational attainment, and GDP per capita for countries worldwide.

was below expected levels [57]. Furthermore, Australia has also faced a slow uptake of engagement with ELSI debates in areas such as health and safety [58], and low levels of public understanding and knowledge about nanotechnology [59].

Considering the importance of the interviewee's own framework of meanings, the 31 interviews in both Australia and Thailand were semi-structured, which allows for a broad framing but individual divergence [60]. Each interview lasted between 20 and 80 minutes, was face-to-face[vi], and interviewees were offered professional translation services. All data was analysed using NVivo™ software, noted for its ability to assist in developing an emergent analysis [62].

3. Results

In terms of how nanotechnology is understood, three areas of interest emerged, constituting the areas explored in this chapter. First were the characteristics seen as defining nanotechnology. Second was how nanotechnology is perceived, in terms of its scope, level of sophistication and complexity. Third was the framing paradigm seen as most relevant to Southern nanotechnology debates.

Nanotechnology's Common, Defining Characteristics

Given the definition is "still evolving" [63] and "very broad" [64], some of the interviewees considered it difficult to define what nanotechnology 'is' [63, 64]. As a Thai policy officer from the Asia Pacific Economic Cooperation Centre for Technology Foresight (APECCTF) noted, presently the "…definition has some diversity that can change according to the context" [65]. Others agreed that there will always be diversity of opinion [66], no matter what certain authorities might specify or claim [67].

However, on the whole, interviewees from all sectors, in both Australia and Thailand, presented surprisingly similar responses as to the characteristics that contribute to nanotechnology's definition. The following six characteristics were seen as fundamental:

- Nanotechnology is based upon a size or length scale (the nanoscale);
- Nanotechnology involves the ability to either 'control', 'manipulate' or 'engineer' on the nanoscale;
- Nanotechnology involves exploiting properties unique to the nanoscale;
- Nanotechnology is the practical application resulting from this exploitation;
- Nanotechnology is often the product of conducting 'old science' in a new way;

[vi] Noted as an advantageous method in future-oriented research [61].

- Nanotechnology is the natural (but sometimes unconscious) progression for those working in cutting-edge areas of science and is, therefore, a new field rather than a new discipline.

The most commonly defined feature of nanotechnology is that it relates to a length-scale (or size). Interviewees generally provided technical explanations, noting that there is a "loose definition of nanotechnology to be between 1 and 100 nanometres…" [68], with a nanometre being equal to '10^{-9}' metres [69]. A Senior Researcher from the Thai National Centre for Genetic Engineering and Biotechnology (BIOTEC) highlighted other standard references such as the 'nanoscale' (the length-scale generally accepted as 1-100 nanometres), and described this informally as "mid-way between [the] atomic scale and the convention[al] scale that we are familiar with…[where one] would think of technology which deals with materials of a few atoms or a few molecules" [67]. Only the Director of the Australian International Health Institute, and the Australian Chief Executive Officer of The Fred Hollows Foundation provided non-scientific responses, referring to nanotechnology as "miniaturisation" [70] or "really tiny things" [71].

Nearly half the interviewees referred to nanotechnology in terms of its command over the small scale. An Investment Manager specialising in nanotechnology from Invest Australia described nanotechnology as "the control and ability to manipulate material at the atomic level" [68]. The Director of the National Nanotechnology Centre of Thailand (NANOTEC), talked in a similar manner of nanotechnology as "the control of microstructure[s] or manipulation of the atoms or molecules or the clusters of molecules" [72]. Both Australian and Thai interviewees commonly referred to this trait as 'engineering' on the nanoscale.

A number of interviewees highlighted that nanotechnology exploits unique properties not exhibited in bulk materials [72, 73]. The ability to utilise these unique properties was seen as the basis for enhanced research possibilities [74].

For many, it was important to make the distinction between nanoscience and nanotechnology. Interviewees distinguished that nanotechnology was the "practical application" of nanoscience [75] "because it has got the word 'technology' in it" [63]. This suggests an important distinction, particularly in terms of discussing a countries' role in nanotechnology research and design, because it means a countries' ability to produce the technology must be considered in addition to its ability to conduct research.

The ethicists and lawyers amongst the interviewees presented nanotechnology as "a new form of technology" [76-78]. However, the majority of interviewees, particularly those with backgrounds in science and chemistry, claimed that nanotechnology was using 'old' science in a 'new way', or what an Associate Professor of Microelectronics at the Asian Institute of Technology (AIT) referred to as "an old wine in a new bottle" [79]. In many instances, interviewees made the distinction between 'nanoscience' and 'nanotechnology', suggesting that nanotechnology builds

on nanoscience knowledge that has "…been in existence for a long time…" [63], with the Senior Researcher from Thailand's BIOTEC presenting the example of liposome drug delivery as a nanotechnology process that has "been going on for some time" [67]. An Australian Research Fellow from the Department of Chemical and Biomolecular Engineering at the University of Melbourne, explained his nanotechnology work in a similar manner:

> …using particles loaded with a drug for drug delivery is very well established and old technology… the particles will become more sophisticated and will become more complex, but it will be the continuous change I see there that builds up from the brilliant work which is already published [80].

An Associate Professor from the Petroleum and Petrochemical College at Chulalongkorn University (CU) made similar comments, noting that the contemporary term 'nanotechnology' can be used to classify previous work that occurred on the nanoscale:

> even [if] we do not have the 'nano' wording… the way that people learn from experience and come to the molecules and start from molecules and go back, is already the nano work… [75].

Interviewees highlighted a subsequent "re-branding of old technologies" [80] to fulfil an organizational objective. The Associate Professor from the Petroleum and Petrochemical College at CU explained a common experience for many Thai scientists where their ongoing research was, all of a sudden, re-termed 'nanotechnology' [75].

Others noted surprise at discovering they had unconsciously been working in nanotechnology. The first reactions of an Australian Medical Doctor, from the Royal Prince Alfred Hospital highlighted this point:

> When you talked about nanotechnology I thought 'what on earth is that?'… and then you sort of brought it down to atoms and molecules, and then, of course, I realised that the antigen/antibody reactions which we have been dealing with for… lots of years, [are] at that scale [81].

This suggests that, for many, this transition may yet be unknown.

The Associate Professor of Microelectronics at AIT saw the positives in these points, suggesting that "the attractive thing about nanotechnology is that everyone says 'hey, I am in it, I know it, I have been working on it but I have not been using that word'" [79].

Furthermore, interviewees described the shift to working in nanotechnology as a "logical migration" [82] for those at the forefront of various cutting-edge areas of science. As a Researcher from the Australian Academy of Science noted, "if people are working in physics, chemistry and biology they are going to be working in nanotechnology because [it is at] the cutting edge of these topics [83]. Interviewees suggested that this loose, and often unconscious, new grouping of research and its cross-fertilisation between both disciplines and sectors, means that nanotechnology is a new field, as distinct to a new discipline or industry.

The sum of these findings suggests relatively common understandings in relation to nanotechnology's distinguishing features and give credence to the comments of the Director of the Nanotechnology Centre with Australia's Commonwealth Scientific Industrial Development Organisation that there is no problem in interpretation and no need to get "hung up on definitions" [84]. The commonality of understandings are made all the more surprising given 12 of the Australian and Thai interviewees had no background in nanotechnology, with some stating that their understandings were very limited [70, 76].

Differing Perceptions

Having identified the characteristics that contribute to nanotechnology's definition, in this section I look at how these factors translate into the way nanotechnology is perceived in terms of its scope, level of sophistication and complexity.

Discussion of nanotechnology's scope was often prefaced by reference to its trait of "…organising present knowledge in various areas; in chemistry… in biology, physics, engineering and so on" [82]. Hence, many interviewees spoke of nanotechnology's wide-ranging nature. The Director of NANOTEC, for example, suggested that nanotechnology "…covers almost everything in all fields and at all levels" [72]. In this sense, interviewees highlighted the substitutability of the word 'nanotechnology' with the, perhaps more appropriate, 'nanotechnologies'.

The Associate Director of the Institute for Nanoscale Technology from the University of Technology, Sydney (UTS) believed the wide-ranging nature of nanotechnology means the boundaries of where nanotechnology starts and begins are unclear [63], with the Director of NANOTEC noting that this can create a tension between having a definition that is "comprehensive" yet "unifying" [72].

The wide-ranging nature of nanotechnology also means that there will be vastly different approaches to research undertaken by different groups. A Professor of Structural Engineering at AIT recognised the possibility of employing either a 'top down' or 'bottom up' approach to R&D in an area such as material science [66].

Given its wide-ranging nature, I was interested in understanding how nanotechnology is generally perceived in terms of its technical sophistication. The results showed that nanotechnology is commonly perceived as 'high-tech' [70, 75, 85], "cutting-edge" [76] or relying on "higher technologies" [67]. Interestingly, Thais saw nanotechnology as less 'high-tech' than their Australian counterparts.

To some extent, the justification for responses came from associated assumptions based on the nature of the word 'nanotechnology'. The Director of the Australian International Health Institute, who noted the limitations of his nanotechnology understanding, went on to state: "…it is all at the high-tech end" [70]. For most, however, nanotechnology's 'high-tech' label was justified by the demands it creates in terms of the level of human or technical resources required [66]. The Director of NANOTEC, for example, spoke of the need for "well qualified technicians" [72] holding advanced knowledge to operate or maintain nanotechnology equipment. He

also highlighted a view held by many Thai scientists when he stated that the equipment is quite specialised and precise and that looking at nanostructures requires very high resolution devices [72].

Yet, others challenged the idea that nanotechnology relies on "…highly sophisticated instruments" [80], paving the way for a belief that, even if nanotechnology is perceived as high-tech, its scope includes a wide range of applications that vary with respect to the demands of required inputs. A number of Australian and Thai interviewees believed nanotechnology is not just high-tech [66] but spans low- through to high-tech [64, 72]. The Australian Executive Advisor to the APECCTF spoke of low-tech nanotechnology having "…existed for a long time in terms of micronised powders" [64] that the Thai policy officer from the APECCTF said can translate into everyday products such as self-cleaning powders or influence manufacturing aspects of textiles such as silk [65]. Even the Director of NANOTEC, who had previously presented nanotechnology as "high-tech", spoke of its scope encompassing "very basic research", such as putting nanoparticles into wine or developing water-repellent surfaces for garments [72]. Reinforcing that nanotechnology represents a spectrum of applications with varying input demands, the Executive Advisor to the APECCTF and the Director of NANOTEC both highlighted the example of 'quantum dots' at the high-tech end of nanotechnology's spectrum that require sophisticated knowledge and intense technical infrastructure [64, 72].

Yet, a number of interviewees believed that nanotechnology is often inaccurately perceived as purely high-tech, a mistake they believed will be clarified with deeper understandings. The Executive Advisor to the APECCTF posited that people who have read about nanotechnology will see the "'gee whiz' stuff" but that "the people who know a bit about it may be a little bit more circumspect…" [64].

Focussing on Near-term Nanotechnology: The Rejection of Molecular Manufacturing

As outlined previously, when it comes to literature linking nanotechnology and the South, commentaries have alluded to nanotechnology in two very different forms. Most commonly, nanotechnology is presented as an emerging field focused on applications arising from everyday science that exploits phenomena unique to the nanoscale. Less commonly, nanotechnology is presented as highly futuristic applications resulting from an ability to manufacture atomic self-replication, also known as molecular manufacturing. Considering the scientific controversy surrounding the latter proposal, in this section I look at interviewee perspectives on futuristic applications and molecular manufacturing.

For some Australian interviewees there was a belief that governments in the Global South might engage with nanotechnology under the pre-tense of its potential for applications of a 'highly futuristic' nature, i.e. applications arising from scientific breakthroughs that are yet to occur or that some challenge in terms of their possibility. The Associate Director of the Institute for Nanoscale Technology from UTS, for

example, was worried that Southern images of nanotechnology might include "nano-bots" ahead of examples such as "energy efficient coatings for windows and paints" [63]. Some interviewees who saw these ideas driven by the media, thought the hype might be even more exaggerated in the South [64, 80]. In addition to futuristic claims, it was also believed this hype, as witness in the North, could lead to a polarisation within Southern discussions. An Australian Professor from the Centre for Applied Philosophy and Public Ethics at Charles Sturt University (CSU) presented this polarisation as similar to the phenomena witnessed with the emergence of Artificial Intelligence in the 1970s and 1980s where groups of people thought it would "save the world" and others thought "…it was one of the worst things that could happen…" [69]. The latter perspectives were seen as incorporating 'doom and gloom' scenarios relating to molecular manufacturing and uncontrolled atomic self-replication that would result in the 'grey goo' phenomenon.

In this respect, discussion of futuristic applications do play some part in the Thai public discourse on nanotechnology, as witnessed by the example from the Senior Researcher from Thailand's BIOTEC of his speaking about the film 'Fantastic Voyage' [vii] to students at Sirinthorn International Institute. Interviewees also acknowledged that a discourse around futuristic threats exists, with the Thai Prime Minister's Science and Technology Advisor saying that "people are talking about the 'grey goo'" [86].

However, although a common belief was held that the bulk of nanotechnology's applications were some way off in terms of Thai actualisation [87, 88], 'futuristic' applications were never central to interviewee responses about nanotechnology. Furthermore, descriptions about nanotechnology and its applications never implied an understanding of nanotechnology as molecular manufacturing. On the contrary, for the few times when molecular manufacturing was raised in conversation, interviewees spoke extremely cynically of its feasibility, particularly in the coming 20 years [79]. The Thai policy officer from the APECCTF claimed this cynicism is supported by most Thai scientists who dismiss the "…realisation of so-called 'self-replicat[ion]'" [65]. Moreover, there was a general absence of the Northern 'doom' polemic, with most scientists dismissive of "the future threats" from potential self-replication [65]. In this light, it would appear that the case of Thailand presents a different picture to the generally polarised views appearing via popular science media in the North. As a speculative explanation, the Professor from the Centre for Applied Philosophy and Public Ethics at CSU suggested that this could demonstrate cultural differences between the North and South:

> It might be sort of a cultural thing, too. The 'grey goo' is sort of a nice image that… our media can do a lot with… Maybe it will not [be the same coverage] in some other countries, particularly… if they think that there are enormous

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[vii] A 1966 film in which humans venture in microscopic submarines into the human body to repair problems one cell at a time.

benefits from other aspects of it [69].

In this respect, the Senior Researcher from Thailand's BIOTEC added that pressing issues such as bird flu mean that new technologies are presented in terms of their ameliorating capabilities rather than the potentially dire future consequences [67].

However, the Thai Prime Minister's Science and Technology Advisor felt that, given the rapid, global nature of information dissemination in the 21st century, a uniform understanding about nanotechnology's overarching paradigm is not guaranteed, and that hype and concerns relating to molecular manufacturing could capture the Thai public's mind and change the kind of nanotechnology being discussed [86]. Yet, the Thai policy officer from the APECCTF only saw this happening if Northern debates further infiltrated Southern settings, saying a shift in public debate could be prompted if more common reference was made to articles appearing in foreign papers such as the *New York Times* [65].

4. Conclusions

Although this research has only investigated the perspectives of a limited number of key informants from Australia and Thailand, the clear identification of six common characteristics, in terms of how nanotechnology is defined, raises the possibility that interactions between the South and North can be based upon shared foundations. These characteristics include nanotechnology's length-scale, its focus on the control of matter; its exploitation of novel scale-based phenomena, its practical nature, its rebranding and integration of existing practices and its subsequent, natural emergence across a number of sectors, resulting in a new field, rather than a new discipline or industry.

However, how nanotechnology is understood goes beyond its defining characteristics, as there appears large difference in nanotechnology's perceived scope, sophistication and complexity. Yet, when comparing Thai and Australian interviewee perspectives, it becomes readily apparent that the distinctions in perception are less between countries than between interviewees with expertise in differing fields. This is particularly true in terms of nanotechnology's claimed novelty, its range of applications and its complexity, and may be explained by an individual's level of nanotechnology awareness or their motivation to present nanotechnology in a way that reinforces their own perspectives.

Overarching these debates is the paradigmatic framework encompassing nanotechnology. Contrary to popular belief amongst Australian interviewees, nanotechnology in Thailand is framed in terms of its near-term capabilities rather than those attributed to the speculative paradigm of molecular manufacturing. Whilst one interviewee suggested this as a phenomenon grounded in cultural difference, the responses from Thai interviewees, as well as previous research (Maclurcan 2005),

suggest that the market guides the framing of nanotechnology in the South, thereby dictating a focus on the kind of nanotechnology that presents foreseeable returns.

Combined, the findings in this chapter suggest both common ground and critical differences in terms of how nanotechnology can be understood. If the way nanotechnology is understood directly affects the framing of discussions about its ethical, legal and social implications, then the international community has both opportunities and challenges to face in order to ensure meaningful discussions ensue. For example, if nanotechnology's complexity is presented in diametrically opposed ways, is it ever worthwhile to compare arguments relating to the expected costs and infrastructure required for a developing country to conduct nanotechnology R&D? Or, if the scope of nanotechnology's application is not clearly defined, how can the international community best respond to issues of risk, law, trade and governance?

Whilst the mainstream absence in Thailand of the 'doom scenarios' that have plagued Northern nanotechnology debates could result in a more streamlined narrative, the international history of debates about genetic modification suggest that wide differences in public perception about nanotechnology could result in a milieu ripe for polarised discussions.

In light of increasing public unrest at nanotechnology's rapid development, and upon the geo-political backdrop of the genetically-modified foods debate, the need for meaningful, participatory engagement would appear obvious. To achieve this, both within the South and internationally, will require greater attention to the way in which nanotechnology is perceived, as part of a more holistic consideration for how nanotechnology is understood.

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