Invigorating 'Nanoethics'

INVIGORATING 'NANOETHICS': RECOMMENDATIONS FOR IMPROVING DELIBERATIONS IN TAIWAN AND BEYOND

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Abstract: Nanotechnology is the new(est) star in the high technologies sky. While nanotechnologies remain technologies of promise and potential, a growing number of nano-materials and nano-particle-reliant products are being produced. And although a growing number of academic, policy and industry reports are exploring nanotechnologies, there are very few genuine ethical assessments of nanotechnologies as they exist and might evolve in the coming years. Many questions have yet to be answered about the nature, development, and social and commercial deployment of nanotechnologies and what that means for the human condition and the preservation of our core values. We argue that the early and potentially risky nature of this interdisciplinary science does not justify a blinkered focus on risk assessment and management to the detriment of deep and ranging ethical evaluations. Much improved ethics evaluations must be undertaken, particularly in Taiwan where very little has happened despite grand expectations for, and funding of, the science. In this paper, we uncover the development imperatives for nanotechnologies, demonstrate the paucity of genuine nanoethics exercises, outline key questions for stakeholders undertaking nanoethisc exercises to consider, and we articulate some preliminary actions for Taiwan (and other similarly situated jurisdictions) to take.

Keywords: Ethics, Nanotechnologies, Risk, Uncertainty, Values, Taiwan

INTRODUCTION

Though predicted over 50 years ago [16], nano-scale science was not truly achieved until the invention of the scanning tunnelling microscope in 1981 [39], its use by IBM researchers to spell the initials 'I.B.M.' using 35 xenon atoms in 1990 [4], and the construction of a group of atoms capable of function in 2000 [36]. Still considered the new(est) star in the high technologies sky [claimed by 11, 48, 64], it is important to appreciate that there is no single, discipline-bounded 'nanotechnology'; nanotechnologies are enabling technologies which draw on biotechnology, chemistry and biochemistry, engineering, physics, and physical/material sciences (and

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combinations thereof). They perform or are produced on an atomic, molecular or macromolecular scale ('nanoscale') so as to produce materials, devices, and systems with fundamentally new properties or functions resulting from their scale and which have practical applications in the real world. Thus, nanomaterials are not smaller versions of their macroscale counterparts, they are materials with new and unique properties, exhibiting altered electronic, magnetic, mobility, mechanical, optical, reactive, solubility, or strength properties leading to new and novel effects [7]. Although there are some nanomaterials being produced (eg: nanosilver, carbon fullerenes and nanotubes, etc.) and some nanoparticle-reliant products being sold (eg: clothes, sunscreens, etc.), nanoscience remains a science of potential with many questions yet to be answered about its nature, development, and social and commercial deployment [14]. Bearing this in mind, this paper, using Taiwan as a case study, considers the state of ethical assessments of nanotechnologies and highlights some core ethical issues and concerns. In doing so, it offers some recommendations for the improvement of nanoethics in Taiwan, although many of the observations and recommendations are applicable beyond Taiwan.

DEVELOPMENT IMPERATIVES IN TAIWAN

It is important to stress at the outset that, although there are a growing number of academic, policy and industry reports exploring nanotechnologies, and addressing issues such as innovation and funding [5, 12, 28], and commercialisation [29, 32, 34], our understanding of the mechanisms, capabilities, and potential effects of nanotechnologies is in its infancy; nanotechnologies are more inspired dreams and hopes than material reality [13, 14]. Perhaps unsurprisingly, then, there is a strongly promissory atmosphere around nanotechnologies, with all manner of claims being made as to their social and commercial transformative potential [51]. This and other characteristics of the evolving field reflects Rip's 'promise requirement cycle' [51], and Taiwan is a model example of that cycle in the nano-field. Generally, 'enactors' (ie: protagonists trying to get the new technology to work, to generate value and wealth, and to enrol early adopters) articulate technological possibilities, signal opportunities, and promise possible future worlds, which, if accepted, result in the provision of resources and the fulfilment of additional requirements by others extant to the undertaking [50, 51], and this has undeniably happened in Taiwan with respect to nanotechnologies.

Like many countries, Taiwan is encouraging networks which link nanoscience 'enactors' so as to cultivate forward-looking innovation policies that will 'ensure' that research equipment is suitable, standards are in place, and lucrative international nanotechnologies collaborations are realised. In Taiwan, very excited forecasting has prompted numerous funding and research programmes. In 2002, the National Science Council (NSC) approved the *National Science and Technology Programme for Nanoscience and Nanotechnology* [40]. Designed to coordinate the efforts of various enactors, including the Ministries of Economic Affairs, Education, and Health, the Atomic Energy Council, Environmental Protection Administration, and Council of Labour Affairs, and to enhance interdisciplinary research, the Phase One (2003-2008) budget was set at approximately US$600 million. The Phase Two (2009-2014) budget is US$726 million, and Wu Maw-kuen, the Programme Director, has emphasised that this second phase will target nano-electronic and opto-electronic technologies, nano-scale instruments, nanotechnologies for energy and environmental applications, and nano-scale biomedical research, as well as uses in potential and

traditional industries [40]. Taiwan's National Research Council (NRC) has also launched a national nanotech research project, and numerous other projects have been initiated aimed at finding nano solutions in a variety of fields (eg: materials, electronics, machines and biotechnology) and across a range of industries (eg: the petrochemical, iron and steel, and other traditional industries).

It is hoped – indeed anticipated – that nanotechnologies will be an 'economic miracle' that will encourage Taiwanese competitiveness and leadership worldwide. For example, Zheng Tianzuo, Director of the Nanocenter at Academia Sinica, stated that, despite existing personnel and budgetary shortfalls, nanoscience represents the road Taiwan must walk into the future, Xu Juemin, Manager of the Industry & Technology Intelligence Services (ITIS), referencing the unmitigated success of the semiconductor industry, claimed that Taiwan can repeat this miracle in nanoscience, and Huang Wenkui, ITIS Industrial Analyst, urged that Taiwan can take the initiative and realise great short-term commercial opportunities in nanoscience [65].

These hopes are encouraged by the economic predictions being made in relation to nanotechnologies worldwide. For example, in 2000, the US National Science Foundation estimated that by 2015 US$1 trillion worth of products would contain nanotechnology [52]. In 2005, nanomaterial sales were reported as being US$30 billion with an expected 15% increase in worldwide manufacturing output by 2014 [19]. One report estimates that in 2008, the EU invested some US$2.44 billion in R&D related to nanotechnology, the US some US$1.82 billion, Japan some US$1.12 billion, and Taiwan, ranked ninth in spending, invested some US$97 million [18]. Another report suggests that applying nanotechnologies to biotech products will have an enormous impact on society, with a market value reaching nearly US$300 billion within the next 12 years [61]. A further report claims that industries utilising nanotechnologies could create 2 million jobs directly and three times that many in supporting activities [45].

Ultimately, as indicated, it is expected that Taiwanese investment in nanotechnologies will encourage economic growth and accelerate Taiwan's development [61], and that, more than anything, seems to be the motivation for its course of action. As is perhaps clear, the Taiwanese example maps quite neatly onto Rip's thesis; the early stages of Taiwan's involvement with nanotechnologies shows how the early promissory cycle has prompted speculation and concerns about future worlds, which has triggered further promises and (to some extent) concerns. The only possible deviation is that agenda-building, rather than being diffuse, has been limited to enactor elites – a small number of actor elites. Old, pre-war authoritarian power structures and methods have been retained as the model for Taiwanese policy formulation, and it remains a centralised and technocratic process whereby even consultations, which are not fully democratic affairs, are conducted largely by central policymaking authorities [9]. There remains an inability or unwillingness to carry out comprehensive and full-blooded policy and risk assessments where sensitive and contentious genetic technologies are involved. By way of example, one might point to the processes that have led to the slow and controversial evolution of Taiwan Biobank. The technocrat-led process was (and, to some extent, remains) a sheltered process wherein issues of risk and safety, public perception and trust, and social values and ethical impacts have been mostly ignored [9, 60]. It took an anonymous 'whistle-blower' writing in the popular press to force the process into the open and the issues into the public debate [60, 68].

The result of this has been that numerous civil society groups (including human rights, ethics, and science-and-technology-studies groups) have been

marginalised, and public understanding of science remains relatively poor. With respect to the latter, a 2009 report from Taiwanese government indicates that nearly 90% of respondents had never heard the term 'nanotechnology', and, when offered a brief description, 60% reported still not understanding it [42]. Of course, this poor public understanding of nanotechnologies is not limited to Taiwan. A 2004 UK survey reported that only 29% of respondents admitted to being aware of nanotechnologies and only 19% could offer a definition [54]. A 2007 US survey, indicated that the public was generally unaware of nanotechnologies, with most respondents having heard little or nothing about them, and the majority being too uncertain to assess risks and benefits [26]. The same trend is discernable in other EU countries and elsewhere [10, 20, 56]. In any event, despite low levels of understanding in Taiwan, 60% of respondents in the aforementioned survey expressed concern about the potential risks, and 75% reported mistrusting the safety warranties of manufacturers. Nonetheless, 80% of respondents felt that nanotechnologies bring (or would bring) benefits to the whole society, and agreed that developing them could bolster Taiwan's ability to compete on the world stage, including in emerging areas such as medical treatments and environmental rehabilitation.

These apparent contradictions are explained by the Taiwanese attitudes toward science and technology which are generally positive, optimistic, encouraging, and liberal [35]. The pursuit of science is highly respected, as are technology experts and their opinions. This 'sciencism' – this national inclination to rely on science as a means of regeneration and competition with existing (and colonising) powers, and the concomitant elevation of science to a national imperative tangled up with nationalism – is common across various parts of East Asia [25, 57]. As a result of this sciencism, for example, the Taiwanese largely accept genetically modified food as safe because it has, on the one hand, been scientifically endorsed by some, and, on the other hand, has not clearly been demonstrated through solid scientific evidence to be dangerous to human health [35]. In short, this sciencism strongly bolsters acceptance of science and technology, making people less questioning of science elites, and it serves in some respects as a cultural counter-point to the precautionary approach (which is arguably dominant in Europe, at least in some technology settings).

OVERLY NARROW 'NANOETHICS'?

Against this economic and development optimism and noise, and this almost purely enactor-dominated and bullish policy backdrop, genuine ethical assessments (ie: collaborative and investigative value- or principle-based assessments) have been muted [9]. If caution or reflexivity is exhibited at all in relation to nanotechnologies, they revolve around risks, particularly the risks posed by nanoparticles to the environment and human health [42]. Of course, the desire, and indeed the need, for risk assessments of uniquely interdisciplinary and therefore difficult-to-govern sciences is predictable, perhaps doubly so in the nanotechnologies setting given the nature of nanoparticles, which [27]:

- have relatively high reactivity in relation to surface volume;
- can deliver low dose toxicity that is more potent than their macro-scale counterparts;
- can enter the human organism through inhalation, oral ingestion, dermal

penetration (and are increasingly likely to do so from multiple routes as nano-particles accumulate in the environment); and

- can more easily circulate to various sites within the human organism once penetrance is achieved.

Clearly, material risks to health and the environment are extremely important issues, particularly given that research and production are proceeding apace [47], but they are not the only important issues, and the emphasis on risk to the abandonment of those other issues is to commit the three 'common errors' that are all too common in nanoethics, which are [13]:

1. confusing ethics with prudence, understood as rational risk management exercises;

2. limiting ethics analyses with consequentialist cost-benefit analyses (if the risk dialogue can be broken away from); and

3. ethically critiquing the scientific technique itself, rather than the technology.

In short, nanoethics is frequently collapsed into concerns with, and concepts of, risk (ie: the potential for negative health and environmental impacts as a result of nanotechnology deployment) [13 and others]. Certainly risk is a public concern: almost 60% of respondents in the 2009 survey expressed concern about the potential risks of dermal exposure to, or inhalation of, nanoparticles, the emphasis of which varied depending on whether one was a nanotech company employee (more concerned about dermal exposure) or a scientific expert (more concerned about inhalation) [42]. Even nanotech enactors warn that companies must be open about their pursuits and discussions, and must engage with risk [17, 66].

However, despite the obvious importance of risk, the ethical aspects of nanoscience (and its resultant technologies and products) are much broader, ranging from social, to political, to regulatory, many of which have socio-moral or ethical components, and many of which arise (or ought to arise) well before risk management stages are reached. In Taiwan, although Article 8 of the *Science and Technology Act* emphasises the responsibility of the science sector, research institutions, and individual scientists to "properly fulfil" their obligations to safeguard not only the environment, but also respect for life, and humanitarian ethics, there is no ethics committee organised for nanoscience [41]. As such, the scope and quality of ethical consideration and evaluation is poor. When debates beyond risk *have* been held, they have been about the economic promise of nanotechnologies, for, as has been noted elsewhere [9], the technocrat-dominated processes that do exist value economic development and favour economic benefits and innovation over other factors.

Ultimately, and on the whole, there is a dearth of genuine ethical evaluations, not only in Taiwan (although certainly in Taiwan), but also around the world. The above shows that ethical assessments (in Taiwan) are not robust; they focus almost entirely on technology promise and economic benefits, or, alternatively, the narrow issues of risk identification, the articulation of levels of risk aversion/acceptance, and the management of risks deemed appropriate. Even these issues are not particularly well explored or managed in Taiwan. As a result of this, there has arisen a general lack of public trust toward key enactors relating to governance of new and emerging

technologies in Taiwan (as opposed to science elites themselves) [60, 68]. With respect to nanotechnologies specifically and public trust of key enactors, 75% of Taiwanese respondents reported not trusting the safety warranties of manufacturers and some 70% reported having little confidence in media reports about nanotechnologies [42].

A CALL FOR EXPANDED NANOETHICS ASSESSMENTS

Like other emerging and powerful high technologies, nanotechnologies are transformative; they have the potential to transform common goods (eg: food, clothes, cosmetics and paint), specialist goods (eg: automobiles, communication and computational tools), health goods (eg: drugs, biochips, novel therapies), and society itself (eg: its modes of production, public institutions, means and nature of interactions). With respect to the latter, although currently marginal and boundary-pushing, nanotechnologies can and do generate uncertainty and division, and they may ultimately shift innovation and marketing paradigms, socio-legal systems and institutions, and social relationships [33, 44]. Additionally, it has (rightly) been argued that existing international capital structures have concentrated nanotechnologies and derivative wealth to certain countries, classes, and sectors, and that their driving force (as further suggested from the above) is little more than national competitiveness, which does nothing to ensure that benefits will be widely enjoyed (most existing nano-products are military or luxury goods), or that living conditions will be improved for the population more widely [18, 55].

Given the strong enactor push, the low levels of trust in enactors, and the (arguably) unique complexity, multidisciplinarity, and heterogeneity of nanotechnologies, a robust approach to the ethics of nanotechnologies – or rather to the collaborative human assessment of their individual, social and environmental consequences – is vitally important. The first and ongoing responsibility of society, especially those involved in nanoethics, is to give serious consideration to a variety of sometimes uncomfortable questions about ourselves, our objectives, and our social trajectories. In the past, this might have meant questioning human nature and locating the ethical technology assessment in the answer to that question. For Kant and Roussseau, human nature was defined primarily by the ongoing search for perfection. Taking up this idea of "striving", Atlan argues that humans attain their nature (ie: their humanity) when undertaking creative activity, for it is through creation that we may associate with God [3]. According to Arendt, a consensus on the content of human nature is unlikely in a modern, secularised society where our power over the world is increasing [2]. As such, the root question is perhaps better formulated as: What is the human condition?

Adopting the position that our human condition is informed by what we know, what we've achieved, and what our dreams are for creation/science (regardless of whether we have the means to achieve that dream), Dupuy disregards references to the sacred as a means of identifying (moral) transgression, and argues that humanity must look within itself for guidance [13]. He claims that the primary role of ethics is not to determine what is good and bad, but rather what elements of the human condition we take for granted, how they are changing, and whether that change is acceptable. In doing so, we must articulate, defend and impose our own norms. Dupuy concludes:

> The human subject will therefore need to have recourse to a

> supplementary endowment of will and conscience in order to determine … what he ought to do … . (2000: 254)

Given that nanotechnologies offer potentially vast powers to reproduce and manufacture nature and life, and given that they could permit humanity to remake itself and redefine its characteristics and limits, we have the responsibility to think very deeply about first order questions which implicate our core values. Such questions include:

- What are our core values?
- How might we define those values at this time?
- Why are they important?
- What is human flourishing and human identity?

Core values may include conceptions of solidarity, equality, autonomy, justice, sustainability, security, safety, health promotion, suffering relief, knowledge generation, and so on [for more on values, see 21, 22, 23]. While these will have to be defined and explored within particular cultural settings (and also within varying social groups within those diverse cultures), such culturally sensitive evaluations must take notice of rhetorical declarations and legal obligations in international instruments as well as emerging universal values and norms [24].

We have the additional responsibility to consider (arguably more instrumental) second order and third order ethical questions. Second order questions include:

- What dreams and social forces are driving our nanotechnologies?
- Are we developing and deploying those technologies justly?
- How are and should these technologies socially embedding?
- What does that embedding mean for people's life chances?

Third order questions, which are arguably somewhat more speculative, include questions about how nanotechnologies might:

- promote or erode solidarity or social cohesion;
- enable human agency and autonomy;
- effect privacy and related rights to family life;
- influence development and political activities;
- inform or transform professional duties; and
- interact or interfere with other core values.

Of course, recognising some of the important observations on the pursuit of overly speculative ethical assessments [15, 31, 43, 67], we would caution against fixing our gaze too far into the future. Rather, we recommend "exploratory ethics", which links up and forms a part of a wider and inclusive discourse which sensitises actors to issues. Inclusiveness is important because different actors have different roles. For example, scientists and engineers determine (and push) technical potentialities and generate the final vision of a technology (by actually producing it), sociologists are sensitive to the relational consequences of technologies, ethicists and lawyers are concerned about exemplary cases and the development of enduring principles. All need a seat at the table if the key values of democracy and transparency are to be

realised [8]. Such exploratory exercises might be techno-moral scenario based, but again, they must not rely on visions too far removed from present capabilities and trajectories and near-future objectives.

As one might expect, while values are deeply held and slow to alter, they are socially constructed and therefore subject to (gradual) change, including as a result of forces external to us as individuals; developments in science are examples of change instigators, and, for many people, will be considered 'external' (even though science is, in many ways, created/shaped by all of us, often diffusely, on an ongoing basis). Additionally, the above recognises that technologies are contingent with no natural order, pace or direction of development; they are dependent on actors, networks, laws, inertia, and momentum [30]. Given the evolutionary nature of values and the contingency of technologies, we might argue that, so long as stakeholders (and the participating public) are active early and remain engaged, much is up for negotiation. Public questioning of the technological promises being made (and their social consequences), the potential for those promises, if realised, to actually rectify pressing (and anticipated) social needs, the availability of alternatives to address social issues/problems, the interaction of these technologies with cherished social values, and so on, could result in better technologies and deployments thereof. (Parenthetically, we note that different social groups have different levels of power (and access and ability to influence) in relation to shaping both technologies and values; technological outcomes reflect these inequalities and, in turn, exert pressure on social values in particular directions, all of which impact on levels of marginalisation and willingness to participate, but these are issues beyond the scope of this paper to address in detail.)

While some of these questions *have* been noticed in the scholarship [58], they have not received sufficient attention, a fact which may stem from nanotechnologies being marginal and not perceived as substantially different in kind or substance from the other new technologies that they are enabling, which has resulted in emphases on risk which otherwise rather uncritically accepts both the science/technique and its resultant technologies. This dearth of deep and compelling ethical analyses of the other important socio-ethical issues, including conflicts about justice, respect for persons, etc., must be reversed. These and other issues relating to practices to which nanotechnologies might give rise must be explored through a variety of ethical approaches, including those based on virtue, consequence, deontology, and justice. And they must be visited and revisited.

A DEMAND FOR TAIWANESE STAKEHOLDER ACTION

Nanotechnologies are entering the Taiwanese market, including products in sensitive areas such as genomics (eg: microarray biochips are popular in many biotech companies). As such, one might have hoped that some genuine and conspicuous ethical assessments of the technologies had been undertaken, but this is not the case. Taiwan has yet to think very deeply about the condition, direction, and realistic implications of nanotechnologies, either through elite enactors or more collectively through public engagement activities [69]. A continuing failure in this regard brings to mind images of Benjamin's (1968: 257) [6] 'angel of history':

> This is how one pictures the angel of history. His face is turned towards the past. Where we perceive a chain of events, he sees one single catastrophe which keeps piling wreckage upon wreckage and

> hurls it in front of his feet. The angel would like to stay, awaken the dead, and make whole what has been smashed. But a storm is blowing from Paradise; it has got caught in his wings with such violence that the angel can no longer use them. This storm irresistibly propels him into the future to which his back is turned, while the pile of debris before him grows skyward. This storm is what we call progress.

As this quote implies, there is a real danger – not only to the pursuit of nanoscience (and therefore to knowledge-generation and commerce), but to society and the environment – when science leaps too far ahead of ethical thinking, social discussion about its potential and consequences, and public governance. Bearing this in mind, and recognising the impossibility of predicting all conceivable research outcomes and effects in this rapidity changing field, we recall Symonides' plea for "biovigilance" in relation to GMOs [59], and call for "nanovigilance" in Taiwan and elsewhere.

For Taiwanese stakeholders in particular, including the NSC, we recommend that immediate action be taken in relation to the following:

- Public Education: Drawing on the scientific and social data that is currently available, authorities should take the lead in educating people about the many promises and (known and suspected) risks of nanoscience and technologies, as well as about the scope of issues beyond this that deserve sober thought. Such simplifying and demystifying efforts (which should be more than mere risk communication) should rely on a variety of media.

- Specialist Analysis: Authorities should actively encourage and facilitate (through funding) specialist meetings and debate on the first, second and third level questions identified above, with a view to regularising critical ethical discussion in the nanotechnologies field. To this end, a specialist interdisciplinary subcommittee within the NSC could conduct technology foresight and exploratory ethical evaluative exercises.

- Public Engagement: Beyond education and awareness-raising, authorities should facilitate interactive public debate and dialogue between lay and specialist communities [53]. A serious consideration of nanotechnologies must be undertaken by more than just ELSI experts; scientists, policymakers, and publics must play a participative role. The above-mentioned NSC sub-committee could also host interactive evaluative events.

- Research Policy: In cooperation with interested stakeholders, including industry and civil society groups, authorities should fashion socially and ethically sensitive research and development policies in the high technologies, including nanotechnologies. In support of this, they should fund empirical studies on public and enactor attitudes, desires, and values and principles.

All of these efforts combined will provide Taiwan with a much more socially and ethically grounded base from which to fashion its governance instruments and thereby shape the evolution of nanotechnologies (which we have every expectation will continue to proceed apace), and there are certainly stakeholders in Taiwan prepared to move on these if properly supported. The science-and-technology-studies community in Taiwan together with certain members of the NSC are interested in a variety of

issues, including the relationships between innovations and society, and the directions and risks of science and technology, and they have increasingly called for improved governance processes and increasingly been willing to engage in forming same [62, 63].

CONCLUSION

Paradigm-shifting technologies are not new – the early machines of the industrial revolution shifted the relation of people to goods and labour, the factories of the mass-production era shifted the relation of people to creativity, and the information and communication technologies of the computer era shifted the relation of people to services, commerce and each other. Nanotechnologies are just the latest links in an ongoing chain of technologies that challenge how we interact with the world and develop artefacts. However, as with many of the previous technologies, despite yawning gaps in our scientific understanding (ie: with respect to nanotechnologies, our comprehension of processes involving nano-particles is only rudimentary [1, 38, 54]), so-called ethical assessments all too frequently start with risk assessments and end with (at least tentative) recommendations for risk governance measures (which inevitably fall short of a full-blooded adoption of the precautionary principle) [37, 46, 49]. As enabling technologies, nanotechnologies implicate a wide spectrum of actors, who must be marshalled, motivated, regulated, and realigned if the science is ever to achieve its (promised) potential. The beginning of good governance in this diffuse area is an understanding of the human condition and a forming of inclusive communities of these same actors to consider the ethical, legal and social aspects of nanotechnologies. We are not so naïve as to think that the development of nanotechnologies can be stopped (nor are we advocating this), but their development can be influenced if actors are well informed and actions are well timed and placed. A robust approach to nanoethics will facilitate that, for, ultimately, ethical assessments are about preparing people for change (acclimating them to new realities). As a scientific leader in this field, it behoves Taiwan to also be a socio-ethical leader.

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