High Level Workshop:

Responsible Development of Nanotechnology: Governance Challenges

Workpackage 7: DEEPEN Project: Deepening Ethical Engagement and Participation in Emerging Nanotechnologies
High Level Workshop: 
Responsible Development of Nanotechnology: 
Governance Challenges

Workshop Information:

Dates: 17 April 2009

Conference Hotel:
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See attached map

Conference Room:
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Travel and Reimbursement Details

All travel, accommodation and conferences meals will be reimbursed to invited participants, and processed by Durham University. The hotel accommodation will be paid in advance. Initially hotel bookings have been made for one night on 16th April. We can offer an additional night on 17th April if necessary.

We will also meet your flight and other travel costs to and from the conference venue in Budapest. Ordinarily your travel expenses will be reimbursed after the workshop. In this case, please retain all receipts of travel.

However, we are able to pre-purchase flights tickets for you, to enable your attendance at the workshop. Please contact us with your flight needs, and we will book tickets for you.

We will, however, be unable to meet any personal or incidental subsistence costs.
Background
Over the last five years an international policy debate has emerged concerning the appropriate mechanisms for the governance and regulation of advances in nanotechnology – notably through the development of governance structures that incentivise forms of ‘responsible development’. The terms of this debate parallel the classic dilemma in the regulation of emerging technologies – how to regulate in a way that enhances the innovative potential of the field and yet is sensitive to emerging risks to the environment or human health.

In this emerging policy debate initial concern has been raised about the possible eco-toxicity of nanomaterials, together with the broader socio-economic and ethical dimensions of a broad range of possible nanotechnologies. More recently regulatory attention has begun to consider the sufficiency of current regulatory frameworks given the novelty of these materials and their increasing use in a number of consumer products. Initially some NGOs and environmental groups called for mandatory moratoria “on the use of synthetic nanoparticles in the lab and in any new commercial products”\(^1\) and “on the release of nanoparticles to the environment”.\(^2\) Equally, the internationally recognised review of nanotechnology, conducted by the Royal Society and Royal Academy of Engineers (2004), suggested that “the present regulatory frameworks for protecting humans and the environment are sufficiently broad to encompass nanotechnologies and that a separate regulator or regulatory framework is unnecessary” (p. 76) whilst also recommending that “all relevant regulatory bodies consider whether existing regulations are appropriate to protect humans and the environment from the hazards [of nanotechnology], and publish their review and details of how they will address any regulatory gaps” (p. 77). Accordingly a number of ‘regulatory reviews’ have recently been commissioned and published internationally, that examine the sufficiency of existing regulatory frameworks and possible regulatory gaps.

In parallel to the publication of these regulatory reviews the nano-landscape has been populated with a number of proposals for new regulatory and governance approaches. Central to this innovation in regulatory thinking is the admitted uncertainty concerning both the possible toxicological risks of nanotechnologies and possible development trajectories of different nano-enabled products\(^3\). The primary uncertainty regarding the trajectory of nanotechnology and its possible risks and broader societal consequences have given rise to the proposition that policymakers and regulators need to identify frameworks of governance that are adaptive and anticipatory, yet which recognize the limits of prediction.

For example a recently published report by the UK Royal Commission on Environmental Pollution (RCEP)\(^4\) articulated the challenge posed by the governance and regulation of nanotechnology as a ‘control dilemma’. The report suggested: ‘The policy challenge posed by novel materials is a specific instance of the more general dilemma of how to govern the emergence of new technologies which, by definition, cannot be fully characterised with respect to their potential benefits and drawbacks’ (p. 7). By definition, the report suggests the governance and regulation of emerging technologies, such as nanoscience and technology, must incorporate broader societal and ethical concerns, to compliment traditional risk-based regulatory approaches. The report argues for a shift in regulatory thinking – away from notions of ‘risk governance’ to those of ‘innovation governance’ that

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incorporates public deliberation as one element alongside more traditional forms of innovation and technology strategy. The twin goals here are to both stimulate innovation in nanotechnology, whilst ensuring that adaptive and anticipatory structures are in place to deal with potential risk management issues and more substantial social and ethical questions. Significantly, in this shift in emphasis from the ‘governance of risk’ to the ‘governance of innovation’ direct public participation and deliberation is to play a formative role.

One recent embodiment of this attention to innovation – rather than risk-based governance – is the recent proliferation of voluntary codes – particularly those concerning the ‘responsible development of nanotechnology’. Building on the broad international policy consensus on the need to build social-science insight, public engagement and deliberation into the development of nanotechnology, together with ongoing studies on the possible toxicology of engineered nanomaterials, a discourse of ‘responsible development’ has emerged that seeks to address these overlapping concerns. Allied to this, the incorporation of ELSA research and public deliberation into nanotechnology research programmes is increasingly embodied in the text of such codes. Additionally, such codes may be characterised as a response to the uncertainty facing the regulation of emerging technologies, both through an attempt to ‘normalise responsibility’ and to pre-empt direct regulation itself. Indeed we suggest that the recent proliferation of voluntary codes represents the culmination of innovations in governance approaches, epitomising the reliance on flexible soft law mechanisms and the attempt to incorporate ethics and best practices into the development of nanotechnology. The recently published European Commission recommendation on a ‘Code of Conduct for Responsible Nanosciences and Nanotechnologies Research’ is one such form of voluntary soft-regulation that will be explicitly discussed at the workshop.\textsuperscript{5}

The Deepen Project

In order to address these issues, the workshop is organised as one part of a European Commission Framework 6 research project: DEEPEN: Deepening Ethical Engagement and Participation in Emerging Nanotechnologies.

The DEEPEN project is Europe’s leading research partnership for integrated understanding of the ethical challenges posed by emerging nanotechnologies in real world circumstances, and their implications for civil society, for governance, and for scientific practice. The project is coordinated by the Institute of Hazard and Risk Research (IHRR) at Durham University. The project team includes researchers based at Darmstadt University of Technology (Germany), the Centre for Social Studies at the University of Coimbra (Portugal), and the University of Twente (Netherlands).

The DEEPEN project employs a unique interdisciplinary approach combining approaches from philosophical and ethical appraisal, qualitative social science, public engagement and deliberative methods. The project is being delivered through nine integrated work packages spread over four phases:

Phase 1 - Surveying Ethical and Societal Issues of Concern
In the first phase, researchers examined what is at stake in nanotechnology – philosophically, ethically and socially. In particular, researchers will focused on aspects of emerging nanotechnologies that challenge traditional ethical thinking and categories, and which represent the key challenges for conceptualising the societal implications of emerging nanotechnologies. Researchers developed a series of empirical engagements, aimed at uncovering the ways in which the ethical and societal dimensions of nanotechnology are framed in research and development, and by the lay public.

Phase 2 – Integration
In the second phase the project drew together the philosophical/ethical and empirical insights raised in the first phase. Through a series of technical workshops, and through the preparation of internal project reports, the project developed a set of fully integrated, interdisciplinary insights.

Phase 3 - Experiments in new deliberative processes
Drawing on the integrated and interdisciplinary insights derived in first two phases, research in Phase Three – which is currently ongoing – is taking two forms. Firstly, the project is currently experimenting with a number of new deliberative processes aimed at deepening the understanding of ethical issues in nanotechnology and across a diverse range of public and political contexts. In addition researchers are currently assessing regulatory and governance responses to emerging nanotechnologies in Europe, and are focusing on creating novel mechanisms through which such deliberation may be incorporated into policy, governance and regulation.

Phase 4 - Dissemination
In the fourth phase the results from the preceding phases is to be analysed, summarised, discussed and presented. The main task in this phase is to contribute to a conceptual and methodological toolkit for integrating novel forms of ethical appraisal into the governance and ethical public accountability of emerging technologies in ways which engender a transparent, non-secretive, non-exclusive, and responsible politics.

www.geography.dur.ac.uk/projects/deepen
**Goals of the Workshop**

This workshop is designed to inform the third phase of the DEEPEN research plan: to critically evaluate emerging policy debates on the responsible development of nanotechnology, across Europe, to examine the limitations of traditional risk-based regulation on HSE issues, and to explore wider concerns regarding the social and ethical aspects of nano-scale research.

The specific goal of the workshop is to consider the governance challenges posed in the ‘responsible development of nanotechnology’ particularly for new accession and Eastern European nations. In particular we will examine the challenges and opportunities for the governance of nanoscience and technology, particularly in light of the recently published European Commission recommendation on a ‘Code of Conduct for Responsible Nanosciences and Nanotechnologies Research’.

The workshop will follow a round table "procedure" whereby every participant will be able to address the challenges posed in the governance of nano-science and technology.

In particular we ask that you prepare a brief statement and presentation on the following three questions. Statements should be circulated before the meeting:

**Question 1: State of Play**

How is the governance and regulation of nanoscience and technology currently being conceptualised in your nation? What regulatory initiatives are being developed/considered in this context?

**Question 2: Situated Challenges**

In light of the political history of your nation – especially on matters concerning science and technology – what are the particular challenges and possible opportunities posed in the governance and regulation of nanotechnology? What are the barriers that exist to greater international collaboration on nanotechnology?

**Question 3: Opportunities**

In light of the political history of your nation what opportunities exist for improving the responsible development of nanotechnology in your nation? What opportunities does the European Commission recommendation on a ‘Code of Conduct for Responsible Nanosciences and Nanotechnologies Research’ present for improving international dialogue and cooperation on these issues?
Programme

Thursday 16 April 2009

Participant Arrival and Hotel Check In

Optional “tour” to the BME (Technological Economic University of Budapest), giving some impression on the scientific and engineering research at the University and including significant places for the Hungarian Revolution of 1956

Time 8.00 – 9.30 pm
Venue: Meeting In the lobby of the hotel

Optional Dinner:

Time: 9:30 pm
Venue: Gellért Söröző, in the building of the hotel
Friday 17 April 2009

Venue: Hotel Gellért, “Kávé” Salon

9.00am  Arrival
Welcome:

- Introduction to the workshop: Prof. Arie Rip – University of Twente
- Plenary Presentation: Norbert Kroó Vice-President, Hungarian Academy of Sciences

10.00am  Session One
Participant Introductions

10.30am  Session Two
Roundtable Discussion – Question 1.

11.30am  Tea/Coffee

12.00noon  Session Three
Roundtable Discussion – Question 2

1.00pm  Lunch

2.00pm  Session Four
Roundtable Discussion – Question 3

3.30pm  Tea/Coffee

4.00pm  Session Five: Chair Prof. Phil Macnaghten
Plenary Discussion

4.30pm  Close
Workshop Participants

1. Enikő Demény, Centre for Ethics and Law in Biomedicine (CELAB), Central European University, demenye@ceu.hu
2. Norbert Kroó, Vice-President Hungarian Academy of Sciences, kroo@office.mta.hu
3. Péter Kakuk, CELAB, kakukp@dote.hu
4. Jakub Jasiczak, Poznan University of Economics, jasiczak@home.pl
5. Sergey V.Kozyrev, Center for Advanced Studies, St Petersburg State Polytechnical University, kozyrev@spbcas.ru
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DEEPEN Participants

9. Phil Macnaghten, Institute of Hazard and Risk Research, Durham University, p.m.macnathen@durham.ac.uk
10. Arie Rip, Centre for Studies of Science, Technology and Society, Twente University, a.rip@utwente.nl
11. Matthew Kearnes, Institute of Hazard and Risk Research, Durham University, m.b.kearnes@durham.ac.uk
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Maps
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Supporting Documents

Below we provide four documents as background to the workshop. The first three of the documents are outputs of both the DEEPEN project and its wider research team. The final document is the recently released European Commission Recommendation on a ‘Code of Conduct for Responsible Nanosciences and Nanotechnologies Research’.

The details of these publications are:


The Emerging Governance Landscape of Nanotechnology
Matthew Kearnes and Arie Rip


Introduction

Over the last five years an international policy debate has emerged concerning the appropriate mechanisms for the governance and regulation of advances in nanotechnology. The terms of this debate parallel the classic dilemma in the regulation of emerging technologies – how to regulate in a way that enhances the innovative potential of the field and yet is sensitive to emerging risks to the environment or human health. Such debates about nanotechnology are at the core of policy innovations which together constitute what we term here the “emerging governance landscape of nanotechnology”. In this emerging policy debate initial concern has been raised about the possible eco-toxicity of nanomaterials, together with the broader socio-economic and ethical dimensions of a broad range of possible nanotechnologies. More recently regulatory attention has begun to consider the sufficiency of current regulatory frameworks given the novelty of these materials and their increasing use in a number of consumer products. Initially some NGOs and environmental groups called for mandatory moratoria “on the use of synthetic nanoparticles in the lab and in any new commercial products” (ETC Group 2003, 10) and “on the release of nanoparticles to the environment” (Greenpeace UK 2003). Equally, the internationally recognised review of nanotechnology, conducted by the Royal Society and Royal Academy of Engineers (2004), suggested that “the present regulatory frameworks for protecting humans and the environment are sufficiently broad to encompass nanotechnologies and that a separate regulator or regulatory framework is unnecessary” (p. 76) whilst also recommending that “all relevant regulatory bodies consider whether existing regulations are appropriate to protect humans and the environment from the hazards [of nanotechnology], and publish their review and details of how they will address any regulatory gaps” (p. 77). Accordingly, as discussed below, a number of ‘regulatory reviews’ have recently been commissioned and published internationally, that examine the sufficiency of existing regulatory frameworks and possible regulatory gaps.

In parallel to the publication of these regulatory reviews the nano-landscape has been populated with a number of proposals for new regulatory and governance approaches. Central to this innovation in regulatory thinking is the admitted uncertainty concerning both the possible toxicological risks of nanotechnologies and possible development trajectories of different nano-
enabled products (Sutcliffe and Hidgson 2006). The primary uncertainty regarding the ment trajectory of nanotechnology and its possible risks and broader societal consequences have given rise to the proposition that policymakers and regulators need to identify frameworks of governance that are adaptive and anticipatory, yet which recognize the limits of prediction (Barben, et al. 2007). For example Roco (2006) suggests that the fact that developments in nanotechnology “may create perturbations that could be difficult to control after the fact” and that “some perturbations might be created that affect the very foundations of life” requires “an anticipatory and adaptive governance approach at the national and global levels” (p. 2). The novelty of nanotechnology applications, together with the limits in current understandings of environmental and human health implications, has been used to argue for innovations in governance that, through appropriate feedback mechanisms, are able to respond and adapt to developments in real time.\[1\] Similarly Barben, et al. (2007) suggest that given the fact that “the future prospects for nanotechnology, or nanoscale science and engineering, are fundamentally uncertain”, the main contribution of a largely unprecedented multipronged, large-scale STS approach to nanotechnology is the creation of a broad capacity for “anticipatory governance” (p. 979-980). Emerging approaches to the governance and regulation of nanotechnologies at European and national levels, including current negotiation of regulations and standard setting on supranational levels in the ISO and OECD, are increasingly attempting to adopt this broad anticipatory approach to governance, particularly through the use of voluntary, principle-based forms of soft law.

Coupled with the articulation of anticipatory modes of technological governance are the fora for anticipatory coordination between the various actors involved in the development and commercialisation of nanotechnologies. This is sometimes explicit – for example, in the strategy exercises and some roadmaps in European Technology Platforms and the development of strategic visions of nanotechnology research. Such explicit forms of coordination are always embedded in informal and implicit approaches – for example in the diffuse communication of research and commercialisation strategies at conferences and meetings and other intermediary spaces. This anticipatory coordination constitutes a form of de facto governance of nanotechnology – that is embedded in forms of anticipatory and informal coordination. Such de facto governance is a response to strategic uncertainties around the new and emerging nanotechnologies. Nanotechnology still lives mostly on promises and visions, which creates additional challenges for governance, as well as the need for anticipatory and adaptive forms of governance.

This coupling of regulation and broader research governance and coordination constitutes what we term here an “emerging governance landscape” in which the specific case of the (possible) regulation of novel nanomaterials is increasingly conceived as one element of the broader governance of nanotechnology. Roco (2006) identifies this shift in what he terms “policy mod-
“ernisation” in which regulation is cast as part of the broader governance of emerging technologies. In reviewing the shift from modes of government to modes of governance he states:

In the most common current usage of the term, ‘governance’ implies a move away from the previous government approach (a top-down legislative approach that attempts to regulate the behaviour of people and institutions in quite detailed and compartmentalized ways) to governance (which attempts to set the parameters of the system within which people and institutions behave so that self-regulation or the ecosystem achieves the desired outcomes), or put more simply, the replacement of traditional ‘powers over’ with contextual ‘powers to’…These assumptions underline the switch from government alone to governance in debates about the modernization of policy systems, implying a transition from constraining to enabling types of policy or regulation. (p. 3)

In this sense governance is broader than simple regulation – encompassing the full range of research and innovation policies that together constitute broad structures for the governance of science. Indeed, the way in which regulation is conceptualised as part of the overall governance of nanotechnology is consistent with the fact that scientific governance and the strategic coordination of research and innovation activities have become increasingly central preoccupations of contemporary liberal democracies. Support for technological innovation is typically represented as a key mechanism through which states compete in what has become known as the “global knowledge economy” (European Commission 2003; High Level Group 2004). As innovation has become a central motif of national science and technology policy, concern has shifted to a consideration of the appropriate governance structures and arrangements to enable the successful development of science and technology (Jamison 1989). Accordingly, Roco indicates that the re-conceptualisation of government as governance also entails a positioning of research policy and regulation as ‘enabling’ rather than ‘constraining’. In casting regulation as simply one of a number of “tools of government” set in the context of the overall governance of nanotechnology development and commercialisation, arguments are made in favour of regulatory frameworks that enable the development and commercialisation of nanotechnologies.

In other words, regulation should be regarded as one element in a range of governance approaches, which together operate at the interface between nanotechnology, society and policy to form a new governance landscape. This implies that the effectiveness of regulation does not derive from its own characteristics, but from how it fits into the larger (and emerging) governance arrangements. In what follows we review current regulatory initiatives concerned with emerging nanotechnologies, and discuss how regulation is itself increasingly presented as an element of ‘front-end’ governance of science and innovation – as providing the foundation for
commercialisation in nanotechnology. We therefore describe recent innovations in the field as an emerging governance landscape. This emerging landscape incorporates a number of recent regulatory initiatives, including: regulatory reviews concerning the sufficiency of existing regulatory frameworks for novel nanomaterials; the incorporation of ELSA research and public deliberation at upstream stages in the development of nanotechnology; the recent proliferation of principle-based voluntary codes concerning the development of nanotechnology and the broader emergence of a discourse of the “responsible development of nanotechnology”. In particular we discuss below initiatives developed by the European Commission, the UK Department for Environment, Food and Rural Affairs (Defra) and the US Environmental Protection Agency (EPA). In addition to these initiatives led by state bodies and government departments we consider the proliferation of non-state initiatives, as examples of the use of soft law in the governance of nanotechnology. In particular we consider: The development of the UK Responsible NanoCode by the Royal Society, Insight Investment and the Nanotechnology Industries Association; A “Code of Conduct – Nanotechnology” developed by BASF; The Nanocare Initiative launched by a number of chemical companies; The “Nano Risk Framework to Aid in Responsible Development of Nanotechnology” (2007) developed through the long-standing partnership between DuPont and (US) Environmental Defense (EDF); and the “Code of Conduct: Nanotechnologies” published by the Swiss retailer's association IG DHS.

We characterise the development of this governance landscape as a response to the ‘too early/too late’ dilemma facing regulators in the case of rapidly advancing technological fields. We also suggest that uncertainty regarding the technical knowledge base concerning current nanotechnologies together with more longitudinal uncertainties relating to the development trajectory and social acceptability of nanotechnology provide the rationale for the development of such ‘soft’ approaches, which lack the legal sanction of traditional regulation. Significantly, such soft approaches are cast as anticipatory given this state of uncertainty.

**Anticipatory Governance and Responsible Development**

As we discuss below, debates about the governance and regulation of nanotechnology have become both symbolic and iconic for a set of more generic concerns about the regulation of emerging technologies. In addition to considerations of the sufficiency of existing regulatory and legislative frameworks, over the last few years the nanotechnology field has witnessed the development of forms of voluntary regulation and codes of conduct – evident particularly in the proliferation of voluntary codes, and the emergence of a discourse of “responsible development of nanotechnology” (Doubleday 2007; Meridian Institute and National Science Foundation 2004; NNI no date; Tomellini and Giordani 2008). Though notions of responsibility and “responsible
development” might be traced to its earlier incarnation in Corporate Social Responsibly (Mari-netto 1999), or to a broader philosophical articulation of these terms (Jonas 1985), the instigation of voluntary and soft-law measures on responsible development of nanotechnology heralds a new form of governance. Whilst consistent with a general shift to soft law across a host of policy domains (see for example: Abbott and Snidal 2000){3} the use of voluntary measures and soft law together with the emergence of a discourse of responsible development of nanotechnology is constructed as a strategic response to the uncertainties that structure current nanotechnology development. As such, current debates about the governance and regulation of nanotechnology are being regarded as a test-case of how to regulate early in the development so as to provide a secure regulatory footing to enable the successful (or responsible) development of the technology.{4}

As such in the emerging governance landscape for nanotechnology two main goals are articulated as providing the rationale for new developments. First is the desire for transparency and responsibility. In its consultation paper for a European Code of Conduct for Responsible Nanosciences and Nanotechnologies Research, the European Commission (2007) emphasised that it was part of an “ambition to promote a balanced diffusion of information on nanosciences and nanotechnologies and to foster an open dialogue, involving the broadest possible range of interested parties” and that “the Code of Conduct would offer those following it recognition of a responsible approach towards nanosciences and nanotechnologies research, making their actions more visible at a European level” (p. 2). The final European Commission Recommendation of 07/02/2008 on a Code of Conduct for Responsible Nanosciences and Nanotechnologies Research (European Commission 2008) voices the same ideas, suggesting that:

Good governance of N&N research should take into account the need and desire of all stakeholders to be aware of the specific challenges and opportunities raised by N&N. A general culture of responsibility should be created in view of challenges and opportunities that may be raised in the future and that we cannot at present foresee. (p. 7)

The second main goal is to enable the (responsible) development of nanotechnologies. This is explicitly articulated in the consultation texts for the UK Responsible NanoCode{5}:

Our aim is to develop a voluntary, principles-based Code, which is appropriate for adoption by organisations of all sizes involved in the research, development, manufacturing and retailing of products using nanotechnologies .Our intention is, through an inclusive process – by engaging with companies, scientists, governments, NGOs and labour organisations – to establish a consensus of what constitutes good practice and provide guidance on what organisations can do to demonstrate responsible governance of this dynamic area
of technology. (…) We believe it is in our collective interests to ensure that this potentially powerful set of enabling technologies achieves its potential to deliver health, environmental, social and economic benefits. We believe that this Code will play an important role in helping organisations to develop nanotechnologies responsibly, helping to ensure that this vision is realised. (Anon 2007, 2)

One can, of course, debate whether such codes are effective in accomplishing these aims – in ensuring “that this potentially powerful set of enabling technologies achieves its potential”.{6}

However, for our argument here we highlight the way in which the use of voluntary codes for responsible development is consistent with Roco’s (2006) view of governance as regulatory policy that ‘enables’ rather than ‘constrains’ technological development. The ambitions of the proposed UK Responsible NanoCode are clear in this respect – to “establish a consensus”, “provide guidance” and to “demonstrate responsible governance” – so as to facilitate the successful development and commercialisation of nanotechnologies. As such the terms success and responsibility almost operate interchangeably, suggesting that the underlying assumption is that if commercial interests (the proposed signatories to the code) operate responsibly in the development of particular nanotechnologies, broader innovation in the field “will not be held back” by unforeseen consequences, or adverse public reaction.

The emergence of discourse of responsible development, and its embodiment in current regulatory approaches and in the recently developed voluntary codes, should be read as a strategic response to a specific set of dilemmas in the governance of nanotechnology. The dilemmatic quality of the governance of a field as diffuse as multifaceted as nanotechnology is characterised by Randles (2008) as a “temporal dilemma of nanoregulation in regulating neither ‘too early’ nor ‘too late’ in the development of this emerging technology”. This temporal dilemma recalls wider debates concerning the incorporation of technology assessment and public deliberation in the early stages of technological development.{7} For example Macnaghten, et al. (2005) demonstrate that proposals for the incorporation of ELSI research and public deliberation into the development of nanotechnology were cast as critical to the future development and success of technological developments. Similarly we discuss below the now commonplace notion that given the earliness of current regulatory thinking, nanotechnology represents an opportunity to “get it right” and “avoid the mistakes of the past” (Krupp and Holliday 2005; Rip 2006). As such the key dilemma in current regulatory debates is cast as temporal one – in which regulation that is ‘too early’ will constrain innovation whilst that which is ‘too late’ will fail to prevent possible negative consequences. There is debate on this point, with critical NGOs asking for more government-led regulations and sanctions, while companies argue that it is too early (too many un-
knowns) to have specified regulation and that voluntary reporting and codes of conduct can fill the gap.

Implicit in this debate about the temporal dilemma in nanotechnology regulation is a set of acknowledged uncertainties that structure current governance approaches to nanotechnology. Perhaps more than any of the other initiatives discussed below, the UK Responsible NanoCode is explicit in responding to the uncertainty facing the commercialisation of nanotechnologies. We quote (at length) from a briefing paper, published before the draft code was released for public consultation, which frames the overall intention of the principles-based initiative.

Commercialising nanotechnologies presents huge opportunities for business. But at the same time - while the evidence of harm is currently limited - there is real uncertainty over the potential environmental, health and safety (EHS) risks of some nanoscale materials, particularly the impact of free nanoparticles and nanotubes. The development of nanotechnologies also gives rise to a variety of social and ethical issues – both in relation to their governance and the impact of specific applications.

All businesses with an interest in this area will need strategies for dealing with these uncertainties. It is still early days in the development of nanotechnologies and the environment in which they will be commercialised is not fixed. There is still time to reduce uncertainty through research into potential hazards posed by nanomaterials. Public opinion is still positive to nanotechnologies, the majority of NGO’s have not made it a campaign issue and regulations haven’t been fully set. (Sutcliffe and Hidgson 2006, 2)

This document should be read in light of the fact that its purpose is to make the case for the subsequent NanoCode. As such it emphasises both the opportunities presented by nanotechnology, and areas of uncertainty that require action by companies involved in nanotechnology research and development. Accordingly the suggestion that ‘all will need strategies for dealing with these uncertainties’ makes the case for the NanoCode, by developing a credible business case encouraging commercial interests to consider their response to these uncertainties. Significantly the report suggests that there are three areas of uncertainty that will affect the successful commercialisation of nanotechnology. The first is that of knowledge uncertainties (what the report term “technical uncertainties”), which concern the limited current knowledge on possible ecotoxicological effects of nanomaterials, despite some early warnings. In concert with a number of recent authors Davies (2006), for example, suggests that:
The toxicity aspects of NT are just beginning to be explored…This and other fragmentary knowledge we have of the adverse effects of NT is clearly rudimentary, but it is enough to show that there are potential or actual effects that warrant concern. (p. 9)

In current debates about the governance and regulation of nanotechnology the lack of basic knowledge concerning the possible ecological or toxicological effects of different nanoparticles is acknowledged as the primary driver for regulatory innovation. The voluntary reporting mechanisms currently initiated by both Defra and the US EPA are designed as mechanisms for combating knowledge gaps through voluntary reporting and capacity building. The objective here is to produce baseline data for future research needs concerning the health and environmental risks associated with nanotechnologies (EPA 2007b; HM Government 2007).

The second set of acknowledged uncertainties concerning strategic or commercial uncertainties surrounding the development trajectories of nanotechnology in different industry sectors. In some industries like semi-conductors, there is uncertainty about the balance between ‘more Moore’ and ‘beyond Moore’ and what this means for new product-value chains and industry structure, but no problem about eventual acceptance of the products. In contrast, Renton (2006) reports that “the food industry is hooked on nano-tech’s promises, but it is also very nervous”. The simple fact is that though nanotechnology is seen as heralding great promise in individual sectors, the innovation trajectory is, as yet, unclear. Accordingly Barben, et al. (2007) suggest that “the future prospects for nanotechnology … are fundamentally uncertain” (p. 979) and thus requires new and anticipatory approaches to research governance and evaluation.

Thirdly, the report indicates that looming on the horizon are also uncertainties about public acceptance. This is a complex issue, because of unsupported projections of public perception by promoters of nanotechnology, and the ambivalent role of NGOs and civil society groups. There are some early indicators of “latent anxiety” (see for example: Kearnes, et al. 2006), typically linked to a range of underlying factors and concerns about the role and intrusion of technologies in everyday life. The concern here is for the uncertainty of responses, and for the potential of adverse public reactions to “hold back” nanotechnology developments.{8} For example, addressing the governance of converging technologies with clear relevance for nanotechnology, Roco (2006) articulates a version of this discourse, suggesting that:

There is genuine concern about the disruptive potential of interventions by the converging technologies. … These concerns about converging technologies resonate with long-standing social science analysis of technology running ‘out of control’ (Winner 1977). Along with the relatively low levels of information about converging technologies available, and the low public trust in industry and government, these factors are leading to an
increasing risk of poor public perception, especially in the preassessment phase of the possible implications. A particular concern is that insufficient formal and informal education will result in the misuse or inefficient application of converging technologies. (p. 2)

As highlighted elsewhere, the potential for public concern to hold back developments in nanotechnology is cast as a rationale for the increasingly institutionalised commitment to including lay voices in the development of regulatory approaches, as well as the incorporation of social science, ethics and public deliberation, in the context of a broader “deliberative turn” across a host of policy domains (Kearnes and Wynne 2007; Macnaghten, et al. 2005). Here we suggest that the uncertainty of public responses to emerging technologies – especially nanotechnology – operates as a third rationale for current approaches in concert with a broader framing of the ‘public as problem’ for successful innovation. In the conclusion we consider the wider political and democratic ramifications of this framing.

Given that each of these forms of uncertainty are acknowledged as rationales for the current innovation of the governance of nanotechnology, set in the context of approaches that seek to enable the development and commercialisation of nanotechnologies, in the following section we review current regulatory initiatives and the emergence of notions of responsible development. In the succeeding section we offer some analysis of the way in which responsibility is positioned in the field.

The emerging governance landscape

1. Regulatory approaches and soft law

A recurrent issue in the discussion concerning regulation of nanotechnology is whether there is a need for unique nano-specific regulation. As discussed above, early debate was initiated by strong precautionary approaches and calls for moratoria on the use of nanomaterials in laboratory settings and on their release into the environment. These calls were countered by a more moderate position exemplified in the Royal Society/Royal Academy of Engineering (2004) report which suggested that, though current regulatory frameworks would (probably) be sufficient, reviews of the regulatory needs posed by nanotechnology be published by relevant regulatory authorities. (9)

In international contexts, similar concern has been raised as to the sufficiency of existing frameworks, and in some cases, there have been consideration of new nano-specific legislation (see for example Davies 2006). Whilst in the US this has focused on sufficiency of the Toxic Substances Control Act (TSCA), in Europe debate has centred in the recently adopted REACH
Regulations – Registration, Evaluation, Authorisation and Restriction of Chemical substances (EC 1907/2006) – which entered into force on 1 June 2007. REACH applies to chemical products above a certain volume of production (1 tonne), while some nanomaterials will be produced below that level. While this may be remedied, more difficult is that all regulation of chemicals included in REACH is based on the notion of a material of which the properties do not change with size of the component entities, while the performance of nanoproducts like gold or titanium dioxide derives from their nanoscale sizes. One proposal is to consider nanoscale gold and titanium dioxide as different chemical materials than their macro-level versions, and then apply REACH again.

Responding to these concerns a number of national and international bodies have published overviews and discussion memoranda examining the adequacy of existing structures and any regulatory gaps. Here, we briefly discuss two regulatory reviews commissioned by the UK government, which show the two main strands.

In these UK reviews, there are two recurrent discourses. Firstly, a review commissioned by the Health and Safety Executive (HSE) finds that current regulatory frameworks will be sufficient for nanotechnology. It suggests: “the principles of the existing regulations and the interconnections between them are appropriate and applicable to nanomaterials. We perceive no need to fundamentally change the regulations themselves, nor to introduce new regulations” (p. 14). Similarly FSA (2006): “We believe from the available toxicological data that current approaches to risk assessment should be appropriate for nanomaterials” (p. 24). However a second discourse emerges in the review completed by Defra, which highlights the existence of regulatory gaps that would call for some regulatory action, but not (necessarily) an overthrow of existing approaches. The Defra report identified a number of regulatory gaps, particularly in areas relating to thresholds and exemptions under existing legislation; current scientific knowledge and understanding of risks; lack of information or uncertainties over clear definitions; and reliable and validated methods for monitoring exposure and potential impacts on human and environmental health. (Council for Science and Technology 2007, 27)

Filling these gaps is a long-term project. For that reason, Defra launched a UK Voluntary Reporting Scheme for Engineered Nanoscale Materials. The reporting scheme relies on the voluntary provision of data by “any company or organisation involved in manufacturing, using, importing, researching, or managing wastes consisting of engineered nanoscale materials” in order to develop “a better understanding of the properties and characteristics of different engineered nano-
scale materials, so enabling potential hazard, exposure and risk to be considered” (Defra 2006b, 3).

In parallel, and on the basis of similar overviews of current regulation (EPA 2007b; National Pollution Prevention and Toxics Advisory Committee 2005), the US EPA developed a similar voluntary scheme, entitled the Nanoscale Materials Stewardship Scheme Under the Toxic Substances Control Act (EPA 2007a). The scheme is designed around a similar form of voluntary reporting, broken into a “basic” programme – which “would request participants to report all known or reasonably ascertainable information regarding specific nanoscale materials” (p. 3) – and an “in-depth” programme – which “would likely apply to a smaller set of representative nanoscale materials designated for further evaluation by mutual agreement” (p. 5). The scheme shares many of the same ambitions as the Defra voluntary reporting scheme, principally in building baseline data on engineered nanomaterials and encouraging the use of appropriate risk assessment measures (National Pollution Prevention and Toxics Advisory Committee 2005).

Though both schemes are cast as interim measures, designed to build a knowledge-base on the use of engineered nanoparticles and materials, they constitute a form of anticipatory regulation, in that they attempt to include actors-to-be-regulated in the process of eventually developing regulation. In this sense both schemes are anticipatory rather than strictly precautionary. Similarly, while both schemes have met with limited enthusiasm, they do signal an international interest in soft forms of voluntary regulation to address strategic uncertainties in and around nanotechnology (Bowman and Hodge 2006; Dorbeck-Jung and van Amerom 2008 forthcoming), which we discuss below.

In addition to such ‘induced voluntarism’ – as led by state-agencies and government departments, there have also been bottom-up initiatives in voluntary regulation. In particular, the Nano Risk Framework was created by the unusual alliance of a big chemical firm (DuPont) and a non-profit group (Environmental Defense Fund [EDF]). The alliance was announced in June 2005, and the eventual risk framework, published in June 2007 after wide consultation, is a substantial contribution, even if the alliance has come under criticism by (other) NGOs and trade unions. In the Executive Summary, the authors actually note the link with government regulation:

We believe that the adoption of this Framework can promote responsible development of nanotechnology products, facilitate public acceptance, and support the development of a practical model for reasonable governmental policy on nanotechnology safety. (DuPont 2007, 7)

While a voluntary scheme need not be more than just that, an invitation to actors, there may be pressures that turn it into de facto governance. Branch organizations with their own responsibili-
ties may get involved, there may be credibility pressures, and some companies may see their engagement in such a scheme as a competitive advantage. We will come back to such dynamics when we discuss voluntary codes. For the moment we note that Dorbeck-Jung and Van Amerom (2008 forthcoming) suggest that “presently, soft law is emerging at various levels of nanotechnological regulation. By soft law we understand rules of conduct which in principle have no legally binding force, but which nevertheless have effects in legal practice”. One reason why there are effects is through the legal principle of good faith.\(^{16}\) This soft approach to regulation is embodied in the proliferation of new regulatory mechanisms which utilise non-State apparatus and forms of voluntarism (Abbott and Snidal 2000; Ahonen 2001; Bowman and Hodge 2006; Trubek, et al. 2005).

As outlined above this development of soft-law approaches to regulation is consistent with the overall ambition to enable continued innovation in nanotechnology whilst anticipating the future need for more stringent approaches. As the European Commission phrased it summarily: “The regulatory challenge is (..) to ensure that society can benefit from novel applications of nanotechnology, whilst a high level of protection of health, safety and the environment is maintained” (Commission of the European Communities 2008). Discussions of regulatory approaches are suspended between projections of the future promise and the possible risks of nanotechnology. These visions are not always articulated in the discussions, which can focus on the technical and administrative aspects but remain the backdrop, and become visible as soon as a proposal for a moratorium incites principled debate. As such, the current regulatory reviews and voluntary reporting schemes seek to address the technical uncertainties concerning the use of nanomaterials and emerging evidence regarding their safety and exposure levels. The voluntary nature of these schemes, although currently under-subscribed, is consistent with the broader reliance on non-state soft law and incentivised approaches in creating flexible and adaptive governance frameworks.

2. ELSA and public deliberation

As introduced above, the second characteristic feature of the emerging governance landscape of nanotechnology is the incorporation of ELSA research, together with public participation and deliberation, into nanotechnology research programmes. This incorporation is part of the governance landscape in so far as it modulates current activities. One strand is the push towards so-called upstream public engagement, particularly evident in the UK (Kearnes and Wynne 2007; Kearnes, et al. 2006; Macnaghten, et al. 2005). Though there is considerable debate about the precise role that these approaches might play in the governance of emerging science and technology,\(^{17}\) there is a broad international consensus on the need to incorporate ethical analysis, societal aspects and public engagement into nanotechnology development programmes (European
Commission 2004; HM Government 2005; Roco and Bainbridge 2001) – a fact which resulted in the US in the funding of a number of social science research centres, considering the role of nanotechnology in society.\{18\}

Macnaghten et al. (2005) trace the emergence in nanotechnology policy of a consensus regarding the potentially constructive role that both social science and public engagement might play in the development of nanoscience and nanotechnology. Building on the model established by the ELSA programme of the Human Genome Programme, in which a proportion of genetics research funding was reserved for identifying the ethical, legal and social implications of human genetics research, early nanotechnology policy documents spoke of nanotechnology as a ‘rare opportunity to integrate the societal studies and dialogues from the very beginning and to include societal studies as a core part of the [nanotechnology] investment strategy’ (Roco and Bainbridge 2001, 2). UK policy on nanotechnology indicates an official commitment ‘to enable [public] debate to take place “upstream” in the scientific and technological development process, and not “downstream” where technologies are waiting to be exploited but may be held back by public scepticism brought about through poor engagement and dialogue on issues of concern’ (HM Treasury/Department of Trade and Industry/Department of Education and Skills 2004, 105).

Nanotechnology is therefore cast as an opportunity to road-test new forms of participatory and deliberative public engagement with a technology in the early stages of its development (Macnaghten, et al. 2005).\{19\} The initiation of forms of participatory and deliberative approaches is also set in the context of what has been described as a deficit in public trust concerning science and technology (House of Lords Select Committee on Science and Technology 2000). Public engagement is therefore represented as a mechanism through which to restore public trust by increasing the transparency and accountability of scientific governance and policy development. Though UK policy increasingly speaks of a commitment to forms of upstream public engagement, the clear rationale of this policy development is to ensure that technologies are not “held back” by public scepticism (Kearnes and Wynne 2007).

The incorporation of ELSA research and public deliberation initiatives into nanotechnology research programmes therefore constitutes an additional element of the emerging governance landscape of nanotechnology. This is further reinforced by the way in which the direct engagement of citizens and their participation in decision making is increasingly cast as a necessary condition of responsible policy making. This is embodied in recent voluntary codes on the responsible development of nanotechnology, which we discuss below, which require signatories both to transparently publish the results of risk research and to engage in stakeholder engagement processes. However, more broadly, the engagement of the public is increasingly cast as a democratic precondition. For example, in the recent resolution, adopted by the European Trade Union Confederation (2008), on Nanotechnologies and Nanomaterials, it is suggested that:
Since nanotechnologies have the ability to profoundly alter the social, economic and political landscape of our societies, it is essential that all interested parties have a full say in the discussions and decisions that affect them. The ETUC therefore calls on the European Commission and Member State governments to commit sufficient funds to ensure real civic participation in the current debate on these new technologies. (p. 7)

There is then a growing expectation that ‘civic participation’ should play a part in the development of nanotechnologies. Though there have been criticisms of this deliberative turn in nanotechnology policy – relating particularly to the capacity of such deliberation to affect strategic change{20} – here we simply suggest that the incorporation of ELSA research and public deliberation into nanotechnology research programmes constitutes an element of the emerging governance landscape for nanotechnology. Importantly this governance function is cast as an enabling one, set in the context of the acknowledged uncertainty relating to public responses to nanotechnology (Kearnes and Wynne 2007).

3. Voluntary codes on Responsible Development

The final element of the emerging governance landscape of nanotechnology that we review here is the recent proliferation of voluntary codes – particularly those concerning the ‘responsible development of nanotechnology’. As outlined above, building on the broad international policy consensus on the need to build social-science insight, public engagement and deliberation into the development of nanotechnology, together with ongoing studies on the possible toxicology of engineered nanomaterials, a discourse of ‘responsible development’ has emerged that seeks to address these overlapping concerns. Allied to this, the incorporation of ELSA research and public deliberation into nanotechnology research programmes is increasingly embodied in the text of such codes. Additionally, such codes may be characterised as a response to the uncertainty facing the regulation of emerging technologies, both through an attempt to ‘normalise responsibility’ and to pre-empt direct regulation itself. Indeed we suggest that the recent proliferation of voluntary codes represents the culmination of innovations in governance approaches, epitomising the reliance on flexible soft law mechanisms and the attempt to incorporate ethics and best practices into the development of nanotechnology.

Recent and overlapping initiatives, developed by both State and non-State actors, include:
2. A “Code of Conduct – Nanotechnology” developed by BASF, which addresses the corporation’s responsibilities to “our employees, customers, suppliers and society but also towards future generations” (BASF no date).
3. The Nanocare Initiative launched by a number of Chemical Companies (www.nanopartikel.info).
5. The “Nano Risk Framework to Aid in Responsible Development of Nanotechnology” (2007) developed through the long-standing partnership between DuPont and (US) Environmental Defense (EDF, see: DuPont 2007).

There are two aspects to proliferation of these codes that are important in considering their governance implications:

a) Quasi- legality of soft law
First is the quasi-legal status of these codes. For example, Mörth (2004) describes the proliferation of soft forms of regulation, as we are currently witnessing for nanotechnology, as a characteristic feature of the distribution of political power and authority evident in the shift from government to governance. She suggests that:

Governance rests upon multiple authorities that are not necessarily public and sharing. In systems of government the law is hard; in systems of governance the law is soft. The crucial difference between these two types of legal norms is that soft-law lacks the possibility for legal sanctions. Thus soft law is not considered legally binding. (p. 2)

In addition to their lack of legal sanction, the interdependence between soft law and governance is reinforced by what Mörth describes as “synergetic relationships between private and public activities that partially reinforce each other” (p. 2). For Mörth, though there are important differences between governance and soft law, they are mutually dependent, such that the turn toward soft forms of law and regulation is consistent with the overall ambitions of governance arrangements that ‘enable’ behaviours by setting goals and incentives, without the use of legal sanction associated with traditional forms of regulation. Similarly Abbott and Snidal (2000) suggest that

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across a number of policy domains and regulatory fields a continuum between hard and soft law approaches is emerging dependent on the perceived transaction costs associated with each regulatory option. As such soft law, particularly as deployed by the state, is typically cast as a flexible approach – with the advantage over more formal regulation of being able to adapt quickly to new situations and regulatory needs (Ahonen 2001; Borrás and Jacobsson 2004). Similarly the use of soft law has become a significant form of governance in a number of international fora – for example in supranational fora such as the EU or OECD – in which international agreement based on the incentivisation of behaviour rather than strict international sanction (Åkermark 2004; Jacobsson 2004; Marcussen 2004; Österdah 2004).

For Webb (2004) the emergence of soft law and what she terms “private governance” over the last twenty years is set in the context of the acknowledged weaknesses in traditional command-and-control regulation. She suggests that issues such as the expense and protracted nature of development and enforcement processes for traditional command-and-control regulation, together with the legal restrictions on regulatory subject matter and vulnerability due to inconsistent enforcement mechanisms, have led to innovations in the use of soft law and voluntary arrangement in involving actors in forms of self governance. For Webb, soft law is therefore defined as mechanisms which rely on non-judicial forms of power that encourage desired behaviours rather than prohibit undesired actions. She suggests that:

Unlike conventional command-and-control regulatory approaches, voluntary codes harness market, peer and community energies to influence behaviour, and draw on the infrastructure of intermediaries such as industry associations, standards organizations and non-governmental organizations for rule development and implementation. In a way, the renewed interest by governments in non-State approaches to governing takes us full circle: voluntary rule systems have been used since earliest times to articulate shared norms and to structure interpersonal relations, and indeed pre-date the modern State. (Webb 2004, 4)

The sheer number of recent principle-based codes concerning nanotechnology that have been developed by both state and non-state bodies suggests that, though each code has its own specific rationale, the coincidence between public and private action is a response to the temporal uncertainty that frames nanotechnology regulation. As Randles (2008) describes the ‘too early/too late’ dilemma, regulators are caught between regulating too early and stifling innovation and regulating too late, and thus fail to have measure in place when needed. The voluntary codes, especially those developed by individual companies or industry bodies might therefore be read as (strategic) attempts to respond to this dynamic. For example, each of the codes is framed as a response to
both the perceived opportunities that nanotechnology presents and the possibility of unforeseen risk and consequences. However each code is aimed differently. For example, the ‘Code of Conduct: Nanotechnology’ developed by BASF begins with the assertion that:

Along with offering opportunities, all new technologies also pose risks and this is true for nanotechnology, too. In order to tap into the opportunities offered by technological progress, we want to use new technologies when manufacturing innovative and market-grade products. Only on the basis of these concrete products can a rational assessment be conducted of the potential risks, compared with the opportunities, these products pose. This means that only the willingness to pursue opportunities and risks on a gradual basis will make innovations based on new technologies possible. (BASF no date, 1)

BASF’s intention here is to present its strategy as providing the basis for “rational assessment” of potential risks – clearly anticipating the possibility of the development of more stringent regulations on nanotechnology, and positioning BASF accordingly. The code therefore operates in an anticipatory fashion as a demonstration of best-practice and a stake in shaping anticipated future regulation through developing an information base on nano-materials. The Nano Risk Framework, developed through a collaboration between EDF and DuPont, situates itself similarly, as a “systematic and disciplined process to evaluate and address the potential risks of nanoscale materials” (DuPont 2007, 7). In a similar fashion to the BASF code, the Nano Risk Framework represents itself as an “information led” approach that develops a rational basis for future regulation. The code operates to both produce baseline data and to demonstrate best-practice within DuPont. As such the framework has six steps for both the development of information of the use of nano-materials, and commissioning of forms of life-cycle analysis and risk management. The six steps, which operate sequentially through the lifecycle and risk assessment processes, include:

Step 1: Describe material and application
Step 2: Profile Lifecycle(s)
Step 3: Evaluate Risks
Step 4: Assess Risk Management
Step 5: Decide, Document Act
Step 6 Review and Adapt (DuPont 2007, 8)

In this respect the Nano Risk Framework is similar to the voluntary schemes developed by Defra and the US Environmental Protection Agency, inasmuch as it relies on developing baseline data upon which to commission life-cycle analyses and further risk assessment and risk management
activities. However the framework goes further than both of the voluntary schemes, in that it requires action on the basis of the information developed. As quoted above, it is through this “information-led” process that the authors of the framework suggest that “the adoption of this Framework…support[s] the development of a practical model for reasonable government policy on nanotechnology safety” (DuPont 2007, 7). In this way the BASF and EDF/DuPont codes operate strategically and in an anticipatory way, in order to guarantee each firm a stake in future regulatory debates, and indeed to frame future debates on the regulation of nanotechnology through the compiling of relevant information and the demonstration of best practice.

It is this final ambition of the nano risk framework – to provide a model for state-led governmental policy – that defines the strategic rationale for such forms of voluntary self governance and demonstrates the interplay between private and public bodies in the regulation of emerging technologies. Significantly voluntary self-regulation is itself modelled on its precursor – the Responsible Care® Programme which was developed in the late 1980s. The Responsible Care® programme shares many features with the current development of voluntary codes for nanotechnology – principally that it is ‘industry led’ and lacks explicit sanction that would be imposed upon signatories that contravene its ten ‘guiding principles’ (King and Lenox 2000).{21} It is perhaps no coincidence that firms currently engaged in the development of voluntary codes for nanotechnology – principally DuPont, BASF and Evonik-Degussa – operate in the chemicals sector, with its historical involvement in the Responsible Care® and corporate social responsibility programmes.{22} Significantly, King and Lenox (2000) identify that the Responsible Care® programme was initiated as a response to a perceived decline in public opinion relating to the chemicals industry, and the recognition that “improved performance among all chemical firms was essential to its public acceptability and intimately its viability” (p. 699).{23}

Here we locate the development of voluntary, industry-led codes on nanotechnology as strategic responses to uncertainty. Lee and Jose (2008) suggest that in the short term, such forms of corporate social responsibility may prove to be the most effective means to fill the regulatory void. Thus many elements of corporate social responsibility (CSR), such as transparency, stakeholder communication and ethical consideration, now fall within self-regulation, given the uncertainties and dearth of data about the risks posed by nanomaterials. Failure to engage with these issues may delay or hinder potential market opportunities while at the same time reducing industry’s capacity to avoid or mitigate potential drawbacks. Thus, according to Lee and Jose, managers in nanotechnology need to manoeuvre their way through this rapidly evolving “uncertain/many-futures world” (p. 118). For example, in a briefing paper for the proposed UK Responsible
NanoCode, Sutcliffe and Higson (2006) outline the business case for such an initiative in the following way:

The challenge for business, therefore, is whether its technology development and commercialisation process is sufficiently inclusive to understand and mitigate risks from these wider uncertainties. There is an essential need for good quality transparent research into the environmental and health risks, and it may be in the long-term interests of business to play a role in filling this gap. Business must convince investors, insurers, NGOs, government, the media and perhaps most importantly the general public that it understands the technology and is taking a responsible approach, which will require a very open style. There is also a case that business has a role in helping get the right legislative and commercial framework to allow it to bring the technology to market safely and profitably. (p. 16)

As such the NanoCode is represented as a response to uncertainty. Indeed the dimensions of this uncertainty – technical, commercial and social uncertainties – define the business case for commercial involvement in early regulation, in the form of a voluntary code. Significantly however, this response operates strategically, through the suggestion that such initiatives might assist commercial interests in “helping to get the right legislative and commercial framework”. The subtext here then is that the code is also a response to a fourth area of uncertainty – that of the anticipated government-led regulation on nanotechnologies. Voluntary codes therefore operate rhetorically to demonstrate best practice whilst anticipating the possibility of more formal, government led regulations on the use of nanomaterials. Allied to this, recent scholarship has highlighted the ways in which voluntary regulation relies on maintaining both credibility and legitimacy in their fields of operation in order to establish and preserve their capacity to influence action (Cashore 2002). Here we see a double move in the establishment of this legitimacy in the attempt by the code promoters to make a credible case for broader commercial interest in the code on the basis that subscription to the code will enable for commercial players a credible basis upon which to influence subsequent regulatory policy.

b) Positioning Responsibility
The second significant aspect of recent, code-based initiatives is the way in which they embody the emergence of a broader discourse of ‘responsible development of nanotechnology’. Though this is immediately relevant for the codes developed by the European Commission (on Responsible Nanosciences and Nanotechnologies Research) and the UK Responsible NanoCode, the inclusion of notions of responsibility in each of these codes represents an emerging international policy consensus in which the ‘responsible development of nanotechnology’ has been cast as a default way forward.\textsuperscript{25} The emergence of notions of responsible development therefore represents the culmination of what we are describing here as the governance landscape of nanotechnology. We depict this landscape in Figure 1, in which the multiple initiatives that address the uncertainties in developing nanotechnology – upstream public engagement, outreach and communication strategies, ELSA and TA research, regulation and soft law – are cast as bridging the gap between ongoing nanotechnology developments and the wider society. Therefore the common diagnosis of such a gap between technology and wider society, and the need the bridge this gap with new initiatives, partly constitutes the governance landscape of nanotechnology. Secondly, due to the (at least discursive) interest in responsible development of nanoscience and nanotechnology, these activities are note separate items, but part of an emerging pattern of governance mechanisms. Governance challenges thus lead to creation of new configurations, and the pattern that emerges then enables further governance functions.

Figure 1: Graphical Illustration of the Emerging Governance landscape of nanotechnology.
What we suggest here is that, for its promoters, the emergence of notions of responsible development represents two key imperatives in innovation of nanotechnology – set in the context of the overarching acknowledgement of uncertainty. Firstly, the conjunction, ‘responsible development’ represents the culmination of a governance landscape – and a set of both state and non-state governmental initiatives – aimed at ‘facilitating’ or ‘enabling’ nanotechnology development. According to the US National Nanotechnology Initiative, for example, the ‘responsible development of nanotechnology’ involves a “multitude of factors” including “the commercialization of widely beneficial applications, simultaneous planning for societal changes that could result from such innovation, and the avoidance of potential negative impacts from new products. And because technological innovation is a global phenomenon, responsible development will be achieved most effectively through international cooperation” (NNI no date). Similarly, the National Research Council (2006) defines the responsible development of nanotechnology in the following way:

Responsible development of nanotechnology can be characterized as the balancing of efforts to maximize the technology’s positive contributions and minimize its negative consequences. Thus, responsible development involves an examination both of applications and of potential implications. It implies a commitment to develop and use technology to help meet the most pressing human and societal needs, while making every reasonable effort to anticipate and mitigate adverse implications or unintended consequences. (p. 73)

As such responsible development offers an overarching framing of the governance of nanotechnology as fundamentally defined by its capacity to ‘enable’ research whilst balancing any negative consequences. As is typical in public representations of emerging technologies, nanotechnology is here framed entirely as a cost-benefit calculus, with the role of governance being to balance between the two. In fact, in contradiction to Hans Jonas’ famous dictum that “it is no sin to delay a benefit”, we are witnessing the framing of responsibility as the necessity to commercialise nanotechnologies for the benefit of human kind, and for this commercialisation not to be ‘held back’.

The second aspect of this discourse of responsible development is the way it operates internationally as a tool for the development of global consensus and strategy. For example, as quoted above, the NNI suggests that “responsible development will be achieved most effectively through international cooperation”. Similarly the European Code of Conduct for Responsible Nanosciences and Nanotechnologies Research, which operates through the “voluntary adoption
of the Code of Conduct by relevant national and regional authorities’, suggests that the recommended code ‘aims at contributing to proper coordination between Member States with a view to optimise synergies between all nanosciences and nanotechnologies research stakeholders at European and international level’ (European Commission 2008, 3). As such the code operates, almost irrespective of the precise wording of the code text, as a vehicle for infra-Europe and international coordination. We therefore suggest that the emergence of the discourse of ‘responsible development’ operates as ‘second order path’ in the international coordination of research activities. Significantly, the rationale for this international and strategic coordination is the acknowledged commercial uncertainty inherent in current nanotechnology development.

The emerging discourse of responsible development and its embodiment in various codes thus open up new spaces where actors from different social worlds meet and interact. This runs from experiments in dialogue to anticipatory coordination meetings to global initiatives. An interesting example of a space created by actors themselves is the International Nanotechnology Conference for Communication and Cooperation (INC), now in its fourth international meeting (in Tokyo, April 2008). Intel Corporation and the US Semiconductor Association are important driving forces, together with Philips, the European Nano-electronics platform ENIAC, and the Belgian research institute IMEC. There is no formal product, like a strategy document, but there is lots of informal interaction. In a sense, a circle of “good” firms that are willing to exchange, to some extent, is created, which then allows further bilateral and multilateral activities. The success of ENIAC, and the ensuing European Joint Technology Initiative Artemis, derives also from their being embedded in the INC world. Another example of a space, now created by administrators/policy makers, is the International Dialogue on Responsible Development of Nanoscience and Nanotechnology. Set in motion in 2004 by Mike Roco (US National Nanotechnology Initiative) and Renzo Tomellini (European Commission’s Program on Nanomaterials and Processes),{26} and still depending on their input, it now has a life of its own – with a fourth meeting planned in Russia in 2009. In this sense global politics go hand in hand with responsible development of nanotechnology. As such we see the entwining of notions of commercial uncertainty, particularly concerning the development trajectory of nanotechnologies in global context, with the wider concept of responsibility.

We claim that this is not just an observable trend towards reflexive, responsible and socially robust nanotechnology, but actually a new aspect of the development of emerging technology in general, which cannot be reversed. It is what evolutionary economists and sociologists of technology have called a (natural) trajectory (Nelson and Winter 1977; Rip 2008). The notion of a trajectory or a path followed by a specific technological development, deriving from a paradigm (Dosi 1984) or dominant design (Tushman and Anderson 1997) that shapes choices and strategies, is well known. Nelson & Winter added long-term overarching drivers or super-heuristics
like mechanisation (since the 19th century). Automation (since the 1950s, with precursors at least since the 1920s) would be another example. Miniaturization would be a more specific, but still overarching natural trajectory. Nanotechnology partakes in such trajectories, but also shows the emergence of further super-heuristics that are now framed as creating socially robust science and technology.\{27\}

**Conclusion**

In this paper we have reviewed a number of current initiatives in the governance and regulation of nanotechnology. We have detailed the current proliferation of activities – which include an array of regulatory reviews, voluntary schemes, public deliberation and ELSA initiatives, as well as both industry and government-led codes on the responsible development of nanotechnology. We suggest that the rationale that frames current governance innovation are temporal in nature and revolve around the perennial question of whether regulation is too early or too late. This is compounded by a state of fundamental uncertainty concerning nanotechnology – particularly in relation to technical data detailing the health and environmental consequences of nanotechnologies, together with wider commercial and public uncertainties. This uncertainty produces a dynamic in which “good governance” is necessarily framed as that which enables rather than constrains the further development of nanotechnology. Significantly, the range of initiatives that constitute the governance landscape of nanotechnology are thus cast as enabling development in multiple ways: through the complication of base-line eco-toxicological data in the case of voluntary reporting schemes, by maintaining public trust and offering insight on wider societal issues in the case of ELSA research and public deliberation; and through the strategic demonstration of best practices in the case of industry-led codes on nanotechnology.

We therefore suggest that the various initiatives that constitute the emerging governance landscape of nanotechnology have culminated in the discourse of ‘responsible development’ which has materialised in recent years in nanotechnology policy. The discourse operates as a meta-framing of the governance of nanotechnology, emphasising mechanisms that enable the ‘benefits’ of nanotechnology to be realised whilst innovating strategies for avoiding possible negative consequences. Indeed, we suggest that ‘responsibility’ is framed as a ‘responsibility to commercialise nanotechnology’ and for such commercialisation not to be held back. This notion of responsible development also operates strategically as a second-order path in the international coordination of research efforts, and should therefore be understood as a strategic tool, rather than simply a socio-philosophical heuristic.

In conclusion, we highlight that currently nanotechnology policy is framed around an opposition between the potential benefits that nanotechnology may produce and factors that
would ‘hold these back’. Building on earlier experiences, like the so-called impasse over (green) biotechnology, there is a sense of ‘getting it right this time, and from the very beginning’. Macnaghten, et al (2005) analyse the way in which nanotechnology has been cast as an opportunity for the incorporation of both social science and public deliberation under the expectation that this will enable the development of nanotechnology to be more successful.\(^{28}\) The notion of ‘getting it right for nanotechnology’ is consistently repeated in the public debate concerning nanotechnology. For example, commenting on the launch of the Nano Risk Framework – itself the product of a novel alliance between the big chemical firm DuPont and the non-profit group Environmental Defense – Chad Holliday, Jr., chairman and CEO of DuPont, and Fred Krupp, president of Environmental Defense, co-authored a Wall Street Journal article entitled, “Let’s Get Nanotech Right” (Krupp and Holliday 2005). Perpetuating the notion that nanotechnology represents an opportunity for earlier identification of risks and appropriate regulatory measures, Krupp and Holliday suggest that “[a]n early and open examination of the potential risks of a new product or technology is not just good common sense—it’s good business strategy” (p. B2). Risk governance, ELSA research and public deliberation are cast as central to achieving the benefits of nanotechnology.

However, whilst this framing of risk, and also of public concern as a “barrier to innovation”, is a consistently repeated framing of public discussions concerning new technologies (see, for example, Expert Group on Science and Governance 2007) it is a deeply flawed logic. The notion that uncertainty caused by public concern may be simply managed through processes of public deliberation is countered by the findings of deliberative research which reports that concern is most consistently about the purposes of technological innovation and the adequacy of regulatory controls, rather than the risks associated with new technologies. Indeed, Sarewitz (2007) makes precisely this point in his contribution to a recent Royal Commission of Environmental Pollution (RCEP) “Novel Material Study”\(^{29}\) suggesting that:

Innovation systems in general do not include mechanisms to make visible and accessible the role and characteristics of diverse decision makers and decision contexts. Decision processes and risk selection mostly remain invisible and in the hands of narrow sets of interests who, almost by definition, will construe their activities in terms of benefits not risks. (p. 4)

He goes on to propose another model of risk governance – consistent with the move made by the authors of the Science and Governance: Taking European Knowledge Society Seriously report (Expert Group on Science and Governance 2007) from “risk governance” to “innovation governance” – suggesting that:
Technologies—the products of the innovation system—[are] not as sources of risk to be assessed, but as nuclei around which segments of society may organize to accomplish goals and select risks. (p. 6)

Our review has shown the emergence of a new governance landscape, framed by notions of risk and benefit and a discourse of responsible development cast simply as a balancing calculus between these two. It thus demonstrates the saliency of Sarewitz’s proposition. Current initiatives in the emerging governance landscape of nanotechnology rely on the assumption that the foundational uncertainties that frame nanotechnology development might be addressed through rational action. However, it should be clear, even in the case of traditional risk assessment, that scientific research rarely ‘reduces uncertainty’. Rather it is able to describe in greater detail the contours of this uncertainty. So too, ELSA research, public deliberation and voluntary regulation are unlikely to reduce public or social uncertainty without a more thorough and transparent reflection on the underlying purposes of nanotechnology and its role in everyday life.
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References


Defra. 2006a: *A Scoping Study to Identify Gaps in Environmental; Regulation for the Products and Applications of Nanotechnologies*. London: DEFRA.


European Trade Union Confederation. 2008: ETUC Resolution on Nanotechnologies and Nanomaterials. Brussels: ETUC.


Simmons, P., and Wynne, B. 1993: Responsible care: Trust, credibility, and environmental management. In K Fischer and J Schott (eds.) Environmental Strategies for Industry: Interna-


Endnotes

{1} See Guston and Sarewitz (2002) on ‘real-time technology assessment’.

{2} At the time of writing this code has yet to be released. An earlier version has been released for public comment as a consultation document. At the time of writing the code website states that the final version of the code and a Benchmarking Framework will be released in October 2008 (see www.responsiblenanocode.org/).

{3} Similarly for companies like BASF and Evonik (Degussa) who have developed their own initiatives on the Responsible Development of Nanotechnology, there is some continuity with
the earlier Responsible Care® Program of the chemical industry worldwide, as well as an attempt to articulate best practice to pre-empt strict regulation (see: King and Lenox 2000; Simmons and Wynne 1993).

4. We refer below to the often repeated notion that nanotechnology represents an opportunity to ‘get it right from the beginning’ or the ‘avoid the mistakes of the past’. In this way current debates about nanotechnology have assumed an iconic or symbolic role in scientific and technological governance more broadly.

5. As discussed below the Responsible Nano Code has recently been developed by the Royal Society, Insight Investment and the Nanotechnology Industries Association (Anon 2007; Sutcliffe and Hidgson 2006). At the time of writing the code has been published in draft format for consultation purposes.

6. For a wider discussion of the political economy of voluntary codes see Purchase (2004).


8. See Expert Group on Science and Governance (2007) and Kearnes and Wynne (2007) on the notion that ‘public concern’ holds back technological development, and then becomes ‘the problem’ addressed by a host of policy initiatives.

9. The report also offered two significant distinctions, now shaping regulatory approaches: between ‘natural’ and ‘manufactured’ or ‘engineered’ nanoparticles, and between ‘free’ and ‘fixed’ nanoparticles. The focus of concern was and is about the possible adverse effects of ‘free’, ‘manufactured’ nanoparticles.


11. These discussions are connected to broader debates about the definition of nanotechnology and the use of the label ‘nanotechnology.’ The common definition refers to scale: for at least one relevant dimension, the size should be between 1 and 100 nanometer. There are also definitions which start at 0.1, and/or do not define an upper limit but require new phenomena and functionalities. Accordingly standardisation plays a part in clarifying the nanotechnology nomenclature (BSI 2005).

By the Health and Safety Executive (HSE 2006), the Department For Environment, Food and Rural Affairs (Defra 2006a), the Food Standards Agency (FSA 2006), the Medicines and Healthcare Products Regulatory Agency (Costgan 2006; MHRA 2008) and Council for Science and Technology (Council for Science and Technology 2007).

See also Frater, et al. (2006) which comes to similar conclusions.

For example, at the time of writing only nine companies had registered with the Defra scheme and the EPA had received four submissions under the basic program (and commitments from 12 more companies) whilst no company has agreed to participate in the in-depth programme. Interestingly, a joint statement by, The Synthetic Organic Chemical Manufacturers Association’s (SOCMA) Nanotechnology SME Coalition, American Chemistry Council’s (ACC) Nanotechnology Panel, and the the NanoBusiness Alliance, recently exhorted companies to participate, under the threat of more traditional regulation. The statement suggests that ‘[a] voluntary program with built-in flexibility is appropriate at this time...If voluntary participation in the NMSP is low, EPA may need to resort to more traditional mandatory information gathering measures [compelling companies to do more work]’ (Synthetic Organic Chemical Manufacturers Association 2008).

This point was forcefully made for codes of conduct linked to corporate social responsibility, by Hoff (2006).


See for example the NSF funded network on Nanotechnology in Society which incorporates NSF funded research centres at Arizona State University, The University of California, Santa Barbara, the University of South Carolina and Harvard University.

See Kearnes et al. (2006) for a description of the way in which this discourse operates to define nanotechnology. This is reinforced by ongoing debates regarding the precise stage in the research trajectory (Fisher, et al. 2006; Joly and Rip 2007).

In a systematic evaluation of the upstream public engagement activities in the UK (Gavelin, et al. 2007) it was shown that upstream engagement projects contributed to improved mutual understanding between scientists and members of the public. An important criticism was the lack of clear links with nanotechnology policy and decision making processes. The authors of the report argued that this was related to the lack of a clear strategy (of the UK government) about what to do with the public engagement activities and offered several recommendations to overcome this problem, including more focus on purpose and outcomes of engagement activities as well as more involvement of decision-makers.

Indeed for the Responsible Care® programme, practically, the only sanction available is the revocation of the membership of the Chemical Manufacturers Association of ‘any company
that persistently conducts its operations in a manner inconsistent with Responsible Care’ (King and Lenox 2000, 700). Curiously for nanotechnology, in which no similar body exists, even this sanction is unavailable to commissioners of voluntary initiatives.

{22} The two exceptions are recent codes proposed by the Swiss retailers’ association and the UK Responsible Nano Code, which are both developed by industrial associations outside the chemical industry.

{23} Webb (2004) locates this decline in public opinion relating to the chemicals industry to disasters such as that which occurred at the Union Carbide plant in Bhopal India in the mid-1980s, which produced the incentive for the Chemical Manufactures Association to devise and implement the Responsible Care® programme.

{24} See Purchase (2004) on the strategic use of voluntary codes in this way.

{25} There are clear parallels here between the notion of responsible development and the more familiar, though equally quixotic, term sustainable development, both of which emphasise development under the conditions of uncertainty.

{26} See the report of the first meeting in Alexandria, Virginia (Meridian Institute and National Science Foundation 2004). Tomellini and Giordani (2008) discuss the third meeting and provide a brief history of the initiative.

{27} In evolutionary terminology, such a trajectory provides a nexus between ongoing variation and selection environments (Van den Belt and Rip 1987).

{28} For example Roco and Bainbridge (2001) suggest that ‘[a]s the NNI is commencing, there is a rare opportunity to integrate the societal studies and dialogues from the very beginning and to include societal studies as a core part of the NNI investment strategy’ (pp. 2, 10, emphasis in original). See also Rip (2006) on the notion of avoiding the ‘mistakes of the past’ that operates as a ‘folk theory’ in the development of nanotechnology.

{29} At the time of writing the RCEP study had received submissions and been published in draft format only for expert review.
Is it all about human nature? Ethical challenges of converging technologies beyond a polarized debate

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This article seeks a better understanding of the debate on the ethical challenges posed by converging technologies in the two versions offered by the United States (NBIC) and Europe (CTEKS) and plans to achieve three things. First, I want to show that the reduction of the ethical challenges posed by these technologies to the question of human nature, creating a polarization of positions, has generated a sort of impasse from which it is difficult to escape. This has already been partly referred to by other authors. Second, I want to show that the European conception of CTEKS proposes a different way of framing the ethical questions surrounding converging technologies. Third, I want to provide a reason why we should follow the route indicated by the European approach and move away from the questions around human nature, being at the same time aware that this approach is only in its initial phase.

Keywords: human nature; enhancement; converging technologies; nanotechnology

At this unique moment in the history of technical achievement, improvement of human performance becomes possible. Caught in the grip of social, political, and economic conflicts, the world hovers between optimism and pessimism. NBIC convergence can give us the means to deal successfully with these challenges by substantially enhancing human mental, physical, and social abilities. Better understanding of the human body and development of tools for direct human–machine interaction have opened completely new opportunities. Efforts must centre on individual and collective human advancement, in terms of an enlightened conception of human benefit that embraces change while preserving fundamental values (Roco and Bainbridge 2002, p. 3).

This quotation is taken from the NBIC Convergence Report published by the American National Science Foundation in May 2001, with the aim of bringing together scientists from different disciplines, government and industry to explore how emergent technologies can be integrated to ameliorate human capabilities (cf. Roco and Bainbridge 2001). The explicit goal of human improvement has clearly placed the debate on converging technologies along the lines of the discussion on enhancement, which has its roots in reflections on the legitimacy of genetic
intervention and its implications for our understanding as human beings. Although the term “human nature” is only mentioned once in Roco and Bainbridge’s first report (2002, p. 22), the debate on the amelioration of human capabilities quickly turned into a discussion on its implications for the philosophical concept of human nature, and on the legitimacy of modifying it. This has led to a polarization of opinions, a strong division between “knockers” and “boosters” of modernity, i.e. of technologies (cf. Taylor 1991). The NBIC vision was acknowledged by the European Union, which in 2004 convened a High Level Expert Group on the new Technology Wave (HLEG) to consider the opportunities and challenges offered by emerging converging technologies, referred to in the final document as CTEKS.3

This article seeks a better understanding of the debate on the ethical challenges posed by converging technologies in the two versions offered by the USA (NBIC) and Europe (CTEKS), and has three objectives. First, I want to show that the reduction of the ethical challenges posed by these technologies to the question of human nature has led to a polarization of positions, and has thus generated an impasse from which it is difficult to break free. This has already been raised by other authors to some extent (cf. Paschen et al. 2004, Schummer 2004, Coenen 2006, 2007, STO 2006). Second, I want to demonstrate that the European conception of CTEKS proposes an alternative way of framing ethical questions relating to converging technologies. Third, I want to provide reasons why we should keep to the European approach and discard the question of human nature, nonetheless remaining aware of the fact that this approach is in its initial phase.

Converging technologies, enhancement and human nature

Convergence primarily refers to the combination of previously separate fields of science and technology. The NBIC approach centres around the idea that technology integration launched at the nanoscale (the science that permits knowledge of the building blocks of matter), using system approaches, computation (in the field of information technology), tools of cognitive science and results in biotechnology, provides new knowledge about the world and a new understanding of the nature of human society and the individual. The idea of convergence itself consists of the mutual enabling of these technologies in the pursuit of the common goal of improving human performance (Roco and Bainbridge 2004, Bainbridge and Roco 2006). Supporters of NBIC convergence argue that it offers – for the first time in the history of human development – a concrete possibility of controlling our own destiny, overcoming the boundaries set by nature and controlling the external world by shaping it “atom by atom” (see National Science and Technology Council 1999, Roco and Bainbridge 2002). The core message of NBIC convergence consists of the notion that humans will soon have the possibility of overcoming many (if not all) of their physical and mental limitations through new efforts in scientific and technological developments, reaching a new stage of development both on an individual and on a societal level. Since such advances are possible both in the long- and near-term future through NBIC convergence, the debate on the significance and the future of human nature has become sharper and more intense in the philosophical arena. The concept of human nature has traditionally been used to capture the fundamental dispositions and traits of humans (see for example Gulsdorf and Tyles 2007).4 Whereas premodern theories of human nature generally characterized humans as being completely
subordinate to a higher order, modern theories see humans as being unjustly limited by this higher order and thus motivated to overcome these limitations by means of better social orders or scientific and technological progress. These theories contrast with the idea of accepting the limitations as God’s will and stress the concept of the self-made person, who can overcome their limitations solely through human means. Reflections on “human nature” are indeed deeply interwoven with perceptions of human perfectibility, with the possibility of improving human performance and achieving a better and more efficient control of nature. This is, on the one hand, seen as an “old” mission of the human being (by claiming that technology has always represented an effort to overcome human limitations) and, on the other hand, as now not only being possible, but also inevitable (I will come back to this point later) (see in particular Roco and Montemagno 2004).

Overcoming the human being’s present state also represents the core idea of the transhumanist (or posthumanist) movement, which, as the word itself entails, embraces the idea of creating biologically and technologically superior human beings (Hayles 1999, Coenen 2006, 2007). In fact, the NBIC programme has been accused of being “too close” to transhumanist objectives and some of its promoters are themselves transhumanists (cf. Nordmann 2004a–c). Or, as Coenen writes:

The NBIC initiative in the US is an important point of reference for transhumanists for two reasons: on the one hand, the prominence of “human enhancement” and the consideration of far-reaching posthumanist visions in its visionary program, and, on the other hand, the propinquity of some of its members to organised transhumanism (Coenen 2007, p. 4).

Transhumanism focuses on the perception of human nature as “a work-in-progress, a half-baked beginning that we can learn to remould in desirable ways” (Bostrom 2003a, p. 493) and acknowledges its philosophical roots in humanism, which places man at the centre of the universe and highlights the struggle for self-improvement (homo faber). In Roco’s and Bainbridge’s reports (2002, 2006), there are clear references to the Renaissance epoch, during which not only the unity of knowledge (convergence) was advanced, but the centre of gravity of reflective thought also descended from heaven to earth, focusing on man, his capabilities and limitations. According to transhumanists, current civilization has not reached its final destination, but has merely taken a step, and they are actively promoting the use of all available means to improve this condition and to establish control of humans’ own destiny and evolution.

Are these ideas of improving the individual and society really new? Since the 1980s, there has been a growing debate within the bioethical discipline (which, for Hughes 2006 can be considered a protoform of technopolitics), regarding the term “enhancement” and the possibility of distinguishing therapeutic from non-therapeutic goals in medicine, owing to the expansion of plastic surgery and the advances made in in vitro fertilization, genetic analysis and gene therapy (Parens 1998). The development of medical knowledge and biotechnology has been transforming medical practice since the 1960s, giving people greater control over their lives and, at the same time, opening up new options for patients in fields where the physician has been the traditional decision-maker (cfr. Veatch 2000). Interestingly, in one of the first documents dealing with the ethical issues of genetic engineering of human beings, the 1982 American President’s Commission report Splicing Life, an explicit
reference to the challenges posed to human nature by new (genetic engineering) technologies is made: “Will gene splicing actually make possible such changes in ‘human nature’ for the first time?” (President’s Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research 1982, p. 69). Though the report states that this question is to some degree unanswerable due to the serious disagreement about which particular characteristics make up human nature, there is reluctance toward making a general statement on genetic engineering until more scientific knowledge about human genetics is available.

Although human nature and fundamental human value remain the focus in the debate, NBIC convergence has given a new connotation to the issue of enhancement for two reasons: because the enhancement of human capabilities is no longer only achievable through medical means, but rather through a new complex of technologies, namely the converging technologies; and because enhancement has become — at least in the American version of converging technologies — the explicit task of these technologies and not just a possible side-effect.

As a result of the first reason mentioned above, a shift has taken place in the debate on enhancement, moving beyond the field of medicine — in which this debate originally emerged because of its strong linkage with the concept of health9 — to a variety of technological developments expected to influence every aspect of our lives and alter the environment (and living beings) around us. After speaking to 26 experts from various scientific fields, all of whom contributed to the NBIC initiative, Bainbridge (2006) predicts that numerous benefits will be gained by NBIC convergence: by 2015, for example, anyone will be able to have instantaneous access to information needed, together with “new organizational structures and management principles based on fast, reliable communication of needed information” and “comfortable, wearable sensors and computers will enhance every person’s awareness of his or her health condition, environment, chemical pollutants, potential hazards, and information of interest about local businesses, natural resources, and the like” (Bainbridge 2006, p. 338); by 2020, people from all backgrounds and of all levels of ability will learn more reliably and quickly, and factories will be organized around increased human–machine capabilities as intelligent environments; in 2025, the human body will be more durable, healthier and easier to repair; in 2030, it will be possible to control the genetics of humans, animals and agricultural plants, thereby increasing human welfare; and in 2050, outer space will be conquered by means of efficient launch vehicles and robotic construction of extraterrestrial bases (Bainbridge 2006, pp. 339–340).

Moreover, the fact that the improvement of capabilities has been set as an explicit goal puts the normative dimension of technologies in the front line. Also, the question of means for achieving the goals for which these technologies are conceptualized and developed becomes central. As Pellegrino (2004) has pointed out, within the “traditional” ends of medicine, the primary intention for using biotechnology was to treat physical or mental disease. Here, the enhancement of a patient’s life may have been a secondary effect of the treatment, as a result of the restoration of health, but was not the explicit goal. In contrast, in NBIC’s vision enhancement informs the technological efforts. The dispute on enhancement, then, also contains a stronger social dimension than in the past, because (re)constructing human nature is — at least in the NBIC vision — becoming the explicit political goal of a new technological complex into which numerous economic and human resources.
are being invested. The socioeconomic impact of converging technologies is already strong and is expected to increase tremendously.

With the convergence of Nanotechnology, Biotechnology, Information Technology and Cognitive science (NBIC) fields promising to change our competitive, operational, and employment landscape in fundamental ways, we find ourselves on the brink of a new technological and science-driven business revolution. The already emerging reality of convergence is to be found in Genomics, Robotics, Bio-information and artificial intelligence applications, such as self-assembled, self-cleaning and self-healing manufactured materials and textiles ..., miniature sensors allowing unobtrusive real-time health monitoring and dramatically improved diagnosis ..., new generations of supercomputers and efficient energy generators based on biological processes, greatly enhanced drug delivery .... These advances are here already, or in development. And Japan, other Asian nations and Western European countries are investing heavily and moving aggressively to develop and apply NBIC technologies. Notwithstanding the passage of the 21st Century Nanotechnology Research and Development Act, significant further funding and action by both government and private industry will be critical to maintaining US scientific and industry leadership (Radnor and Strauss 2006, p. 370).

The idea of the inevitability of technological progress being orientated toward the enhancement of human performance plays a central role in the ethical debate on converging technologies in the logic of NBIC's approach. Enhancement has repeatedly been reinforced through different workshops on NBIC convergence: the very optimistic tone of the first report (Roco and Bainbridge 2002) also continues in the second report (the workshop was held in 2003), although it refers to the possibility of abuse by autocratic regimes (see Canton 2004), stating that human enhancement will be the future tool for shaping societies (Roco and Montemagno 2004). Here, even ethical reflection and social science are seen as part of the convergence, because by applying a biological approach to them it even becomes possible to engineer culture, i.e. to prepare society for technologies (so-called “memetic engineering”, see Bainbridge 2004). In the NBIC's most recent report (Bainbridge and Roco 2006), George Khushf argues that the only way to properly discuss what form of development we actually want to achieve through converging technologies is by adopting enhancement as a goal – and this is the direction we are heading in, whether we like it or not. For him, the issue of enhancement represents what is decidedly unique about convergence. Furthermore, he maintains that, in order to properly discuss and ethically assess the challenges posed by new technologies, we have to conceive ethical reflection as converging with scientific and technological development, in the sense that we have to move away from the old paradigm of the separation of humanities from natural sciences (in his 2006 article, Khushf refers to the classical “two cultures” divide, as indicated by Snow in 1959) to a new kind of convergence, based on the idea of interdisciplinarity across the barriers between the sciences and humanities. He presents the controversy on enhancement as a clash between the culture of scientists, who identify ethical reflection with risk assessment, and the culture of social scientists and philosophers, who perceive ethics as concerning the narratives of meaningful life, of renunciation and wisdom (Khushf 2006, p. 274). Khushf (2006) points out that, interestingly, the debate on enhancement was not really a topic in the first NBIC workshops, yet it stimulated a broader discussion in Europe, where the counterposition of the two above-mentioned cultures is stronger. On the contrary, he proposes explicitly facing the possibility of enhancement because this is
the only way to openly confront and address this new challenge, since it allows a direct incorporation of ethical reflection into the R&D phase of technologies, in the name of the idea of convergence (Khushf 2006; cf. also Khushf 2004a,b). In other words, Khushf supports the discourse on the legitimacy of changing human nature, arguing that this question represents a sort of educational ideal which pushes us to reflect, since self-creation and the construction of a technological future require caution and deep reflection. According to this logic, the polarization of the debate does not represent an impoverishment, but rather an enrichment in terms of reflection, because it stimulates further analysis and societal debate.

A polarized debate

The discussion on possible technological modifications of (certain) human individual capabilities and of society has very quickly become characterized by a polarization of positions. On the one hand, supporters of NBIC convergence defend the re-engineering of human nature via genetic engineering, the deceleration and arresting of ageing, cybernetics and the use of nanotechnologies, and thereby promote the creation of biologically and technologically superior human beings and consequently the evolution or transformation of human nature (see Nordmann, Schummer and Schwarz 2006). As already argued, defenders of NBIC convergence share many similar positions with transhumanists. On the other hand, most opponents of such liberal use of technologies stress nature and character as being morally valuable categories and rely on concepts such as finitude and humility, i.e. the inviolability of human nature. These contradictory positions of frontal defence and attack on new technologies are accompanied, respectively, by an optimistic and a pessimistic attitude towards them. This polarization of opinion is not at all a novelty of the debate on NBIC, but reflects the typical split into the “technoprogressives” (or “bioliberals”) and “technoconservatives” (or “bioconservatives” or “bioluddites”) in the American bioethical debate, which can to some degree also be found in the European context (see the debate on the production and use of embryonic stem cells when it is dominated solely by the issue of the moral status of the human embryo). As a matter of fact, promoters of modifying human nature through technological means are very well represented in the European context, as are critics who defend a more conservative view on technology.

Joel Garreau (2005) distinguishes three scenarios for the future: an optimistic one (the “Heaven” scenario), advocated by the promoters of NBIC convergence, by some visionary engineers and scientists (such as Eric Drexler and Ray Kurzweil) and by organized transhumanists; the pessimistic one (the “Hell” scenario), envisioned by critics of these new technologies; and the “Prevail” scenario, based on the idea that human behaviour determines the direction of technological development, and thus the outcome of this development is essentially uncertain. All these scenarios rest upon assumptions that cannot be substantiated (what the world will be like); whereas in the “Heaven” and “Hell” scenarios it is implicitly assumed that human destiny can reliably be projected, the “Prevail” scenario is essentially driven by a “faith in human cussedness” (Garreau 2005, p. 209), as well as by the idea that future changes will be determined in a messy and chaotic way (not by up or down curves as in the other two scenarios). The “Prevail” scenario is the “search for a complex, evolving, inventive transcendence”, it is an “infinite game” because it rejects the idea of singularity and it is “fundamentally imaginative”, since this scenario is measured by its impact on
Garreau then admits that the American debate is, *de facto*, dominated by the “Heaven” and “Hell” scenarios.

Garreau then admits that the American debate is, *de facto*, dominated by the “Heaven” and “Hell” scenarios. The issue of human nature polarizes and simplifies the debate, reducing it to a seeming dichotomy. Francis Fukuyama, one of the most famous representatives of the American technoconservatives and a member of the President’s Council of Bioethics, who defines human nature as “the sum of the behaviour and characteristics that are typical of the human species, arising from the genetic rather than environmental factors” (Fukuyama 2002, p. 130), ascribes a normative value to this given set of characteristics. As a consequence, attempts to change these standards are seen as unethical; thus transhumanism is defined as one of the most dangerous ideas of the twenty-first century (Fukuyama 2004). The President’s Council on Bioethics (2003) warns about the “Promethean” aspiration to recreate nature, including human nature, to serve human purposes, and conceives it as a misconsideration of the “giftedness” of the world. Technological enhancement of the mind and body provides a quick solution for the passive subject who cannot understand the meaning and profound implications of these interventions, and who has done nothing to earn them. These interventions therefore represent a violation of respect for human activity (they are also defined as a form of cheating). The aims of perfecting our children and of superior performance through genetic engineering are not contested, rather “our misguided idea of their attainment or our false way of seeking to attain them” (President’s Council on Bioethics 2003, p. 333). The core of the critique refers to the vision of the conception of a world which is at the complete disposal of human beings (the transcendence becomes a human one) and is achievable through technology. The idea of ageless bodies and happy souls is particularly criticized, because it overlooks the fact that many human characteristics and achievements depend on the finitude of life and its possibilities.  

Interestingly, transhumanists and supporters of NBIC convergence also defend a normative use of human nature, but they provide a different version of it. They argue that the essence of a human being consists of shaping and recreating her own future, reinventing herself through culture and technology. For transhumanists it is natural that man struggles for perfection and self-improvement, and the position of their opponents is thus seen as unnatural and even contradictory to respect for human dignity. Both critics and supporters of NBIC convergence and enhancement appeal to the same values, but in a specular manner: for critics, respect for human dignity implies respect for the current given physical and mental state of the human being as provided by nature; for supporters of enhancement through NBIC, the present state is only a step in evolution and is quite unsatisfactory. Bostrom (2005a,b) argues, for example, that human and posthuman dignity have to be seen as compatible and complementary, because “dignity, in its modern sense, consists in what we are and what we have the potential to become, not in our pedigree or our causal origin” (Bostrom 2005a,b, p. 213). The positive aspect of enhancing human performances represents the core presupposition of NBIC because it represents its orientation, its ultimate task: thus, it cannot be questioned. Efforts have to be made in order to best manage this tremendous potential. The role of ethical and social reflection is seen as supporting the coming revolution. In a contrary manner, critics of enhancement conceive the role of ethical reflection as setting boundaries and limits to determine which actions are legitimate or not.
For Hughes (2006), technopolitics is essentially a new dimension of political debate in the twenty-first century, which has to be seen as something positively challenging because it cuts across existing political lines (such as the division between left and right) and creates new alliances on the basis of contrapositions already known in the bioethical debate. I profoundly disagree with this interpretation, not because I think that the creation of new alliances and the consequent increasing complexity of the debate are wrong, but because I, on the contrary, consider the division of technoprogressives and technopessimists to be an impoverishment of the debate. The polarization of positions on technology, owing to the mirroring of the discussion on pros and cons, is based on the same line of argumentation. Both supporters and adversaries of NBIC presuppose the inevitability of the forthcoming technological revolution. As a consequence, the debate has become deadlocked on the issue of either accepting or opposing a future which is inevitably going to come (cf. Lopez 2004). The inevitability of the future is increasingly being recognized and consequently reinforces the hype that surrounds these kinds of technologies. The utopian and dystopian visions are thus permanently amplified and have become the focus of the discussion.

Much of the current ethical analysis of the challenges posed by converging technologies suffers from being too narrowly focused on the alternative of either a utopian or dystopian future as a result of NBIC convergence. As Kurt Bayertz (2003) has pointed out, the hopes and visions of recent technological advancements seem to have rendered human nature technologically contingent, because what the human being will look like and what it will be is expected to be determined by new technologies. It is precisely this idea of the “transformation” of human nature into something changeable, man-made and dependent on a particular scientific and technological development, which has disturbed many authors, who then urge a return to the normative use of the concept of human nature (cf. Habermas 2001).

Although I can relate to the perplexity of the critics of human enhancement, I also understand the fascination of the proponents whose line of reasoning centres around the human efforts of self-discovery and self-creation. The problem I see in much of the current discussion on improving human performance is that it tends to reduce the social and ethical reflection on technologies to the explication of the normative aspects of balancing risks and benefits. Applying this to the discourse about human nature, the myth of the radical change of humanity is criticized by analysing the potential risks connected with this evolution, sometimes portraying them as outweighing the benefits. For example, it is argued by the opponents that allowing genetic or neuroimplants would create a divide between the rich who can afford these technologies and the rest of the population (at an international level as well) (see, for example, Wolbring 2006, The President’s Council of Bioethics 2003). Furthermore, the suggestion that enhancements would not render humankind happier since they rely on a form of cheating and only provide provisional, quick and apparent solutions to a permanently unsatisfied human being who is unable to accept his limitations, is also contested (see The President’s Council of Bioethics 2003; Fukuyama 2002).

Framing the problem of enhancement in this way indirectly permits its supporters to criticize these significant conclusions with the same arguments, i.e. by simply contesting the conclusions. Transhumanists like Bostrom (2003a, 2005a,b) or Caplan (2006) can easily counter these arguments by claiming that enhancement technologies alone do not cause this divide, which has existed since the onset of technological development, and that inequity and the two-class society are to blame rather than the
modification of human nature. In addition, some supporters of enhancement argue that it is difficult to imagine that people would feel unsatisfied if they won easy victories, considering that we are beings in a flux, destined to change permanently (Caplan 2006, pp. 36–37), and because, with our cognitive resources, we will even be capable of reinventing the world and a new mode of life, if our mortal and finite natures change (Harris 2006, 2007; cf. Miller and Wisdom 2006).

An attempt to frame the discourse on converging technologies in a different way has been offered by the European High Level Expert Group predicting the new technology wave (HLEG 2004).

The European response

In 2004, HLEG offered an alternative analysis of converging technologies, starting with a different concept of “convergence” and a distinct reference to the technologies involved. Instead of referring to the four fields mentioned by NBIC, the European group, proposing a different abbreviation (CTEKS), described a convergence of many more disciplines, including the humanities, such as social sciences, policy and philosophy, and emphasized the idea of a coevolution between technology and society (HLEG 2004). Here the focus is put on the agenda-setting strength of specific research goals, which means integrating technological development with recognized scientific interest, limits, and consideration of European needs and of the economic opportunities (HLEG 2004, p. 19). In particular, the European approach stresses the importance of critically scrutinizing the broad promises made by converging technologies, avoiding the suggestion that their potential is unlimited, but rather taking their limits into consideration.

The European’s concept of CTEKS sees technological development as inherently political and open to social shaping (HLEG 2004). Richard Saage (2006) describes, for example, the European approach as promoting a sort of social contract that considers the technological advance not as the myth of an inescapable fate, but as a result of a democratic agreement between the European civil societies themselves. This approach ascribes a different role to ethical and social reflection than it plays in the NBIC convergence. Whereas each tentative criticism of and resistance toward technological development is presented as negative and anachronistic by promoters of NBIC convergence, because it hinges on a conservative and negative attitude about the human being, who has to accept his finitude (thus identifying resistance per se with the position of bioconservatives), according to the European perspective, resistance to new technologies is taken as only one standard for assessing a technology, which can even be seen as a positive element of a social selection process and not necessarily only as an obstacle (HLEG 2004, p. 31).
The final recommendation no. 7 of the report states, among others: “As CTs pursue the perfectibility of humans and society, evolutionary anthropology needs to study and communicate the meaning of seeming imperfection, diversity and human limitation” (HLEG 2004, p. 53). The question of changing human nature is described as ‘open’ and the question of legitimacy is not explicitly posed:

The construction of an artificial nature requires philosophical and social orientation and critique especially as it regards the foundation of ethics and societal values in concepts of freedom and human nature. It also may create new economic dependencies, opportunities and constraints for wealth-generation that need to be investigated (HLEG 2004, p. 53).

Central to the HLEG report is the identification of specific societal needs in order to take advantage of and preserve Europe’s cultural diversity and to create economic opportunity (HLEG 2004). This idea is developed without taking for granted the notion that revolutionary technological changes will take place – a more sober view is taken.16 Nordmann (2006) sums up this diversity by claiming that, while the United States presents convergence as being already a reality and invites us to prepare for it, Europe insists on conceiving these technologies as enablers, and this, together with many pressing societal issues (such as global warming and the scarcity of energy and primary resources), challenges us to create converging technologies “as a means of gearing emerging capabilities towards common goals” (Nordmann 2006, p. 5).

In a recent article, Bainbridge (2007) explicitly criticizes what he calls the precautionary attitude of the European approach to converging technologies, judging it as unsatisfactory and based on a problematic and outmoded religious stance opposed to technological development. In contrast to these ideas, Bainbridge affirms a science-based worldview, in which transcendence is no longer mysterious and unreachable but attainable in the near future through the convergence of various technologies (cf. Khushf 2006). He sees that

there are two possible positive futures for humanity: 1. A radical retrenchment that leads to a world fragmented among competing religious fundamentalisms. . . . Faith would bring scientific progress to a halt and enslave technology in service of the ruling elites 2. A transcendence of the traditional human condition — made possible by the unification of all sciences and technologies, establishing a dynamic new creed to replace religion (Bainbridge 2007, p. 198).

Therefore, he argues in favour of the NBIC project and the possibility of liberating humanity from physical and cultural constraints. The price to pay for rejecting or opposing technological development will be the onset of a new “Dark Age”.

No similar “predictions” or strong statements can be found in the HLEG report. The CTEKS are constructed on the premise that the future is still open, so that no general forecast or visionary statement can be made. In contrast to those expressed by scientists, politicians and industrialists in the NBIC reports, the European vision builds on the idea that social sciences and humanities should be integrated as accompanying and critical forces of technological development. They can provide orientation where technologies could disrupt traditional ways of life, serve as intermediaries between political actors, CT researchers and society, and help to assess risks (Coenen et al. 2004). Whereas the American report, providing an overview of many scientific fields, is essentially centred around visionary statements,
the European document is philosophical and, as a matter of fact, was by and large written by social scientists and philosophers (Khushf 2006).

Regarding the goal of transforming the human being, the European group implicitly criticizes the American perspective, defined as the “engineering of the mind” approach, proposing instead “engineering for the mind” and “engineering for a healthy body”, based on the idea that people’s needs should play a central role in the shaping of technologies. Supporters of the NBIC vision highlight the need for overcoming bodily and mental imperfections, thus defending the idea of “engineering the mind and the body”. In contrast, the idea underpinning the European CTEKS vision is that technology adapts the world to the requirements and needs of frail and limited human bodies. The framing of the question of human enhancement is therefore one of the key issues to understanding the difference between the American and the European approaches: it has been claimed that whereas the credo of NBIC convergence is that we need technological innovation to realize human potential, CTEKS’s credo posits, in contrast, that we need social innovation to realize technological potential (Josephine Green of Philips quoted by Nordmann 200617).

Stressing the importance of the mutual shaping of social forces and technological development, the European approach advocates an alternative to the polarized debate. The reflection of some authors and institutions appears to be moving in this direction.

The reduction of the debate on the challenges of converging technologies for human nature

The problem about the dispute on the legitimacy of changing human nature originates from the fact that this term is plurivalent and needs further clarification: “human nature” can, on the one hand, indicate the biological, i.e. “natural” characteristics of human beings, such as the biological and genetic traits relevant to their species. On the other hand, this expression is used to refer to the complex of characteristics of human beings, i.e. their biological and cultural ones (Bayertz 2003, Birnbacher 2006).

A precise and unambiguous explanation of human nature is difficult, since the term “nature” itself is unclear. In his dialogue “Timaeus”, Plato distinguishes between two concepts of nature: nature identified as the physical world that changes and perishes, i.e. as something distinct from the “supernatural” and eternal transcendent world (the world of “ideas”); alternatively, nature can be seen as something spontaneous, which transcends human capacities for making things, i.e. for creating artifacts (Zeyl 2000)18. David Hume (1739) also points out that the concept of what is “natural” changes, depending on how the opposing concept (“artificial” or “unusual”) is defined. Furthermore, difficulties arise with regard to the exact definition of the term “nature” when it is taken to be the opposite of “artificial”, since humans have a “natural” tendency to develop culture and instruments.19

Apart from these semantic difficulties, the normative use of this term is highly controversial and this dispute has a long tradition in the history of philosophy. John Stuart Mill (1969 [1874]) criticized the doctrine that man ought to follow nature, showing that it results in meaningless or irrational and immoral conduct, depending on which concept of nature it is based upon. If nature is identified with the entire system of things, it does not make any sense for man to “follow” nature, because he
would not have the possibility of acting differently. If nature is identified with things as they would be, apart from human intervention, this doctrine would make Mill’s opinion seem irrational, because all human actions alter the course of nature and are immoral, as there are many tremendous and negative natural phenomena. As a consequence, for Mill,

the scheme of Nature regarded in its whole extent, cannot have had the good of human or other sentient beings as its sole and principal object. Whatever good it brings to these beings, is mostly the result of their own exertions. Whatevsoever, in nature, gives indication of beneficent design, proves this beneficence to be armed only with limited power; and the duty of man is to co-operate with these beneficent powers, not by imitating but by perpetually striving to amend the course of nature – and bringing that part of it over which we can exercise control, nearer into conformity with a high standard of justice and goodness (Mill 1969 [1874], pp. 64-65).

Many modern ethical theories reject this metaphysical background and rely on a “denaturalization” of the human being (in the sense that the essence of man is no longer perceived in terms of his “nature”, but in terms of his power to self-develop; cf. Heyd 2003). Traditionally, the normative use of descriptive concepts has been criticized as a form of naturalistic fallacy, i.e. an identification of the descriptive level (what an entity is) with the normative one (what an entity should be) (cf. also Corradini 2003). Further objections concern the risk of discrimination implicit in the normative use of the concept of human nature identified in its empirical terms: if a set of biological properties is taken as a standard of “normality”, beings not having these properties can be discriminated against. Birnbacher (2006) gives the example of the (past) discrimination of women based on the assumption of their different “nature” (this kind of objection is particularly relevant in disputes on genetic enhancement).

In an interesting analysis of the enhancement debate, Parens (2005) has shown that the differences between critics and proponents are easily overblown, because although they propose diverse ways of understanding “the moral idea of authenticity”, no ultimate illustration of this view can be provided, resulting in the differences being less stark than they may have seemed. For Parens (2005) the different frameworks of critics and proponents “are built of answers to questions that do not have only one good answer” (Parens 2005, p. 37). Both of these frameworks are attached to interesting and at the same time problematic visions, which can function or lead to reasonable results, depending on the context in which they are applied. Parens (2005) contends that, when we try to find arguments against improvement, we run the risk of forgetting that one of the fundamental impulses of the human being consists in being creative and in constantly transforming. However, when we try to emphasize our creativity, we easily become hubristic, forgetting that our talents lead to an outcome for which we are responsible, and this leads to the neglect of solidarity. Parens (2005) concludes by highlighting that, although both frameworks deserve equal respect, they are not in equilibrium in the present debate, because the creativity framework (that of the proponents) dominates. However, he thinks that the existence of both frameworks should not be seen as something negative, but as the symbol of an irresolvable tension underlying the complexity of our understanding of authenticity, which differs depending on time and contexts: “moving between frameworks, being ambivalent, seems to me to be a sign of openness and thoughtfulness, not confusion” (Parens 2005, p. 38).
In contrast to the centrality of discussion on human nature, I think that the polarization of the position on enhancement works due to the presupposition of the inevitability of its future. I do still believe that the issues of enhancement raise interesting and fundamental questions, but only if they are articulated in a broader and more complex framework, as is the case with many current analyses.

The necessity for a different framing

The European approach has offered a different frame for understanding the challenges of converging technologies, not because it has developed a diverging view on the issue of the legitimacy of changing human nature as advocated by NBIC supporters, but because it has partially avoided this question, focusing instead on the consideration of the special context in which the technologies are shaped and the role and goals of these technologies for society. In contrast to the view of the NBIC on the inevitability of technological progress, the European concept of CTEKS sees technological development as inherently political and open to social shaping, embracing a more problem-oriented approach based on the idea that, while technological development has an effect on our culture and values, it concurrently is also informed and shaped by our social values. “Converging Technologies (CTs) present equally significant opportunities and challenges” is the phrase that opens the report’s conclusions and recommendation (HLEG 2004, p. 51). Consequently, the European concept of CTEKS does not correspond to any of the “Hell” and the “Heaven” scenarios described by Garreau (2005), with a techno-optimist or techno-pessimist position. Instead, it lies contrary to the prevailing state of the American debate. The difference from the “Prevail” scenario is, however, more subtle and gradual. While Garreau places a stronger emphasis on technological development in his description of the “Prevail” scenario, claiming that the creativity of humans could unexpectedly shape the impact of technology on human nature and society (Garreau 2005, p. 206), the European approach rests on the idea of the coevolution of science and society. Common to all three of Garreau’s scenarios is the notion that the result of technological development will definitely involve radical change. This is not made explicit in the European report in which, for example, the future is referred to in terms of challenges and possibilities rather than the idea of revolutionary change. This aspect remains perhaps part of a more cautious and optimistic European approach, which aims to evolve without technological determinism.

The CTEKS approach clearly contrasts with that of the NBIC regarding future predictions, especially when noting the previously quoted drastic visions about the future of humanity proposed by Bainbridge (2007). No such drastic predictions about the future can be taken for granted, according to the European approach. Instead of regarding technological development as an independent variable with its own rules, and whose impact is evaluated in terms of risks and benefits, the European approach regards this development as being both social and technical, so that society’s perceptions (i.e. the public’s, politicians’ and industry’s perceptions) gradually inform and influence this development and, in a certain sense, causally codetermine it.

Currently, some experts are moving in this direction (some of them being previous members of the HLEG group) and have expressed interest in scrutinizing the philosophical conceptions of the human being, of nature and of the role of technological development which underpin the image of these technologies. In
UNESCO’s (2006) report, which is dedicated to the specific topic of nanotechnology and presents general reflections applicable to converging technologies, the need for ethical reflection on the very structure of science itself is clearly stated and includes the issues of intellectual property, secrecy and legitimacy of scientific results, as well as public trust and accountability. Thus, it argues for reflection beyond risk assessment (UNESCO 2006, pp. 17–19). For UNESCO (2006), it is not the specific questions regarding the possible dangers stemming from technological developments that are philosophically and ethically interesting, but rather the analysis of the reasons why the debate has been centred around typical questions. The report asserts that the powerful or destroying potential of technologies, as is currently being discussed, depends on some form of technological determinism “in which advocates or opponents presume that technology develops autonomously, and is beyond human, social, or governmental control” (UNESCO 2006, p. 19). Such questions therefore concern the modality in which emerging technologies are perceived and presented, and this means questioning technology from the perspective of the coevolution of technology and society. Subsequently, for UNESCO, concerns about “post-humanism” are disturbing factors in the reflection of emerging technologies, representing “ethical issues that aren’t” (UNESCO 2006, p. 19), because they assume that we have to prepare ourselves for an inevitable, problematic future. As I have already pointed out, an analogous criticism of this reference to an inevitable future was already mentioned in the HLEG report.

Jean-Pierre Dupuy has proposed the use of the Popperian concept of the metaphysical research program in order to investigate the philosophical foundations of converging technologies (and of emerging nanotechnologies). The concept of the metaphysical research programme dates back to the theory of Karl Popper (and previously to Meyerson, 1927), who highlighted that every scientific theory and enterprise relies on a set of values and worldviews, which is based on general presuppositions about the structure of the world (Grinbaum and Dupuy 2004; Dupuy 2005, 2007). In the NBIC convergence, according to Dupuy, knowing is identified with making, because the programme, as a product of itself, loses the significance of the distinction between scientist and engineer by remaking nature in such a way as to make humans become perfectly aware of it. In this sense, converging technologies support a progressive “technoscification” of knowledge. For Dupuy, at the very core of the NBIC convergence is the project of cognitive science, which dates back to cybernetics, based on the idea of a “mechanization of mind”. The metaphysics beyond the project is monist and not reductionistic: monist because it reduces life, nature and the human mind to the same organizational principles, proposing again the idea of the cybernetics’ project; and non-reductionistic because it gives importance to the multidisciplinarity. As a result, the NBIC project directly neglects the human being via a reductive view of nature (nature as conceived what we make of it) and a sort of banalization of ethics (Dupuy 2007). For Dupuy, framing the discourse in terms of risk and possible consequences as proposed by the US project of NBIC, centred on the idea of a “transformation of civilization” (Roco and Bainbridge 2002, p. 21), is problematic. Describing the ethical conflict in this way, we implicitly assume that the transformation of society by this convergence is going to take place (as a sort of self-fulfilling prophecy) and the only thing left to do is to accept it or find strong arguments against it.
Reflecting on nanoethics, Dupuy (2007) sees the first pitfall in the philosophical foundation, precisely in the reduction of ethics to the sole analysis of risks. Dupuy (2007) criticizes much of the current work on the ethics of converging technologies because they confuse questions about human nature – for example, by continuing to ask whether we should maintain some natural characteristics of the human species and what the consequences of changing them would be – with questions about human condition in the sense expressed by Hannah Arendt, that is, about the profound significance of what it means for us to be human and how this is affected by new technologies. Reflecting on the launch of Sputnik into orbit in 1957, Arendt (1958) highlighted the importance of the dreams of science, which existed long before a particular technique was created, because they have a causal effect on the world and transform the human condition. As a consequence, “the object of ethical assessment must therefore be, not the technique alone, but this structure displaying a common cause” (cf. Dupuy 2007, p. 7). If, on the one hand, no answers can be given to questions about the “typical” characteristics of human beings, then, on the contrary, we are forced to question the conditions that we, as human beings, are constructing for ourselves.27

For Nordmann (2007c), the debate on human enhancement is a typical example of speculative ethics, which, though sometimes encouraging reflection on the nature of technology and its purposes by posing general and “if-and-when” questions, in this particular form detracts from the more immediate issues of technological development. The efforts of transhumanists only seem like ethical questions, because they can only function by taking for granted a particular attitude towards the future (that is, that technology is going to effectively provide a means for human enhancement, as illustrated by transhumanists), i.e. these debates “are premised on a believing attitude towards the future, indeed, they lend credibility to it” (Nordmann 2007b,c). As a consequence, these questions presuppose blindness to the historical contingency of human beings, disassociating them as technical systems from the particular situation in which human desires are shaped. According to Nordmann (2007c), ignoring the contingency has two consequences: it induces us to neglect the fact that goals and aims are also contingent (since human frailty relates de facto to how our existence and efforts towards technological development are framed), and it also leads us down a false path, because since our fragility constitutes a limiting starting point, we cannot act regardless of what we are, nor can we conceive ourselves as being currently deficient and that we will become fully realized at another time.28 For Nordmann, there is nothing wrong with a public debate about human enhancement technologies or molecular manufacturing, where such visions incite society to reflect upon itself. However, this point is misleading if the aim is to demonstrate foresight or to contest the ethics of technologies that converge at the nanoscale. This discussion distracts us from more urgent and concrete questions (Nordmann 2007b,c).

Swiestra and Rip (2007) claim that the discussion of what might define “nanoethics” as a specific area of reflection represents a clear example of what they call “NEST-ethics” (NEST stands for “New and Emerging Science and Technology”), which shows stereotypical patterns of argumentation that can be found in other discussions on emerging technologies (thus it presents some characteristics which are also interesting for our case of converging technologies and enhancement). For example, a typical feature of NEST-ethics is represented by the dual way in which the reference to past experiences and to future promises is
presented. On the one hand, the past is mobilized to give credibility to arguments that promote new technologies, arguing that these technologies will bring positive results in the future because they have done so in the past. On the other hand, this reference to the past is used by opponents as well, who underline that technologies always have unintended side-effects and create divides. This is where supporters of new technologies face a problem, because they have stressed the novelty of emerging technology and made great promises from the start. This situation creates an opposition that cannot simply be negated, and the only possible solution seems to be the reaching of a compromise based on the negotiation of the novelty of emerging technologies. This leads the supporters of technologies to neglect the real novelty and to stress the continuity of past technology (Swiestra und Rip 2007). In the case of enhancement, this trend is clearly demonstrated by the argument that criticizes the distinction itself between enhancement and therapy or education (see, for example, Bostrom 2005a,b; Caplan 2006).

Playing with the novelty of technologies as a way of reaching normative conclusions can be a double-edged sword, because it directly offers its counterpart the possibility of reinventing and reversing the situation.

In their explanation of the fears associated with emerging nanotechnologies, Laurent and Petit (2005) have visualized these fears in form of a triangle: the first corner represents the fear of loss of control (when the experiment goes wrong), the second the fear of abuse of the discoveries (they could be used in an unforeseen manner), and the third represents the fear of transgression (technological development attempting to overcome natural limits and to “play God”). There is then a tendency by supporters of NBIC technologies to delegitimate the third corner of concern about transgression, and reduce the focus on the other two. For their part, the opponents of enhancement, insisting on a “strong” metaphysical concept of the human being as a basis for ethical reflection, cannot easily find broad consent in a pluralistic society, where there are many different views on life, man and progress. The battle over human nature results in a discrediting of the question about the limits of our knowledge, reducing it to a decision about the existence or non-existence of the naturalness of some technologies and to speculation about the probability of the loss of control over abuses of these technologies.

These methodological criticisms about the biasing centrality of questions about enhancement, which again propose the same argumentative logic as the ideas of the NBIC programme, play a very important role in the debate, because they call for a more realistic and more profound reflection on all implications of converging technologies which goes beyond stereotypical responses. The debate is still open and in its infancy, thus a quick “recipe” for reframing the questions cannot be found. However, it is very important to understand that there is a growing need in the current debate to rethink appropriate ways of discussing the social, ethical and political implications of emerging technologies in an attempt to give technological development some direction.

**Conclusion**

This paper argues that the current polarized debate on the legitimacy of changing human nature cannot offer a proper account of all the profound and subtle implications of the challenges posed by emergent converging technologies. The
questions raised by these technologies are not all reducible to questions about what human nature is and where it is heading, because this would push the debate on a fundamentally unanswerable question when formulated in general terms, and would consequently lead to an impoverishment of the reflection on emerging technologies. The orientation of NBIC convergence towards the amelioration of human capabilities, celebrating the triumph of technological control of every dimension (the individual, the societal, and the natural one), obviously represents a provocative project, but criticizing it by advancing arguments like the loss of authenticity and of humility seems not to have really grasped the challenges posed by new technologies.

This discussion appears not only constructed on the illusion of the possibility of providing a definitive and univocal answer to the essence of the human being, but is also preposterous in its claim of objectivity. As a consequence, much of the current debate on enhancing human nature tends to be reduced to a discussion on the possible risks (harms and abuses) of new technologies, offering nothing else as a sophisticated form of risk assessment, losing the critical appraisal that represents the crux of ethical analysis. In this way, the dispute about mankind’s future will become synonymous with the question of who offers the best foresight. Who is going to win – the transhumanists who say that it is not only possible, but desirable for all human beings to live forever, or those who claim that immortal beings will be unhappy?

The reduction of ethical and social discourse on science to a refined method of performing risk assessment poses the threat that the game will be played according to the NBIC perception of ethics. If ethical reflection focuses solely on the aspect of risk, issues of public perception will become of fundamental importance, not only for obvious governance purposes, but also eventually for reframing the ethical discourse on the basis of “true and factual” conclusions.

Here I do not provide an account of concrete solutions to responding differently to the question of human nature. The European CTEKS approach on converging technologies seems to indicate an initial tentative direction in which further discussion could evolve, but a lot of work still needs to be done. My hope is that, by illustrating the deadlocked tensions of the debate on human nature, I am able to make a small contribution towards a better understanding of it. Ultimately, I can only express my “intuition” that the questions surrounding converging technologies could gain a lot if they were framed in a more concrete way, based on scrutiny of the socioeconomic effects and the environmental impact of these new technologies, focusing on how power is distributed and which model of technological progress is supported. What is most urgently relevant, politically and ethically, is the way in which goals and conceptions about the role of technology may have concrete effects, because they inform and inspire research programmes in which financial resources of the public and private domains flow together.

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Notes
1. NBIC refers to the convergence of information technology, biotechnology, cognitive sciences and nanotechnology.
2. In the executive summary of the report, there is an explicit call for the participation of NGOs, the media and private research foundations in the discussion on ethical issues of NBIC convergence and on the implications of transforming human nature.

3. CTEKS stands for Converging Technologies for the European Knowledge Society.

4. As a matter of fact, in Ancient Greek philosophy the term “nature” was sometimes used as a synonym for “form”, indicating the essence of a being, i.e. its metaphysical place or characterization.

5. In premodern theories of human nature, human beings learn to live in accordance with the “natural” order by means of religious practice or ethics. The Greek concept of “hubris” or the Biblical concept of “sin” serve to indicate when human beings defy this order (Stevenson and Habermas, 2004).

6. The term “transhumanist” was used for the first time by the biologist Julian Huxley in his work *Religion without Revelation* (1927), indicating the desire of the human species to transcend itself by realizing new possibilities of and for human nature (Bostrom 2005a,b). The World Transhumanist Association (WTA) was founded in 1998 by Nick Bostrom and David Pearce as an international non-governmental association with the aim of promoting transhumanism. In 1999, the WTA adopted the Transhumanist Declaration (http://www.transhumanism.org/index.php/WTA/declaration/), and in the document “Transhumanist FAQ” Transhumanism is defined as “(1) The intellectual and cultural movement that affirms the possibility and desirability of fundamentally improving the human condition through applied Reason, especially by developing and making widely available technologies to eliminate aging and to greatly enhance human intellectual, physical, and psychological capacities. (2) The study of the ramifications, promises, and potential dangers of technologies that will enable us to overcome fundamental human limitations, and the related study of the ethical matters involved in developing and using such technologies” (Bostrom 2003b, p. 4).

7. Bostrom argues that “[t]ranshumanism has roots in secular humanist thinking, yet is more radical in that it promotes not only traditional means of improving human nature, such as education and cultural refinement, but also direct application of medicine and technology to overcome some of our basic biological limits” (Bostrom 2003a, p. 495).

8. One of the first authors to analyse the challenges of enhancement in the American context was the scientist W. French Anderson, a pioneer in gene therapy (Anderson and Fletcher 1980; Anderson 1984).

9. The traditional definition of enhancement regards it as something “beyond therapy” (cf. The President’s Council on Bioethics 2003), as etymologically something that increases, intensifies, heightens and exalts some characteristics or functions. These descriptions entail the connotation of going “beyond” what exists at some moment.

10. The modern memetics movement dates back to the mid 1980s and was largely influenced by the *selfish gene* theory of Richard Dawkins, who coined the term “meme” to describe a unit of information as analogous to the gene that resides in the human brain and is the mutating replicator in human cultural evolution. (For further information see the broad and useful description on Wikipedia, available at http://en.wikipedia.org/wiki/Memetics.) In his article on “The evolution of semantic systems” Bainbridge (2004) claims that a proper scientific understanding of the structure and dynamics of culture can lead to a new kind of technology, *memetics engineering*, which lies at the convergence between biology and information and cognitive sciences. Just as the correct understanding of biology and the development of biotechnology have permitted manipulation of living beings, the understanding of the evolution of semantic systems will allow us to engineer culture (Bainbridge 2004, p. 174). Semantic systems are described by him as a set of concepts connected by meaningful relationships and include scientific typologies and ontologies, as well as naturally occurring subcultures.
11. Khushf highlights that the culture of social scientists and philosophers sounds fuzzy, reactionary and ambiguous to scientists, as a result of the premodern mind. As a consequence, scientists seem not to take into real and appropriate consideration the ethical issues advanced by the humanities (Khushf 2006, p. 274).

12. On the one hand, the World Transhumanist Association has many headquarters in Europe and many prominent European thinkers promote this or similar views on technologies (for example, the philosophers Nick Bostrom – the founder of the Transhumanist movement – and John Harris); on the other hand, the Roman Catholic Church, and in many cases also the Protestant Church, as well as other religious groups in Europe severely criticize specific modern technologies, especially in the field of genetic engineering and reproductive technologies (cf. Harris 2006, 2007).

13. “For us, today, assumed that we are blessed with good health and a sound mind, a flourishing human life is not a life lived with an ageless body or an untroubled soul, but rather a life lived in rhythm time, mindful of time’s limits, appreciative of each season and filled first of all with those intimate human relations that are ours only because we are born, age, replace ourselves, decline, and die – and know it” (The President’s Council of Bioethics 2003, p. 337).

14. Hughes (2006) represents the current political sphere and the ideological positions as a sort of cube, determined by two opposite attitudes (conservatives and progressives) in the three directions of technopolitics, economic politics and cultural politics (Hughes 2006, p. 293).

15. In this paragraph, I am concentrating on the philosophical differences between the American and the European approach. For an account of the differences in policy see in particular Jasanoff (2003, 2005).

16. In their literature study assessment on converging technologies, STOA (2006) analyse the current debate by taking the three scenarios of Garreau (2005) into consideration and identifying the “Prevail” scenario in line with the European perspective (STOA 2006, p. 30). However, there is, in my opinion, a slight difference between the two perspectives: although the European approach explicitly calls for a sober look at technological development and criticizes many speculations about the future, Garreau, describing the “Prevail” scenario (2005), explicitly refers to the concept like the curve of exponential growth (p. 206) or a future of radical evolution, pointing out that the difference between this scenario and “Heaven” and “Hell” consists of the recognition of human beings’ creative role in shaping the impact of technological development on society and nature; yet he does not de facto question the hype surrounding converging technologies. Garreau writes: “For all previous millennia, our technologies have been aimed outward, to control our environment. Starting with fire and clothes, we looked for ways to ward off these elements. With the development of agriculture we controlled our food supply. In cities we sought safety. Telephones and airplanes collapsed distance. Antibiotics kept death-dealing microbes at bay. Now, however, we have started a wholesale process of aiming our technologies inward. Now our technologies have started to merge with our minds, our memories, our metabolisms, our personalities, our progeny and perhaps our soul. Serious people have embarked on changing humans so much that they call it a new kind of engineered evolution – one that we direct for ourselves.” (Garreau 2005, p. 6). In the European report there are no similar descriptions of the future (Nordmann 2004a).

17. At a meeting of the European Commission in September 2005 – organized by the Directorate Research conference on Key Technologies in Brussels – Green took this credo to express the favourable conditions for technical research and development in Europe (see Nordmann 2006).

18. The cause of the universe for Plato is a divine craftsman, the Demiurge, who has taken the world of ideas, the eternal and perfect one, as the model for the universe. Lacking the capability to create things ex nihilo, the Demiurge was able only to organize the universe to
a limited extent, despite imposing mathematical order on a pre-existent chaos to generate an ordered universe (kosmos). See Zeyl (2000).

19. This differentiation finds interesting interpretation in the German tradition of philosophical anthropology at the end of the last century, which was centred around the question of the essence of the human being with respect to the contraposition of nature and culture, i.e. the question of the place of man in the world, nature and history. For Max Scheler, the real essence of the human being exists in her spiritual essence, in the fact that she tends to transcend (Transzendenz). The human being is a being who looks for God, who is essentially “theomorphic” (theomorph), because to build up his real essence, man has to detract from his materiality, to give up his reality (entwirklichen). For Arnold Gehlen, the human being is, by nature, a “deficit being” (Mangelwesen), lacking specific instruments to adapt to the natural environment, which tries to supply its deficits through the development of culture and technology: man is “by nature a cultural being”. For Helmut Plessner (1928), the human being is characterized by an “eccentric positionality” (exzentrische Positionalität), because he is simultaneously placed within the boundary between his body and a corresponding environment, but is also open to the world, falling outside this boundary. In accordance with this eccentric position, humans must establish artificial borders and embody them.

20. The naturalistic fallacy was originally described by G.E. Moore as indicating the attempts to prove claims in ethics by using natural properties. In other words, it represents an identification of the natural with the inherently good or with righteousness. Sometimes, the naturalistic fallacy is also referred to as the “is-ought problem” – originally described by David Hume in the third book of the Treatise of Human Nature – that represents the efforts to draw ethical conclusions (normative level) from natural facts (descriptive level). Hume criticized those thinkers who maintained that the world is good as it stands and needs no improvement, i.e. who claimed that just because something is the way it is, it ought to be that way. A broader discussion of this topic would go beyond the scope of this article.

21. Critics of enhancement see these technologies as threatening our efforts to achieve authenticity. In contrast, the proponents of these technologies see them as tools to achieve our authenticity (Parens 2005).

22. In his theory, “metaphysical” refers to non-falsifiable assumptions, i.e. assumptions which cannot undergo an empirical test. In the “Metaphysical Epilogue” to his work Quantum Theory and the Schism in Physics (1992), Popper points out that, in nearly every phase of the development of scientific metaphysical ideas, not only are the problems of explanation we choose to attack determined, but also the kinds of answers we consider satisfactory and as representing improvements (Popper, 1992, p. 161).

23. Dupuy (2007) has described the origin of this knowledge’s view in the principle of verum factum by the Italian philosopher, Gianbattista Vico (formulated initially in 1710 as part of the work De Italorum Sapientia). The principle states that truth is verified through creation or invention and not through observation. Originally, this principle was understood as a symbol of human finiteness, particularly in comparison to God’s wisdom (only God can entirely know nature because he created it), but this assumed a positive connotation, meaning that what human beings can do can be rationally understood – despite their finiteness. The definition of technoscience dates back to the postmodern works of Bruno Latour (1987) and Donna Haraway (1997) in the sociology of science, and it indicates a new modality of conceptualizing science. While “classical” science is interested in the theoretical representation of nature and its understanding, technoscience is more oriented toward the fabrication of tools and devices. In this conception, technology and science, i.e. transforming the world and knowing it, are inextricably interrelated. Currently there is an ongoing debate about the technoscientific character of emerging technologies, in particular, nanotechnologies (cf. Nordmann 2005).
24. The core of cybernetic credo is the idea that every behaviour that is unambiguously describable in a finite number of words is computable by a network of formal neurons (Dupuy 2000). In this programme, nature is conceived as an artefact.

25. Indeed, Dupuy believes the cognitive sciences provide the guidelines for NBIC convergence (see, in particular, Dupuy 2000).

26. For example, Dupuy (2007) points out that the idea of defeating death (i.e. of eliminating pain and diseases and becoming immortal) relies on a wish to go beyond the human condition of finitude, which is determined by nature.

27. Dupuy quotes Arendt’s description of the unanswerability of the Augustinian question on human nature and on the opportunity of analysing human self-made conditions (see Dupuy 2006).

28. The claim of transhumanists that enhancement is in some way presupposed from the imperfection of our body is problematic for Nordmann (2007c), because, in contrast, awareness of the frailty of the body is a reason for some people to decide to undergo cosmetic surgery, for example. These people accept an enhancement technology without being committed at the same time to a notion of technological transcendence of human limitations.

References


National Science and Technology Council, 1999. Shaping the world atom by atom. Washington, DC.


Nordmann, A., 2007b. If and then: a critique of speculative nanoethics. in Nanoethics, 1 (1).


Nanotechnology, Governance, and Public Deliberation: What Role for the Social Sciences?

In this article we argue that nanotechnology represents an extraordinary opportunity to build in a robust role for the social sciences in a technology that remains at an early, and hence undetermined, stage of development. We examine policy dynamics in both the United States and United Kingdom aimed at both opening up, and closing down, the role of the social sciences in nanotechnologies. We then set out a prospective agenda for the social sciences and its potential in the future shaping of nanotechnology research and innovation processes. The emergent, undetermined nature of nanotechnologies calls for an open, experimental, and interdisciplinary model of social science research.

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Social science historically developed alongside the new industrial order, which was based on novel technologies of steam-based power, the railways, and the factory system. Marx analyzed this new technological society

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as it unfolded around him in mid-nineteenth-century Britain. However, during the twentieth century, social science often struggled to keep pace with new and emerging technologies. It was slow to provide intelligent and reflexive analysis of the implications of personal automobility, the splitting of the atom, and the significance of early computing.

In this article we argue that nanotechnology represents an extraordinary opportunity to build in social science insight from the outset. By thinking of its role in a new way and taking the reflexive governance of nanotechnologies as a central concern, social science has novel opportunities to become an actor in these changes and to provide insights that are simultaneous with scientific, technological, and social changes.

However, analysis of all such “technosocial orders” presents significant challenges to existing ways of doing social science, especially in the outmoded idiom of seeking to examine a categorically social realm as distinct from physical and material elements (Latour 2004). Historically, the academic literature has framed technology as “black-boxed” and well defined, with an independent asocial logic that results in “impacts” or “effects.” Social questions are often narrowly framed as “impacts” or “risk” issues, placing the site of social science inquiry firmly “downstream” of innovation processes (for a recent nanotechnology example, see European Commission 2004). However, various approaches in science-and-technology studies have shown how technologies cannot be black-boxed and separated from sets of constitutive social relations (see Law and Hassard 1999; Pinch and Bijker 1984; Wynne 1988).

“Constructive technology assessment” (Rip, Misa, and Schot 1995) and “real time technology assessment” (Guston and Sarewitz 2002) represent two approaches that problematize the determinism of black-boxed technology. Both approaches focus on how “technical” processes often make implicit upstream assumptions about the social uses to which the technology will be put: under what conditions, by which kinds of actor, and with what aims (Grint and Woolgar 1997; Law and Bijker 1992). Social and political relations, or imagined relations, are “hard-wired” into technological designs, and performed by them (Winner 1977). Science-and-technology theorists suggest that a fundamental characteristic of any technology is its heterogeneous, hybrid mix of material, social, and discursive relations, its mix of pure and applied elements, and its associated and often prescriptive social expectations or assumptions (Latour 2004; MacKenzie and Wajcman 1999). The
goal of such processes is to engage forms of public participation before innovation processes become locked in—in other words, at an upstream stage. In this article we set out and critically engage with the notion of “upstream public engagement” as a further and potentially useful addition to the unfolding academic and policy debate.

Such a conceptual approach lies in stark contrast to the more limited role of the social sciences that tended to characterize its use in the development of biotechnologies. Dominant approaches, institutionally cemented through programs aimed at understanding the ethical, legal, and social issues (ELSI) surrounding the Human Genome Project, locked into a framing that assumed the technology as a given, and as such, assumed the project of ethical and social reflection as one largely reduced to conceptualizing, evaluating, and managing “the impacts.” Through such framing commitments, ELSI programs lacked any mechanism to affect the innovation process itself. Relatedly, the birthing of “bioethics” that arose out of this agenda has been largely complicit with deficit models of science communication (Hedgecoe and Martin 2003; Wynne 2001). Indeed, we have argued elsewhere that the framing of the social sciences in the development and utilization of genetically modified (GM) crops and foods was such that its mobilization was often too late and without any real purchase on on-going processes of governance (Kearnes et al., forthcoming).

More generally, in the domain of biotechnologies, there was little institutionally sanctioned space for the social sciences to engage with wider social and political questions about purposes, ownership, control, and responsibility (Grove-White et al. 2000; Wilsdon and Willis 2004). Why these technologies? Why not others? Who needs them, and what human purposes are driving them? Under what conditions will they be enacted; and who sets those conditions? Who is controlling them? Who benefits from them? Can they be trusted? Drawing on the lessons from GM and other controversies, nanotechnology reflects an opportunity for the social sciences to explore how governance and regulation can be extended to incorporate a wider set of cultural and social, and indeed technical, factors (Grove-White et al. 2004). We suggest that unless this challenge is addressed, the latent tensions inherent in the technological transformation of democratic society are likely to remain unaddressed. Far from being a “critical” project, therefore, this is a constructive one, requiring robust collaborative interactions with scientists and technologists.

Significantly, there appears to be some institutional recognition of the need for a wider role for the social sciences in the development of nanotechnologies, including a clear undertaking for novel forms of public dialogue and engagement (see Department of Trade and Industry/Office of
Science and Technology 2005; Royal Society/RAE 2004). In this article we address some of the underlying machinations and rationales at work for building social science into the development of nanotechnology. These include:

- The appeal to social scientists as experts in the study of public opinion and political mobilization processes, hence leading to promises that such socially sensitive intelligence may help avoid future disruptive public controversy;
- The ability of social science to help shape innovation processes in tune with wider public and consumer attitudes, thus helping governments and corporations “pick winners” and “avoid losers”;
- The exploitation of social scientists as (good) public communicators and disseminators of nanoscience and nanotechnologies, often in an outreach capacity, thus again helping shape a more informed and arguably less emotive but not necessarily less critical public debate;
- The attempt to use social science techniques to open up the “black box” of science and innovation, so that tacit assumptions shaping its development can be opened to wider public scrutiny, to induce greater reflexive awareness among scientists in their specialist work worlds, with the expected result that innovation processes indirectly gain added sensitivity to human needs and aspirations, and thus greater resilience and sustainability.

The distinctions between these framings are, of course, ambiguous—indeed, most are at play in different ways in multiple contexts. Similarly, it is an open question which of these framings will come to the fore and dominate. In this sense nanotechnology represents an opportunity to innovate new and more reflexive relationships between the social sciences and the physical sciences. However, despite this renewed openness to social science input, there is a danger that such input is framed in ways that assume the \textit{prima facie} beneficence of technology and that would seek to limit the scope for social science input to disturb core innovation processes. We argue below that in both the United States and United Kingdom there is an emerging dynamic aimed at both opening up, and closing down, the role of the social sciences in shaping future nanoscience and nano-innovation research agendas and trajectories. We then set out, in programmatic form, what a more open-ended agenda for the social sciences of nanotechnologies might look like.

\textbf{The Public Debate}

In the past two years, a policy and media debate about nanoscience and nanotechnologies has emerged, characterized by competing visions of prom-
ise and threat. For their advocates, nanotechnologies are seen to have huge economic and social potential, ushering in a “new industrial revolution” that will include breakthroughs in computer efficiency, pharmaceuticals, nerve and tissue repair, surface coatings, catalysts, sensors, materials, telecommunications, and pollution control (European Commission 2004; House of Commons Science and Technology Committee 2004; Roco and Bainbridge 2001). Worldwide research funding for nanosciences and nanotechnologies is increasing rapidly, and is estimated to have reached $8.6 billion in 2004 (Lux Research 2004).

At the same time, ethical, social, and environmental concerns that originated with dystopian fears of “grey goo” (Drexler 1986; Joy 2000) are rapidly taking on a sharper focus around the potential toxicity of nanoparticles and the need for tighter regulation (Nature 2003; Royal Society/Royal Academy of Engineering 2004). Nongovernmental organizations (NGOs) have criticized the vested interests that lie behind the science, and Prince Charles has raised the specter of thalidomide in an effort to encourage a more precautionary approach (ETC Group 2003; HRH The Prince of Wales 2004).

Such bipolar characterizations are, of course, an oversimplification. The questions, challenges, and opportunities that surround nanotechnologies will take many forms. Indeed, the very definitions and constitutions of nanotechnologies are themselves the subject of lively debate, within the scientific community and beyond (House of Commons Science and Technology Committee 2004).

As conventionally understood, the term “nanotechnology” refers to the design or manipulation of structures and devices at a scale of 1 to 100 nanometres (or billionths of a meter). Yet scale is one characteristic that unites the diverse activities and applications commonly referred to in this way. A crucial further issue is the novelty and unpredictability of what occurs at this scale. When broken down into such small particles, the properties of materials can change in fundamental ways. Gold and silver are good examples. Normally inert and unreactive, at the nanoscale gold acts as a highly effective catalyst, and silver displays bioactive properties (Smith 2004).

Working at this scale requires a high degree of interdisciplinarity, and nanoscience increasingly extends across a range of fields, from chemistry, physics, and biology, to medicine, engineering, and computer science. Yet while the term “nanotechnology” may be relatively new, much of the science behind it is not. Many existing chemical processes have nanoscale features, and nanotechnologies have been used to create computer chips for the past twenty years. From a social science perspective, this raises important questions about the processes through which such terminologies are being
defined, contested, and continually adapted in relation to external economic and political drivers.

Given the novelty of what becomes possible at the nanoscale, it is perhaps unsurprising that nanotechnologies are giving rise to new, and potentially profound, social questions. These have moved with remarkable rapidity onto the political and regulatory agenda in the UK, across Europe, the United States, and beyond. Additional complexities flow from the convergence of nanoscale innovations in different domains: notably, the life sciences, cognitive sciences, and information technology (European Commission 2004; Nordmann 2004; Wood, Jones, and Geldart 2003). We now address the policy debate shaping the role of the social sciences in the United States.

The United States

In the United States, the context for research into the social and ethical dimensions of new and emerging technology has been shaped fundamentally by the institutional support and commitment granted to the ELSI program of the Human Genome Project (Ramsay 2001). The ELSI program was established to provide:

A new approach to scientific research by identifying, analyzing and addressing the ethical, legal and social implications of human genetics research at the same time that the basic science is being studied. In this way, problem areas [would] be identified and solutions developed before scientific information is integrated into health care practice. (National Human Genome Research Institute 2004)

The ELSI approach clearly sets the institutional and intellectual context for current considerations of nanotechnology. As already noted above, however, there remains a fundamental tension at the heart of the approach. Although research is clearly intended to feed social and ethical insight into science-and-technology developments in “real time,” it is framed as being able to scrutinize only the impacts or effects of the technology rather than (as set out above) deeper social and political considerations about driving purposes and visions that may be exercised in shaping knowledge production, as well as broader issues about ownership, control, and responsibility. Rather than being a mode through which social science insights may be “built into” technological development, both upstream and in real time, it is becoming increasingly apparent that the ELSI agenda reduces such scholarship to a downstream “bolt on.” In its focus on impacts and effects, the ELSI program assumes the inevitability of prevailing and future forms of technology and
limits the role of social science to downstream questions. As such, social science scholarship is invoked only after significant commitments are already made and technological pathways have become locked in, thus without any real purchase on the development of such technologies.

The way that ethical and societal enquiry is positioned in relation to nanotechnology in the United States demonstrates the influence of this approach and the tension therein. The National Nanotechnology Initiative report, *Leading to the Next Industrial Revolution* (National Science and Technology Council 2000), for example, outlines the role of ethical and societal inquiry in the following terms:

> Ethical, Legal, Societal Implications and Workforce Education and Training efforts will be undertaken to promote a new generation of skilled workers in the multidisciplinary perspectives necessary for rapid progress in nanotechnology. The impact nanotechnology has on society from legal, ethical, social, economic, and workforce preparation perspectives will be studied. The research will help us identify potential problems and teach us how to intervene efficiently in the future on measures that may need to be taken. (p. 13; see also Bennett and Sarewitz, forthcoming)

The report further outlines how such research will be carried out in real time, in concert with scientific and technical innovation, and how it will provide early evidence of potential social and ethical “problems” enabling upstream intervention. However, as with the ELSI program of the Human Genome Project, such research is also implicated in the “success” of the federally funded National Nanotechnology Initiative (NNI). That the NNI is, at least rhetorically, to lead to the “next industrial revolution” is not subjected to ethical or sociological inquiry. And in this particular sense, the envisaged role of the social sciences can be seen as a social lubricant in the drive toward industrial success and commercialization. This is a position more or less enthusiastically embraced by Roco and Bainbridge (2001) in their report on the National Science Foundation–sponsored workshop on the “Societal Implications of Nanoscience and Nanotechnology.” Indeed, in their introduction to the workshop, Roco and Bainbridge set out the role of social science research in the following terms:

> Research on societal implications will boost the NNI’s success and help us to take advantage of the new technology sooner, better and with greater confidence . . . [and later] Nanotechnology’s effect on society—legal, ethical, social, economic, and workforce preparation—will be studied to help identify potential concerns and ways to address them. As the NNI is commencing, there is a rare opportunity to integrate the societal studies and dialogues from the
very beginning and to include societal studies as a core part of the NNI investment strategy. (pp. 2, 10, emphasis in original)

In this way, although the social sciences are seen as playing a legitimate and potentially integrating role in the development of nanoscience and nanotechnology, such an involvement is still coupled to a relatively unproblematised notion of “success,” and to a very downstream vision of the scope for social science that excludes social dimensions of the processes shaping the knowledge and technologies themselves. The positioning of societal and ethical research in this way is, therefore, imbued with the same, unresolved, tension as in the Human Genome Project. Though such research is to be both funded and supported by central government, and positioned in such a way as to promise to influence the trajectory of developments in nanotechnology, it is currently unclear whether such research will be able to achieve the necessary distance from projected innovation roadmaps. The ELSI component of the NNI is framed in a way that makes this tension both ambiguous and unresolved.

Such unresolved tensions can also be identified in the 2003 21st Century Nanotechnology Research and Development Act, a largely administrative act designed to authorize appropriations for nanoscience, nanoengineering, and nanotechnology research. While specific legislative clauses are written into the act to ensure that ethical, legal, environmental, and societal concerns are addressed during the development of the technology, it remains unclear as to how and in what ways such an integrated agenda is imagined to impinge on the development of the science agenda itself. Such tensions are currently being played out in 2005 in relation to National Science Foundation proposals for a major $13 million “Center for Nanotechnology in Society,” not least in relation to the legal stipulation to consider the potential use of nanotechnology in human enhancement.

To summarize, even though the role of the social sciences in the United States has tended to be framed as limited to the exploration of the societal impacts arising from nanoscience and nanotechnology, there remains significant scope for a wider role due to the parallel ambitions for social research to become integrated with innovation processes in real time. Such ambiguity has created an opening in the normally “black boxed” processes of technological development and innovation, the effect of which will become visible only in the coming years.
The United Kingdom

Although the social sciences benefited from a well-targeted ESRC-funded report on the Social and Economic Challenges of Nanotechnology (Wood et al. 2003), it was the publication in July 2004 of the UK Royal Society/Royal Academy of Engineering report on nanotechnologies that signaled the start of a new phase in UK debates on nanotechnology and society. Learning from recent experience with biotechnology, the Royal Society highlighted a key role for the social sciences to help provide improved insights into the implications of nanotechnologies and their role in helping facilitate more socially robust technologies.

This move poses significant challenges and opportunities that are only beginning to be conceptualized. Not least on account of the widespread public ambivalence toward science that is manifest in the UK, to what extent is it possible to create frameworks of governance that can sustain economically vibrant, socially legitimate, and environmentally sustainable technological enterprises? How are individuals and institutions, confronted with rapid technological change, to imagine new social possibilities, and choose among them wisely? And how may all of this pan out for the poor, for developing countries, and for the development process generally. A number of initiatives in the UK have begun research aimed at developing insights on these questions, so as ultimately to generate more socially intelligent processes of regulation, public dialogue, and technology assessment (Department of Trade and Industry/Office of Science and Technology 2005; Macnaghten et al. 2003; Wilsdon and Willis 2004; Wilsdon, Wynne, and Macnaghten 2005).

The policy context in the UK, including its particular preoccupations with “public engagement,” needs to be situated within a particular historical context. Following a series of controversies—such as “mad cow” disease and genetically modified crops and foods—there is growing institutional commitment for new mechanisms of public involvement in the social and ethical dimensions of science and technology (Better Regulation Task Force 2003; House of Lords 2000; Royal Commission on Environment and Pollution 1998). More recently, policy discussions have started to focus on the need for public engagement to take place “upstream” in processes of innovation, at a stage when it can influence research decisions, and before entrenched or polarized positions emerge (Grove-White et al. 2000; Wilsdon and Willis 2004; Wynne 2003). For example, the UK government’s new ten-year strategy for science and innovation includes a commitment “to enable [public] debate to take place ‘upstream’ in the scientific and technological development process, and not ‘downstream’ where technologies are waiting to be exploited but may be held back by public scepticism brought about through
poor engagement and dialogue on issues of concern” (HM Treasury/Department of Trade and Industry/Department of Education and Skills 2004, 105). This argument has now been adopted in relation to nanotechnologies by the Royal Society, the Science Minister Lord Sainsbury, and the Office of Science and Technology (Department of Trade and Industry 2004; Department of Trade and Industry/Office of Science and Technology 2005; Royal Society/Royal Academy of Engineering 2004).

These commitments to “upstream” public engagement in processes of scientific-technological innovation are a significant shift in public-policy discourse, and raise many unresolved questions for social science as well as for science itself. At what stages in R&D processes is it realistic to raise issues of public accountability and social concern? How and on whose terms should such issues be debated? Are dominant institutional discourses of risk, ethics, and “social responsibility” adequate for addressing these issues? Can citizen-consumers exercise constructive influence over the pace and direction of technological (and related social) change? How can these questions be reconciled with the need to maintain the independence of science, and the economic dynamism of its applications?

Of course, such a portrayal of UK policy making on nanotechnology and the extended role of the social sciences is only one part of a complex and unfolding set of forces. There is a further and more familiar conservative dynamic at play in which social science is seen as having a far more limited role in the development of nanoscience policy. Indeed, such a view was reflected in the UK government response to the Royal Society/Royal Academy of Engineering report in which the social sciences barely made a mention, where the language of “upstream” public engagement failed to make the final draft, and where no new money was offered (HM Government 2005). Even the Royal Society declared itself “very disappointed” (Royal Society 2005)!

It has been striking to see the rapid official uptake in UK and EU science-policy communities of the idea of upstream public engagement with science; an idea that emanated from an extensive academic scholarship in science- and technology studies and more recently in the writing of key scholars involved in public policy (see Marris et al. 2001; Wilsdon and Willis 2004; Wynne 2001, 2003). However, the more complex shift of focus that an “upstream” focus was intended to introduce has rarely been noticed in this official uptake, and which thus has remained riddled with confusion and ambiguity. This can be noted, for example, in the otherwise admirable UK Royal Society/Royal Academy of Engineering (2004) report on nanotechnologies. Thus, whereas Wynne and colleagues have emphasized that upstream forms of public engagement with science are emphatically not
pretending to earlier prediction of impacts or social reactions so as better to manage these, the Royal Society/Royal Academy of Engineering report—in a single chapter on public engagement and the need to move upstream—refers to this ambition at least ten times. By contrast, Wynne and colleagues have stressed the logic that the predicament of ignorance and unpredictability—of which ordinary publics appear only too aware (Grove-White et al. 1997; Marris et al. 2001)—implies that we need to develop novel techniques aimed at eliciting, explicating, and subjecting to wider debate and scrutiny, the driving purposes, expectations, imaginations, and social ends of upstream knowledge. Such debate would provide a different ethical and social context for scientific practice, including R&D investment.

Thus, we suggest, upstream engagement does not concern publics telling scientists what to do or think, nor assert that ordinary people know better than scientists about risks, as the prevalent, and blatantly confused, prediction-immersed understanding of upstream engagement with science still mistakenly implies. Rendering scientific cultures more self-aware of their own taken-for-granted expectations, visions, and imaginations of the ultimate ends of knowledge, and rendering these more articulated, and thus more socially accountable and resilient, is a radically different kind of role for the social sciences. This, we argue, lies in science’s own best interest, as it would provide the grounds for a public legitimacy that its patrons and exploiters are so anxiously seeking.

What Kind of Social Science is Required?

As we have demonstrated, the science-and-policy debate around nanotechnologies represents a novel opportunity for building the social sciences into its upstream development. As we seek to map out such an agenda, we need to bear in mind that such upstream terrain has traditionally been regarded as properly fenced off from social attention. How can this complex and difficult terrain, as yet uncharted, be addressed in a constructive and responsible way? We conclude this article by setting out a prospective agenda for the social sciences and its potential in the development of nanotechnology research and innovation processes. The emergent, undetermined nature of nanotechnologies—technoscience “in-the-making” (Latour 1987)—calls for an open, experimental, and interdisciplinary model of social science research. From the outset, the ambition is to develop interdisciplinary approaches that seek to embrace the complexities of nanotechnologies, and their emergent, materializing, and condensing social relationships. We now discuss five potentially rich veins of social science research activity:
I. Imaginaries. A social science of nanotechnology should seek to unpack the ways in which nanotechnology is imagined—in both technical and social terms—and to assess the role that such imaginaries play in innovation processes. Understanding the implicit assumptions, values and visions—or “imaginaries”—of key actors has been recognized as a central part of the social science challenge, because of their significant role in shaping research and innovation trajectories (Brown and Michael 2003; Hedgecoe and Martin 2003; Kearnes et al. forthcoming; Rose 2001; van Lente 1993).

The term “imaginary” shares the sense of vision and fantasy implied by the term “imagination.” But it dissolves the opposition of the imagined and the real: whether an imaginary is based in fantasy or in evidence remains an empirical question rather than one to be settled a priori (Marcus 1995; Verran 1998). The key point is, imaginaries are materially powerful; they do shape practices, relationships, and commitments (which are often rendered irreversible), and as such, they demand reflective, accountable attention and debate.

As well as shaping the expectations of individuals and institutions, imaginaries are mobilized through ongoing public discourses and enacted in everyday practices. They are multiple, partial and often internally inconsistent (Fleck 1979; MacKenzie 1992; Squier 1995, Suchman and Bishop 2000). Emerging technologies, surrounded by ambivalence and conflicting narratives of utopia and dystopia, provide fertile ground in which the moral dilemmas of modernity are rehearsed. While some visions are repeatedly promoted—progress/cornucopia, a world of leisure or the conquest of disease—others may be repressed in official discourse, such as the narratives of Frankenstein or Brave New World (Bloomfield and Vurdubakis 1995).

Scientific practice has traditionally been seen as insulated from such cultural forms, yet, whether implicitly or explicitly, it is routinely influenced by them, as for example, the often unstated “cultural” drive of science toward “precision” and “control.” A major object is to explore what form and extent this influence takes. How do imaginaries shape trajectories of scientific research, and help define “doable” and worthwhile scientific problems? What role do they play in the allocation of funding? How do they mobilize public and private interest and opposition? And how can social science help open up such imaginaries to wider public scrutiny and debate, for the benefit of science as well as society? In the context of a general dialectic between openness and closure that characterizes any process of innovation, the aim is to open up nanotechnological imaginaries and scientific potentialities before they are inadvertently closed down and “black boxed” through commitments to specific problems, products, and applications (Stirling 2005).
Nanotechnologies are framed by scientific and engineering imaginaries that have longstanding antecedents (see, for example, Noble 1977, 1997; Shapin 1994). Their promise is infused with dreams of perfect engineering, of complete control over the physical structure of matter, and, eventually, the creation of autonomous, self-replicating entities. Such imaginaries render nanotechnologies visualizable and to some extent already familiar (e.g., the macrolevel machine expressed at the nano-level). The ability to operate at the nanoscale—atom-by-atom—symbolizes an expression or ambition of power. It represents the material world subordinated to human will with unprecedented degrees of precision and control.

At the same time, this vision of total control is something of a double-edged sword, if not an Achilles heel. For the empirical invisibility of nanotechnology, beneath the threshold of the human senses (rather like genetic modification and nuclear technology before it; see Beck 1992; Erikson 1994), makes it almost impossible to verify whether it is in fact under human control—thus providing fertile ground for voices of opposition; for instance, dystopias that build upon Drexler’s imaginary of self-replicating “grey goo” as a central motif. Indeed, whilst this notion of “grey goo” is dismissed by mainstream nanoscientists (Royal Society/Royal Academy of Engineering 2004), it has achieved a certain prominence among the public and media, not least due to interventions by the heir to the UK throne. In debates over GM food, negative popular imaginaries tended to be dismissed or ignored and it would seem prudent that the same mistake is not repeated in the area of nanotechnology.

Such research poses significant methodological challenges, including the development of novel and reflexive relationships with nanoscientists and other relevant actors, both at academic research sites and within corporate R&D settings. To understand the nature, origins, and effects of such imaginaries, and to find ways of opening them to greater scientific reflection and public debate, will require informed interaction with scientific actors in their own “lifeworlds.” This implies a potential role for social scientist ethnographers as a new kind of actor-participant in those scientific knowledge communities. Similar developments are afoot in social science research with the postgenomic sciences.

II. Public Engagement. A social science of nanotechnologies should ask in what ways can processes of public dialogue open up and help indirectly to shape “upstream” R&D of emerging nanotechnologies, and seek to build appropriate models of public engagement into the development of nanotechnologies.
Since 2000, when the UK House of Lords Science and Society report buried the misconceived deficit model of public understanding of science (Wynne 1991, 1995), “public engagement” has become the new mantra (at least in UK and EU science policy). Much of this new “listening mode” for science has been taken up with the aim or expectation of restoring public trust and authority for science. The more radical idea that public inputs might legitimately reshape scientific and technological enterprises as a condition for their public legitimacy has not been a prominent feature of the new discourse of public engagement. The suggestion that public engagement may have several different rationales and objectives, including the stimulation of greater self-reflection within science about its own assumptions and expectations, effectively about its own cultural forms, has been made more recently (Wynne 2003). As described before, there is also an emerging consensus that such engagement should be focused on upstream processes of R&D priority setting and funding, in addition to the downstream impacts of innovation (Department of Trade and Industry 2004; Grove-White et al. 2000; HM Treasury 2004; Macnaghten 2004; Nature 2004; Royal Society/Royal Academy of Engineering 2004; Wilson and Willis 2004; Wynne 2001).

However, even though there is increased policy and institutional acceptance of the need to move upstream, precisely what this entails remains ambiguous and open to multiple interpretations. For some, upstream engagement is still assumed to be about earlier anticipation and more effective management of risks, impacts, and consequences. Such assumptions downplay a critical dimension of public concern, which is that there are unpredicted consequences that scientific risk assessment is incapable of identifying, whether it takes place upstream, downstream, or somewhere in between (Marris et al. 2001; Wynne 2001). Instead, publics often want to ask more fundamental questions about driving human purposes, ownership, control, and responsibility. Modern science and technology in general has suffered an unhealthy dearth of any such debate, which has instead been focused on risk.

It has been recognized that nanotechnologies and their convergences with adjacent domains such as Information and Communication Technologies (ICTs) and biotechnologies make prediction of future effects a decreasingly credible aspiration—and this from an unpromising starting point in terms of existing track record (Joy 2000). The claim of reliable predictive control through risk assessment has to be rethought as the basic reflex response of policy and scientific institutions to public concern or hesitation (Guston and Sarewitz 2002; Sarewitz et al. 2000). Upstream public engagement may sometimes help to create the conditions for better risk prediction. But this should not be the primary reason for this change of focus. Rather, it is that upstream processes are key sites of undeliberated shaping of future worlds,
as explained in the previous section. If these are to be elicited, debated, and maybe amended, social science needs to develop frameworks of accountability and learning that so far remain undeveloped.

The methodological challenge is to build on a range of “upstream” deliberative methods, involving both experts and public, through innovating novel techniques such as focus groups, citizen juries, scenario workshops, and deliberative mapping (Grove-White et al. 1997, 2000; Macnaghten 2004; Stirling 2005; Stirling, Davies, and Burgess 2004), as well as ethnographic methods. Key research questions that need to be addressed are: How can “upstream” questions be addressed in open, accountable, and resolvable ways? How can conventional forms of risk assessment and ethical analysis be integrated with wider social and political questions about purposes, alternative scientific trajectories, ownership, control, and responsibility? And what lessons can be drawn from technological domains where upstream public engagement is exclusively staged at the downstream stage—as took place, arguably, in the case of GM crops? It is also important to scrutinize what counts as successful public engagement. Is it the avoidance of immediate conflict, or longer-term changes toward greater resilience in the culture and practices of science? (Nowotny, Scott, and Gibbons 2001).

III. Governance. By building social science research into the upstream development of nanotechnology, it will be possible to innovate new frameworks for the governance and regulation of nanotechnologies that seek to be more anticipatory, resilient, and socially intelligent.

Confronted with rapidly advancing and converging nanotechnologies, policy makers and regulators need to identify frameworks of governance that are adaptive and anticipatory, yet which recognize the limits of prediction (Bentley and Wilsdon 2003; Sarewitz et al. 2000). When technological controversies erupt, the usual political response has been to look for regulatory solutions based on familiar science-based techniques of risk assessment. This pattern is already evident in debates around nanotechnologies, which are focusing heavily on regulatory responses to the uncertainties and potential hazards of nanoparticle toxicity (European Commission 2004; Royal Society/Royal Academy of Engineering 2004).

These responses, using the best science available, are necessary—but crucially, not in themselves sufficient. Further insights and policy innovations need to be developed and explored in practice. As Michael Power has argued, there is now an overwhelming tendency in political and organizational life to reach for the “risk management of everything” (Power 2004). However, when faced with potentially disruptive innovations, the danger is that risk assessment—however participatory—merely digs us deeper into the hole
from which we are trying to escape. It avoids a much deeper predicament that arises from recognizing the realities of ignorance and ambiguity. Debates that are too often framed in terms only of risk and safety—typically asking the question, “Is it safe?”—imply that the likelihood of certain outcomes, and the question of social commitment, is susceptible to rational calculation. More challenging questions that flow from ignorance concern the longer-term social purposes as well as consequences of a technology’s development, and what are the alternatives that might be available?

This concentration on risk is an understandable way of rationalizing an otherwise open and daunting set of questions. It reflects what Zygmunt Bauman describes as modernity’s “gardening instinct” (Bauman 1991). Yet this desire to tidy the borders of our democracy means that frameworks of governance and regulation may be stripped of meaningful content. Fundamental questions arise from further examination of today’s “global knowledge-economy,” perhaps the dominant self-characterization of contemporary society and its established institutions (de Sousa Santos 2003). What kinds of cultural conflict are now emerging centered on the production of scientific knowledge? Are there forms of politics (e.g., new social movements and mass forms of alienated citizenship) that call for new forms of governance of science and technology as the major forces shaping human worlds? What new institutional and organizational forms may be appropriate to articulate these inchoate, globally-distributed concerns, conflicts, and democratic aspirations?

From these wider perspectives, conventional discourses of regulation, risk, and ethics look increasingly inadequate. New government commitments to “upstream” public dialogue with science—if taken seriously—may run rapidly into head-to-head conflict with concerns about global competitiveness and the economic potential of national science systems competing aggressively for global investment and trained personnel. These issues may be difficult to address in a purely national context, especially when public concerns do not correspond with those assumed by scientific, industrial, and policy-making elites (Grove-White et al. 1997; Marris et al. 2001).

In the case of nanotechnologies, the contours of public concern are not restricted to the risks of nanoparticle toxicity. There are other fundamental questions that need to be asked: Why these technologies? Why not others? Who needs them, and what human purposes are driving them? Under what conditions will they be enacted, and who sets those conditions? Who is controlling them? Who benefits from them? What contingency plans might there be to contain unanticipated disasters? Can those in charge be trusted? Drawing on the lessons from genetic modification and other controversies, programs of research need to explore how governance and regulation can be
extended to incorporate a wider set of cultural and social, and indeed technical, factors (Kearnes et al., forthcoming).

**IV. Globalization.** Fourth, we need to examine the emerging patterns of nanotechnological innovation worldwide, and what social and governance challenges these pose both globally and for nation-states.

*Research is required to map the shifting geographies of nanotechnological innovation and knowledge production.* As nanotechnologies start to play a more significant role in the global knowledge economy, what new opportunities for wealth creation will they create? How will they contribute to shifts in the global distribution of knowledge, resources, and power? What forms will these take? Might they allow developing nations to “leapfrog” into a new technological paradigm? Or might they reinforce inadvertent forms of epistemic exclusion, stratified industrialized knowledge-economy divisions of international labor, and new forms of public alienation (Castells 1996)? How will such governance challenges play out across different geopolitical and knowledge sectors?

It is important to understand how the global development of nanotechnologies will be shaped by the relationship between the different temporalities of technological innovation, regulation, and societal deliberation (Jessop 2000). Increasingly, risk discourses are intervening intensely in the very process of product innovation, shaping the direction of entire industries in ways that are not easily anticipated. Nanotechnologies are emerging in a situation of “risk sensitization,” which creates tensions between cycles of innovation and capital accumulation, and the need for governments and industries to respond to public anxieties about possible hazards. Regulation, product testing, and more expansive modes of public engagement and dialogue slow down the process of entry to the marketplace, which may sit in tension with the need for rapid investment return.

Conventional characterizations suggest that precaution acts as a barrier to innovation. In a European context, several recent studies have shown that this is not necessarily the case, and precautionary approaches can, in fact, act as a stimulus for new forms of innovation (European Environment Agency 2001). However, it remains an empirical question as to how such interactions will play out on a global scale. Regulation may slow down the product cycle, or it may provide advantages to some economic actors, possibly favoring larger corporations over smaller start-ups. It may reinforce the economic power of the United States and other leading nations, or enable new, niche players to emerge (as for example, Finland became a surprisingly successful player in mobile communications technologies). In any case, the escalating stakes of managing the public acceptance of scientific innovations in the
interests of keeping competitive in the global knowledge economy have brought newly emergent pressures and expectations on the social sciences as policy actors. Our scholarly communities will have to respond constructively and responsibly to such pressures; our proposals attempt to do this, in part, by trying to step ahead of those pressures, and by suggesting other opportunities and agenda, both for research and for the policy it hopes to enlighten.

To summarize, a political-economy social science agenda might embrace the following questions: Where is nanotechnological R&D being carried out and by which kinds of institutions? What factors shape, accelerate, or impede national and international innovation trajectories? What is the impact of emerging regulatory and governance (including civil society) processes on R&D and product development? And how are these dynamics directly or indirectly influencing the substantive intellectual contents and cultures of nanoscientific knowledge?

V. Emergence. Finally, we need to develop new frameworks of theoretical reflection to understand the emergence of nanotechnologies, and, in particular, to develop approaches that move beyond conceptualizing the future in terms of prediction or control.

In moving from a predictive to a postpredictive paradigm, social science needs to develop a set of theories and methodologies for relating to the complexities of multiple “futures” (Grove-White et al. 1997; Prigogine 1997; Sarewitz et al. 2000; Urry 2003; Wilsdon and Willis 2004). The central notion here is that nanotechnologies are a set of dynamic and potentially unbounded systems. Science and technology as cultural forms are the ultimate objects of interest, however precisely these might be defined in all their variety. They develop collective patterns and non-linear consequences not present within their individual components. Such systems demonstrate both the “end of certainty” and long-term irreversibilities, as well as heterogeneity and emergence, as they become locked in to certain path dependencies (Prigogine 1997; Rip and Kemp 1998).

In exploring the nature of technological emergence, the goal is to understand the complex role that these systems and their different temporalities play (Adam 1998). A number of social scientists have analyzed the role of expectation, or future-oriented imaginaries, in emerging technologies (see, for example, Brown 2003; Brown and Michael 2003; Brown, Rappert, and Webster 2000; van Lente 1993; van Lente and Rip 1998). Such analyses are fundamentally about future promises, and their epistemic and ontological dimensions. They suggest that the emergence of new technologies is characterized by complex and heterogeneous cycles of hope, expectation, hype, and disappointment, which are connected with material realities. Understanding
the heterogeneous time horizons and expectation dynamics embedded within new technological domains is crucial to how new technologies may materialize and become “stabilized” as a transportable “actor network.”

Twenty years ago, the philosopher Hans Jonas warned that “Modern technology has introduced actions of such novel scale, objects and consequences that the framework of former ethics can no longer contain them” (Jonas 1984, 34). At the time, he had in mind the awesome transformations wrought by nuclear and genetic technologies. But his analysis can be applied with equal force to the changes that now are underway at the nanoscale. The questions that Jonas posed can be posed afresh today. If these technologies enable human interventions at a novel scale—the very atoms and molecules that are the building blocks of matter—does this require an equivalent shift in the scale of our ethical and sociological imagination?

**Conclusion**

This article has sought to outline a prospective social science agenda on nanotechnologies as a particular means to further develop a social science of science, technology, and society relations. Such a program of research promises to develop wider social learning and insight on questions of emerging technologies more generally, and on the ways in which social and ethical considerations can be built into the technical and scientific agendas at an early stage. A program of research of this kind promises to build capacity in the social sciences in at least three distinct ways.

First, it will do so locally by drawing upon, extending, and connecting theoretical insights in social theory, postmodernism, actor-network theory, science-and-technology studies, and complexity. Second, it will significantly advance the theory and practice of interdisciplinarity as it applies to collaboration between social sciences, humanities, natural sciences, and engineering disciplines. Third, it will develop a social science that engages with and contributes to policy debates in “real time.” Both these latter capacity developments involve more than intellectual developments in themselves. They also involve new knowledge-producing relationships and professional responsibilities, with respect to both the natural sciences and policy practices. Potentially this would involve social sciences becoming, modestly, actors in those worlds and not only observers and commentators of them.

Such an enhanced capability would enable the social sciences to play a strategic role in providing the social research and analysis necessary for the future governance, regulation, and public appraisal of emerging nanosciences and technologies. By clarifying the differential social values
and implications embedded within prospective nanotechnology developments, such a program would contribute actively to society’s resources for more intelligent and more humanly—as well as technically—robust debate and practice in such matters.

References


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Researching technoscientific concerns in-the-making: narrative structures, public responses and emerging nanotechnologies

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Abstract: This paper engages with debates on technoscientific governance, narrative and emergent public attitudes. Building on a piece of social research addressing public responses to the social and ethical dimensions of emerging nanotechnologies, the paper develops a methodology and mode of analysis designed to take into account four distinctive features of nanotechnology discourse and its constitution in the public sphere, namely: its unfamiliarity; its promissory quality; its uncanniness; and its metaphysical assumptions of progress. Through an analysis of common narratives that shape and structure lay public responses to the technology, and in response to framings of how the technology and its applications are being crafted in the public domain, the paper argues that nanotechnologies offer a site for an intense future politics centred on dilemmas of body invasion, unanticipated risks, nature’s revenge, control, inequalities and pace of change. The paper concludes with a set of reflections on the role of the critical social sciences in such a future techno-politics.

Key words: nanotechnology, technoscientific governance, emergent public attitudes, narrative, metaphysics

Introduction

In response to widespread public reaction to technological risk issues over the last two decades, we have witnessed a move internationally, and especially in Europe, towards state funded initiatives aimed at encouraging wider public engagement and societal participation in technoscientific processes as a means of improving relations between science and society. Such initiatives are developed for multiple and overlapping reasons, both instrumental and normative, and include the belief that they will, inter alia, help restore public trust in science, avoid future controversy, lead to socially robust innovation policy, democratise scientific governance, and render scientific culture and praxis more socially accountable and reflexive (Kearnes and Macnaghten, 2006; European Commission, 2007). While one can question the cumulative effect of such initiatives and whether they amount to, in effect, the new social contract between science and society that has been suggested in official documents (House of Lords, 2000; European Commission, 2000), one can nevertheless witness a new and significant role being crafted for the social sciences (Irwin, 2006; Hagendijk, 2004).

These developments are arguably most advanced in policy and governance debates on nanotechnology, both in the United States and in Europe, and for good reasons. Here is a technology with substantial and strategic levels of investment and expectation seen as in danger of running up against comparable adverse public reaction to that experienced with genetically modified foods and crops. Here, using the language of ‘responsible innovation’, social scientists are being asked not simply to characterise broader societal concerns in a
proactive manner, but also to integrate such considerations into nanoscience and nanotechnology research programmes at an early stage (Barben et al, 2007; European Commission, 2004; NSTC, 2004; Royal Society/Royal Academy of Engineering, 2004). Alfred Nordmann has playfully characterised the role of science and technology studies (STS) within these debates, from the ‘science wars’ of the 1980s and 1990s to the ‘love fest’ of contemporary times (Nordmann 2007).

At the core of this paper is an attempt to engage critically and empirically with one hitherto under-researched element of this role: that of the need for innovation in methodology and analysis in the reflexive examination of technoscientific concerns – and citizens – in-the-making. Just as Rose and Novas has argued that the biosciences are reshaping the contours of contemporary subjectivity and citizenship through new understandings of minds, bodies and responsibilities (Rose, 2007; Novas and Rose 2000), so too can this dynamic be seen to be taking effect through nanoscience discourse and practice. However, my argument is more experimental and speculative. Given that the technology exists largely in terms of future oriented promise rather than as material reality, the methodological requirement for the research outlined in this paper was to produce a space in which lay technoscientific citizens could be produced through an innovative public engagement exercise, able to offer opinions, discuss the issues and reflect on future politics and their contingencies (Michael, 2006). The research outlined below was part of a wider project, conducted in partnership with the UK public policy think-tank Demos, designed to explore the role of the social sciences in contributing towards a more anticipatory and socially robust governance framework (Kearnes et al, 2006). There are four sections to this paper. First, the methodological challenges in fostering a public dialogue on the social and ethical dimensions of emerging nanotechnologies are summarised. Secondly, a methodology is outlined designed to respond to such challenges. Thirdly, the results from the public dialogue event are reported, focusing in particular on the narrative process that shaped and structured public responses to the technology. And fourthly, reflections are offered on the implications of the research for the institutional governance of emerging technologies and on the role for the social sciences.

So what are the challenges in negotiating a public conversation on the social and ethical dimensions of emerging nanotechnologies? Firstly, it is clear from the literature that most people are unfamiliar with the term and have little to no factual knowledge of what it is or of what it could be, a finding shared in survey research conducted in the United States (Macoubrie, 2006; Sheetz et al, 2005; Waldron, Spencer and Batt, 2006), in the United Kingdom (BMRB Social Research, 2004; MORI, 2005), and across Europe (Eurobarometer, 2005). One implication that derives from this finding is that if one is to understand emergent public attitudes to nanotechnologies one needs to pay particular attention to the underlying frameworks and dynamics that are likely to structure their development and evolution (for an elaboration of this approach with reference to biotechnologies, see Grove-White et al, 2000; Macnaghten, 2004).

A second complication arises from the fact that most nanotechnologies remain at an early or pre-market stage of development, existing largely in terms of their future-oriented visions of promise and abundance. The institutionally-endorsed rhetoric of a future enabled by nanotechnology is beset with references to its role in enabling breakthroughs across multiple sectors and applications, from electronics to materials, health care to pollution control, and of a market that has been projected to exceed $4.0 trillion by 2015 (Lux Research, 2008). The future-oriented and promissory character of nanotechnology has been noted by scholars, notably in relation to the speculative claims of its future potential
(Nordmann, 2007b), the ways in which expectations of a ‘fantastic future’ is driving current scientific practice (Selin, 2007), and the role of science fiction in shaping the moral imagination of nanoscientists (Berne, 2006) and the development of nanotechnology policy (Milburn 2004).

The third complication arises from the so-called ‘uncanniness’ of the technology (Nordmann, 2005). Not only is it a technology that operates at the unbelievably small: nanotechnology is commonly defined as the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where comparative size of a nanometre to a metre is the same as that of a marble to the size of the earth; but it is also at a size where novel or unusual or surprising properties take effect. Nordmann (2005) has reflected on the incredible tininess of nanotechnology by speaking of it as a ‘noumenal’ technology, utterly beyond human action, perception and causal control.

The final complication arises from considerations of metaphysics. Following Popper’s observation that all science rests on a ‘metaphysical research program’, a set of presuppositions about the structure of the world which are neither testable nor ‘falsifiable’ empirically, but which nonetheless play an essential role in the progress of science, analysts have begun to examine the metaphysical assumptions, tacit or otherwise, that tend to underpin national and international programmes of nanotechnology and related initiatives (see Dupuy, 2005). Kearnes at al, (2006) have analysed a set of ‘programmatic imaginaries’ that operate as meta-level discourses and that drive the development of the technology, including the foundational conviction that nanotechnology represents a new paradigm of scientific endeavour based on its ability to control and manipulate matter at atomic and molecular scales. While such metaphysical assumptions are unevenly distributed within and across nanotechnology’s constituent scientific disciplines (Bensaude-Vincent 2004), and while there may be cultural differences between European and US versions of nanotechnology policy (Nordmann 2007a), there nevertheless can be seen to exist a strong and unified global programme of nanotechnology that is imbued with its own distinctive metaphysics. Central to its metaphysical programme are visions of control and precision (Kearnes, 2007), of abundance and escape from scarcity (Schwartz, 2004), of emulation and/or improvement of nature (Nordmann, 2005), and of a ‘dream of reason’ that is to overcome once and for all every given that is a part of the human condition (Dupuy, 2007).

Methodology: eliciting technoscientific concerns in-the-making

A methodology was developed aimed at responding to the challenges outlined above and thus at helping towards a contextual understanding of the factors likely to shape future public responses to nanotechnologies. A focus group methodology was chosen, designed to encourage discussion of potential issues arising for nanotechnology in an active learning setting, where the analytical task was one of examining the narrative forms and processes through which the unfamiliar was rendered familiar. Narrative was a key category of analysis (for accounts on the performative role of narrative in producing knowledge, see White, 1987; Taylor, 1992). What kind of stories would people tell about nanotechnology? To what extent would they be informed by direct experience with the world, or from mediated experience, from books, fables, movies, television, the internet, videogames, and so on? How would these narratives be drawn upon, argued over, and negotiated in the craft of producing opinions and attitudes? And in what ways would publics respond when confronted with narratives reflecting dominant institutional norms and aspirations?
This paper thus can be seen as benefitting from insights drawn from the sociology of expectations and from a body of scholarship that has examined how the future, as an analytical object, has been mobilised through discourse, motif and representation (Adam and Groves, 2007; Brown, 2005; Brown and Michael, 2003; Brown et al, 2000). The focus on lay public narratives structures offers a distinctive contribution to this literature and complements existing analyses of how new science is discursively narrated through expert media (e.g. for an analysis of role of the breakthrough motif in reporting new science, see Brown 2000).

Given the promissory character of most nanotechnologies, considerable thought was given to the institutional forms and narratives through which the technology is being introduced in the public domain (e.g. in the form of policy reports, newspaper articles, television documentaries, industry presentations, campaign materials, and so on). Two dominant frames were identified: one that interpolated nanotechnology as a new science that would contribute to projected breakthroughs across multiple sectors and spheres of application (European Commission, 2004; House of Commons Science and Technology Committee 2004); the other more avowedly utopian and revolutionary, with promises of how nanotechnology will extend and transform human sensory and physical capacities to transcend natural and physical constraint (Roco and Bainbridge, 2003). In addition, a third frame was added, derived from civil society actors and sceptics that focused on the potential and uncertain risks of the technology on human health and the environment, and of wider concerns of the technology running ‘out of control’ (ETC, 2003; Joy, 2000; Lloyds, 2007). These three visions were encapsulated in stimulus materials as reflective of three dominant frames – or styles of thought (Fleck, 1979; Hacking, 1992; Rose, 2007) – involving not simply what nanotechnology is, but what it explains, and what it represents. By exposing participants to the multiple frames characteristic of the emerging public debate, and by encouraging discussion and exchange on the credibility, legitimacy and authority of such frames, the design was intended explicitly to simulate the real-world dynamics through which nanotechnologies and their associated social relationships become co-produced.

The methodology further aimed to explore the ‘uncanniness’ of the nano world, and how it differed from the world of everyday experience. The participants were encouraged to develop a ‘nano imagination’ through design choices that included: extended time (the focus groups took place over two consecutive sessions, each session lasting two hours), a dedicated task between the sessions (people were asked to research for themselves the issue of nanotechnology, and to explore the topic with friends and colleagues, consulting websites, and keeping a journal for any reflections arising), an ‘in action’ focus (in which participants were encouraged to understand the arguments and debates surrounding nanotechnology as it was being practiced by actors in real-world circumstances), and a sample aimed at group enculturation (the groups, all non-expert in the field of nanotechnology, were chosen on the basis of common work or life histories – see also section below). To engage with the metaphysical dimensions of nanotechnology, the research was moderated in such a manner as to encourage discussion not simply on the technology as technique, but also on the underlying visions and motivations that appear to be driving the technology.

The sample consisted of five groups, recruited by professional recruiters on the basis of their existing participation in local community or political issues, but with no prior involvement or exposure to nanotechnology. They included a group of professional men (doctors, architects, civil servants etc.) – Group 1; a group of professional women (mostly employed as middle managers in business) – Group 2; a mixed gender group with
demonstrable political interests – Group 3; a group of women with children at school age – Group 4; and a mixed gender group all of whom expressed an interest in technology – Group 5. The groups were conducted in Manchester and London in the late summer of 2005. The groups were not recruited to be representative of British society in a formal sense. Rather, the groups were chosen for two intersecting reasons: to have shared life histories or work experience on issues that were seen as potentially relevant to the framing of response to nanotechnology (e.g. sharing interests in technology or politics; sharing know-how of raising children; sharing experience of business management or the professions); and to have relevant intellectual or social capital to develop collective imaginations of the nano world (e.g. the participants tended to take an interest in topical affairs, to have participated in higher education, and to be involved in local community matters). The fact that these groups were selected on these criteria did little to mitigate against the generalisability of the findings given the diversity across key factors (age, gender, location), and our interest in understanding the narrative dynamics through which ‘uninformed’ publics develop responses to nanotechnology.

Conceptualising public concerns to nanotechnology

Unsurprisingly, when participants were requested to offer an opinion on the term nanotechnology, there was little familiarity or knowledge, a finding that parallels attitudinal survey research as noted above. When pressed, participants tended to characterise nanotechnology as scientific, clever, small, possibly medical, strange, futuristic, and something associated with science fiction. Even for the more technologically literate participants who had heard of nanotechnology and of its ‘uncanny’ potential (Nordmann, 2005), it nevertheless was perceived as foreign, strange and other-worldly:

Alistair: “It’s almost the best of all the terms for being one where I know the idea that nanotechnology is really small technology and occasionally I’ll read something in The Guardian or wherever about – ‘it’s amazing, these guys have written their names in atoms on something’ and you’re like, wow, that’s cool. And you have this very nebulous notion that this is really clever and that there are … all these possibilities that are, you know, waiting to be unlocked in nanotechnology. But I actually have no idea you know what they’re really doing and or what these possibilities are. I just have this very vague notion that it’s very clever and it could be really important. And that’s kind of the epitome of what we were talking about before, about not really knowing the detail.”

(Group 3)

This background and vaguely affirmative sensibility can help to explain the relatively positive perceptions of nanotechnology found in attitudinal surveys, where people may be responding broadly to the connotations of the term ‘technology’ without much understanding of the detail (Gaskell et al, 2005). This research sought to deepen this analysis through examining the narrative structures through which people came to develop collective and shared accounts of what was ‘at stake’ in the technology. Typically, the evolution of expressed attitudes followed a pattern roughly as follows: from a state of initial ignorance, to surprise at how much research and R&D was being invested by both governments and industry, to enthusiasm as to the potential for social good not least in the medical domain, to unease and anxiety that nanotechnology innovation might lead to largely unanticipated and disruptive problems in real-world circumstances, to pessimism over our ability to govern and regulate the technology for the common good. What led people to positions of unease and apprehension was not simply a consequence of realising that nanotechnology would
enable scientists and other actors to extend control radically over matter, nature and the human body; but that such control over the pace, scope and direction of change would be governed by powerful bodies, propelled by the logics of industrial capitalism, and where the lay public would be ‘kept in the dark’. These perceived ‘real world’ dynamics led to predictions that nanotechnologies would exacerbate global inequality and facilitate evermore intense subjection of individual bodies. What emerged thus was a dense array of concerns; few specific or unique to nanotechnology but distinctive in their sheer breadth and convergence. For reasons that will be discussed later in this paper, nanotechnology appeared to have intensified response along familiar and consistent themes around the body, unanticipated risks, nature’s revenge, control, inequalities, and pace of change.

For many people the anxiety potential of nanotechnology came to the fore in relation to the concerns of nanoparticles potentially violating bodily processes, either through cosmetics or foods. Just as genetically modified foods heightened concern on account of being undetectable by texture, smell or appearance (Adam, 1998), the invisibility of nanoparticles and their potential ubiquity into everyday consumer goods resonated with background fears linked to an enduring narrative of ‘bodily invasion’.

Rosie: "I imagine. This face cream which has got very small nanoparticles in it, I don’t know whether it’s made of nanoparticles or whether it’s just using nanotechnology. But if I rub that on my skin or someone’s rubbing it into their skin and therefore there’s things going into my skin I’m not aware of. We’ve already said this really but no-one knows exactly what that’s going to do and it might have long term effects where, just imagine, free radicals which I’m sure you know potentially make cells get confused and breaks the genes in the cells and makes them grow out of control. Any little bit of dirt, like something that shouldn’t be in there pops into the cell, messes with the actual sequence of what that cell does and you know - that’s so scary.”

Julie: “Yeah because it can happen without you realising, whereas before, things, if they were going to invade your body or invade something, you would see it happening.”

Philip: “It’s the invisible threat.”

Julie: “Yeah, that’s it.”

Helen: “Because you cannot see it...”

(Group 5)

A visceral example of this dynamic was voiced in the London group of women with young children. In the initial session these women had clearly enjoyed the proposition that nanotechnology might visibly and demonstrably ameliorate signs of ageing through newly potent anti-wrinkle creams. Now, when confronted by acknowledged uncertainties as to the potential toxicological effects of nanoparticles, the conversation shifted in tone:

Rochelle: “Since last week I’ve completely changed my approach to these creams. When you said it had those ‘nanosomes’, I thought, ‘oh great, fantastic, I’d use it’ – [now] I wouldn’t touch it now with a barge pole [even] if you paid me money to put that stuff on my face now. It’s so frightening.”

Victoria: “I think we’re very trusting as buyers in the market, or in general, the public, we’re very trusting of the products we’re given and, the thing is, now you find out afterwards – we’re suddenly having to become very sceptical because things come out afterwards.”

Renee: “Well, you sort of assume it’s always been tested.”

Karen: “Yes.”
Renee: “Which clearly obviously things like cosmetics don’t have the controls that the drugs do.”

Rochelle: “But surely wouldn’t they be better to sort of like say, right, we don’t know enough, and until we know enough, or we’ve changed our regulations, or whatever, then we don’t let it go on the market.”

Victoria: “There’s too much money in it I think.”

(Group 4)

The potential for harm – for example in the unknown toxicity of nanoparticles – was commonly seen as symptomatic of the wider phenomena of advanced technology proceeding in the face of natural limits and processes. GM foods, MRSA, mad cow disease and others, were presented as examples of technological innovation that had been developed in the face of unanticipated risks of a complex and uncertain nature. Beck’s ‘Risk Society’ had become an everyday reality for our participants (Beck, 1992). Nanotechnology was seen as a further and worrying extension of this dynamic, led, as it appeared to be, through a hubristic sense of its perceived ability to transform both society and nature:

James: “They will find new bacteria and we will be more resistant. Antibiotics and things are becoming resistant. There will be more diseases that will come. We will never completely get rid of disease.”

(Group 5)

Neil: “I think it’s accelerating the evolution of disasters... You were going on – on the board there – about accelerating the evolution of human systems, brain power and healing powers and stuff. It’ll get ‘out of the cage’, I’m sure, and evolve through various bio-strains and mechanisms and it will be adapted, possibly. There are cases with GM super weeds now.”

(Group 1)

The metaphysical explanation

So why did nanotechnology present such troubling visions. There are perhaps three interlocking explanations. First, people responded to the metaphysics embedded in the radical and utopian vision of nanotechnology as cause for alarm. The metaphysical project, common in this particular narrative of nanotechnology, presents the technology as an enabler of human capacities, needs, desires and potentialities. Through nanotechnology, the argument runs, people will be able to transcend their material and ‘natural’ constraints and thus realise full liberation and emancipation. While such a narrative has been given most visible expression in the National Science Foundation report on Converging Technologies (Roco and Bainbridge, 2002), it nevertheless represents a wider emergent style of thought characteristic of much of nanotechnology especially in the US policy context (Nordmann, 2007c), and reflective more widely of characteristically American ideals of technology (Noble, 1999). Below is how one of the groups attempted to express what they found troubling in this vision:

Neil: “If you actually took that wholly on board, everything that’s printed on there, it’s quite a frightening scenario, isn’t it. So this wonderful nanotechnology is going to be a cure all for all human ills, it’s going to make us all super brilliant and clever and work that much better, our transport’s going to be far better even though the fact that nobody will be dying of old age, nobody will be dying of any illnesses so we won’t be able to move on this planet. Yet we’ll be able to move about quicker because the
trains or whatever will be much more efficient. It’s – a lot of what is written there is really [is] in effect going against nature isn’t it, it’s trying to beat nature at its own game and going back to what I said before about the medical side of it, it is rather frightening I think. It is very welcoming if it’s used to treat cancers and stuff like that but I think that somewhere along the line we’re getting into this Brave New World scenario here where everything’s [pause], it’s this ideal world where everyone lives forever and everybody has everything, everybody can do everything... It’s [a] very, very frightening scenario.”

Steve: “Well there’s echoes of science fiction coming through, Brave New World, to space exploration, super new transit systems and just human evolution as well, being accelerated.”

Neil: “But going back to our earlier conversation about the pace of change and there doesn’t seem to be any stopping it, this is only $10^{-9}$, so 20 years on are we on $10^{-12}$ and $10^{-15}$, this is just the next step…”

Barry: “Exactly. When do you get to that final point, the absolute if you like? They may be nearly there but they may not be.”

(Group 1)

These were not gut reactions to some rather optimistic claims of the benefits of a particular technology. Rather, they represented deeper unease with the metaphysical programme driving the technology, its embedded assumptions of what constitutes human progress and improvement, and its potentially troubling implications for wider society. However, perhaps even more than biotechnologies, here was a technological programme based on a style of thought that conceives of nature and humans as infinitely malleable, and which presents a thoroughly questionable view of human improvement as a given. For Dupuy, who has developed perhaps the most systematic critique of the metaphysical programme that underpins radical nanotechnology, the most conspicuous element of the nanotechnological dream is its dissatisfaction with the world as inherited through ‘bricolage’ and ‘hit and miss’ evolutionary process (Dupuy, 2009). By contrast, the world – and its component constituents of living and non-living matter – is in principle reconstructable and thus available for redesign and improvement, literally from the bottom-up, atom by atom (NSTC, 1999). This can thus be seen as an extension of a biopolitical style of thought, engendered through biotechnological innovation, in which the biological can no longer be assumed to impose limits to human endeavour and well-being (Franklin 2003; Rose, 2007). Indeed, nanotechnology’s much cited goal of ‘controlling the structure of matter’ through interventions at the nanoscale (from 1 – 100 nm), is at that precise scale at which the distinction between life and non-life has lost all meaning. For Dupuy (2009) this represents a clandestine attempt to blur a fundamental distinction that has until now been a significant source of everyday moral judgement and ethical reason.

The imputed ideal of a hyper-technological age involving radical ‘improvements’ in bodily function and capacity was debated in other groups. While superficially appealing to some, these developments were seen to raise substantial moral and social issues, not least the ability for governments, industry and other darker forces to exercise sufficiently robust forms of control and oversight over its mediation on everyday life activities. The consensual response was to appeal for such innovations to ‘slow down’ to ensure that scientific advance was properly in tune with wider public values and societal oversight. The discussion below highlights the sensed dangers of technology proceeding as if it, and we, were not part of life and natural process:

Sally: “I find it quite daunting actually, I find it a bit scary.”
Rochelle: “This is the vision of the robotic environment with everything controlled for you and everything 100% perfect and plastic.”

Renee: “It’s like even the food... Food has got a process the same as we’ve got a natural process you know, you’re born, you get older, you get wrinkles, you die. Same as fruit, you buy a piece of fruit it’s healthy, after a piece of time it wrinkles you throw it away or whatever and that is a natural process and I think in some ways it’s kind of fiddling with that natural process.”

Moderator: “So you think skin should be allowed to wrinkle?”

(Group 4)

How should one characterise the ethical character of concerns that are being appealed to? As with Davies’ (2006) characterisation of ethical talk on xenotransplantation, it is apparent that nanotechnologies have the potential to blur key distinctions through which social life is ordered. This constitutes the second explanation and includes, inter alia, the blurring of the idea that enhancement is distinct from therapy, that we can never completely get rid of diseases, that humans live and die, that humans and machines are fundamentally distinct, that matter can be made from the bottom up, and that everything can be made, unmade and remade. It is the perceived neglect of such boundary work within the broader nanotechnology community – or what Dupuy (2009) calls a false humility that consists in denying that anyone has been done out of the ordinary - that people found disturbing, as illustrated in one particular apt remark by a participant in Group 5: ‘It’s like nanotechnology is the new God’. This comment, deploying the ‘false humility’ narrative, reflects not simply the perceived lack of limits in much of nanotechnology talk, but the more troubling perception that nanoscientists were proceeding with little regard or understanding or even awareness of the endeavour in which they were participating. In particular, and making use of an older set of metaphysical assumptions premised on the notion that there exists a wider patterning and order to life which we ignore at our peril, were expressed concerns about the ‘unnaturalness’ of the undertaking. One way in which this was expressed was in arguments on the likelihood of ‘nature’s revenge’: that the more radical and interventionist the attempt to control and intervene in nature the stronger and more potent the likely retort. The exchange below articulates the use of such a ‘Promethean’ narrative, and of nature taking vengeance as a direct consequence of human interference and meddling:

Julie: “That’s the problem, is what we’re interfering with again is nature, the natural cycle of things, which is where I have a problem. It’s partly that it is sort of right that sometimes crops are wiped out, there’s sort of a reason for everything I think.”

Rosie: “I wouldn’t trust nature not to seize upon it as it’s done with these super-weeds…”

(Group 2)

An interesting variant of the above critique were accounts arising from the mechanistic metaphor that tends to imbue much nanotechnology rhetoric. Bernadette Bensaude-Vincent analyses the ways in which molecular biology and materials science converge on a thoroughly ‘artificialist view of nature’. She sets out the multiple ways in which nanotechnologies rely on a conception of biological life and the human body using mechanistic concepts and metaphors: most notably around the cell and its molecular components as nanoscale machines (Bensaude-Vincent, 2004). Using George Canguilhem as inspiration, she argues that that such a project has demonstrable ethical components, and that the mechanization of life is inseparable from a project of instrumentalization of life and control over nature. In our discussion groups, the extreme mechanism which

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1 I am indebted to Alfred Nordmann for this observation.
nanotechnology represents was also seen as connected to forms of government and corporate control and their propensity for new and more direct forms of subjection and surveillance. This unease, making use of such ‘artificialist’ narrative, was voiced eloquently by the one of the London groups, that, ‘we’re turning into robots’:

Renee: “I mean it’s exactly what somebody over here said before, we’re turning into robots. That is exactly what it sounds like...”
Renee: “When it comes directly to human beings and trying to make them..., it’s like trying to make a perfect race again, going to that.”
Karen: “We just don’t know the long term effects do we, that’s the problem.”
Renee: “But you have to know the side effects and what we’re letting ourselves in for.”
Toni: “So basically our generation’s going to be like the ones that they test this all out on, if it all goes horribly wrong, we’ll be the guinea pigs.”

(Group 4)

Again Dupuy provides a metaphysical explanation to such commentary arguing that precisely when ‘being human’ is reduced to the status of an object that can be fashioned and shaped at will – the very conception of mind as machine that enables us to imagine our ability to recreate life and matter in our own image – we lose much of our ethical capacity for critical reflection (Dupuy, 2009). Without ethical boundaries grounded in a conception of social order the concept of self limitation loses meaning. In such an ethically restricted world there is little reason to presume why nanotechnologies will not be deployed to extend control and reduce autonomy. The exchange points to the forms of subjection that a programme of human enhancement was seen as likely to engender:

Paul: “I think the worrying thing for me... is that it’s almost as though we lose control of what’s going on because the technology itself is capable of almost taking, replicating, and almost making, you know, pretty much making its own decisions.”
Philip: “I think that is a big problem. It’s like the thing you were saying with the creativity as well. If the human controls the technology that’s fine, as soon as it becomes the technology making all the decisions then that’s when you have a problem, because... humans are completely different from a computer.”
Paul: “There’s some scary dark futures where you have strains of children who are, and are not enhanced in some way, and that’s a really dodgy thing. I mean enhancement, the ageing process and things like that...”
James: “Do you have your kids injected at birth to enhance their, the way their muscles grow and things...”

(Group 5)

The above dynamics contributed to the sensed difficulty of developing robust and effective systems of governance and regulation. One the one hand, there was a perceived requirement for wise and strong forms of government and oversight. Yet, on the other hand, there was a shared concern that governance structures and requirements would be compromised, inevitably, by ‘real-world’ contingencies arising from the constraints of living in a globalised economy as well as the sensed intractability of nanotechnology’s metaphysical programme.

Conclusions

I conclude by reflecting on the reflexive politics of this particular piece of research, and on its contribution to debates on the institutional governance of emerging technologies. It
could be argued that this piece of public engagement research is limited for two reasons: for being too ‘upstream’ and thus not reflecting solid public opinion (see Rogers Hayden and Pidgeon 2007 for a version of this criticism); and for having had little demonstrable direct input into matters of practical governance. However, in response, the purpose of the research was not intended to inform directly public policy. Rather, the purpose was to seek to characterize emergent public opinion, and to develop a methodology and mode of analysis for researching technoscientific concerns in-the-making (see also Macnaghten et al, 2005). The subsequent results were indeed shaped by the research design but again that was precisely the point: to expose participants to the styles of thought in which the technology is being framed in the public domain such as to reflexively examine the power of such narrative forms. Finally, while the research process may have inadvertently masked difference within the public groups it nevertheless presented a picture of emergent public opinion characterized by a dense array of issues that remain woefully under-represented and marginal to public policy discourse. Indeed, notwithstanding the recent move in critical public engagement studies, away from emphases on talk and discourse and towards a focus on the embodied and performative dimensions of deliberative practices (see, for example, Chilvers, 2008; Davies and Burgess, 2004; Irwin, 2006), this paper suggests that innovative and theoretically-informed group talk offers an enduring medium to critically engage with a future-oriented techno-scientific politics.

Perhaps most significantly the research offers an explanation as to why people expressed such bleak and pessimistic views on the future prospects of the technology; that just when we as a collectivity require strong ethical and regulatory governance structures to guide and shape the development of nanotechnologies in socially progressive and responsive directions, that very possibility appears to be denied by a socio-technical system that believes that nothing special is being undertaken, that considers its dreams of control and improvement to require little external endorsement or explanation, and that is embedded within a set of master narratives in which science and technology are staged unambiguously as the solution to a range of social ills (European Commission, 2007). Faced by such double-blind it is inevitable that people respond to what is at hand, mobilising the range of cultural resources and ‘folk theories’ through which they can make sense and render familiar a strange, uncanny and potentially transformative set of technologies (Rip, 2006). For this reason the research sought to articulate the kinds of narrative strategies used by participants to justify their positions.

Parallel research has outlined several prominent tropes and narratives underpinning public responses to nanotechnology: ranging from the ‘slippery slope’ narrative, that technological advances that seem beneficial now will inevitably evoke further technological steps and applications that are morally doubtful; the ‘colonisation’ narrative, that technology will spread out and ultimately colonise life denying autonomy and agency; the ‘Dr Strangelove’ narrative, that advanced science designed for ‘good use’ will become corrupted and manipulated by evil people for evil purposes; the ‘Trojan Horse’ narrative, that innovations developed for progressive purposes will in the long term have unforeseen and potentially irreversible effects; and the ‘it’s out’ narrative, that involves the accidental release of harmful substances often due to technological and/or human failure (Swierstra and Rip, 2007; Rejeski, 2007). In the research we can add at least five further narrative variations. These include: the ‘kept in the dark’ narrative, that nanotechnology reflects a further instance of not being able to participate in decisions that will structure future social relationships; the ‘bodily invasion’ narrative, that involves the introduction of invisible substances that subsequently violate natural processes; the ‘Promethean’ narrative, involving nature taking retribution on nanoscience’s hubristic sense of its ability to transform...
both nature and humans to its own will and in violation and disregard for evolutionary process; the ‘artificialist’ narrative, that inadvertently instrumentalises life and human relationships through conceiving of biological and mental life purely as machines; and the ‘false modesty’ narrative, involving the pretense that nothing special is being undertaken.

These narratives are by any means new. Many have their origins in ancient classics and philosophy and have found on-going and enduring expression in the form of fables, morality tales, literature and more recently in films, science fiction and video games. However, just as Jon Turney (1998) has analysed the long shadow of Frankenstein in debates on the new genetics, one needs to understand why certain narrative forms continue to resonate and why they continue to provide an enduring resource for contemporary political argument and thought. My argument is that it is precisely these kind of narratives that will continue to shape popular perceptions of science and technology, and which will provide the landscape over which future techno-politics will be articulated. Of course, there exist counter narratives too, around technology as progress, science as salvation and enabler through heroic discovery and breakthrough, and so on. But such narratives will be played out on the larger cultural stage whose interplay will depend on complex institutional dynamics where the telos of scientific endeavour – its purposes, priorities and imaginings – will come to be increasingly scrutinised.

There is a further reflexive element that warrants attention. Bensaude-Vincent (2004) has highlighted a marginal voice within the nanoscience community – comprising largely of chemists such as George Whitesides and Richard Smalley and in stark opposition to the hard engineering paradigm promoted by Eric Drexler – who advocate a different model of nanotechnology and its relationship with nature. Unlike Drexler’s machines with their underlying and driving aspirations to emulate and improve on nature, Whitesides and colleagues posit nature as ‘art’, and of nanotechnology as offering ingenious and artful solutions to complex problems in nature. Such an understanding of what nanotechnology is proposing to do with regards to nature fits within a historical tradition of human technique (or arts) working in harmony with nature, as revealing the powers inherent in nature, and as mimicking the tricks that nature actually uses to solve our own problems. It remains an open question whether this different configuration of nanotechnology’s metaphysical project would offer a differing ethical response. If such a metaphysical programme were to rise in prominence, and to be given official recognition in institutional programmes of nanoscience, we might question the enduring coherence of nanotechnology’s future-oriented visions, and indeed, of the very meaning of the category of emerging nanotechnologies.

Finally, there remains the thorny question of the relationship between emergent public attitudes and the institutional governance of emerging technologies. In a previous research project on emergent public attitudes to genetically modified crops and foods, conducted in 1996 in the UK two years prior to the public controversy that took place between 1998 and 2000, public groups were found to express profound ambivalence towards the technology (Grove-White et al, 1997). This arose for multiple reasons that included: shared perceptions of inevitability and fatalism; mistrust in the integrity and adequacy of government regulation; unease about the apparent transgression of moral boundaries for no apparent ‘good reason’; and disquiet about the limits of ‘expert’ knowledge in anticipating conceivable and potentially irreversible mishaps. The relationship between such emergent public attitudes and the subsequent and unprecedented political rows of 1998-1999 is complicated and uneven. However, what is undoubtedly the case is that the institutional handling of the controversy – notably its denial of adverse public responses as reasonable – created the conditions under which public reactions and subsequent mobilization came to
be significant, *inter alia*, through NGO campaigns, media coverage, food labelling, supermarket purchasing, consumer boycotts, and subsequent political debate (Grove-White et al, 2000; AEBC, 2001). Another way to read this dynamic was as follows. While the research process had fostered the creation of the ‘technoscientific citizen’, who became authorised to hold opinions on the social, ethical, environmental and health dimensions of the technology, the subsequent and novel opportunity structures authorised the creation of the activist technoscientific citizen who was now able to enact such opinions through an array of everyday consumer and lifestyle practices.

The message for policy institutions is that public reactions to emerging nanotechnologies have the potential to become significant so long as the questions that appear to underpin emergent public attitudes remain occluded from public dialogue and processes of decision-making. One role of the social sciences is to examine the dynamics through which a nanotechnological gaze opens up new configurations of minds, bodies, relationships, responsibilities, subjection, surveillance, finitude, choice, risk, self-limitation, autonomy and much more. Key questions in this vital politics include: the question of limits to intervention on nature and associated assumptions of control; the ability for advanced technology to transgress moral orderings; the inadvertent social effects arising from an artificialist account of nature and what an alternative might look like in practice; and to whether it is prudent to experiment with technologies likely to produce irreversible effects. Developing the conversation, in partnership with the wider scientific and policy community, and with an eye towards long-term shifts in R&D practice, will be a major endeavour in which the policy-oriented critical social scientist has a distinct role.

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**References**

Adam B, Groves C, 2007 *Future matters: action, knowledge, ethics* (Brill, Boston (MA))
Agriculture and Environment Biotechnology Commission (AEBC), 2001 *Crops on Trial* (AEBC, London)

Berne R, 2006, *Nanotalk: Conversations with scientists and engineers about ethics, meaning, and belief in the development of nanotechnology* (Lawrence Erlbaum, Nahwah NJ)

BMRB Social Research 2004 *Nanotechnology: Views of the General Public. Quantitative and qualitative research carried out as part of the Nanotechnology study* (The Royal Society and Royal Academy of Engineering Nanotechnology Working Group, London)


ETC Group, 2003 *The Big Down. Atomtech: Technologies converging at the nanoscale* (ETC Group, Winnipeg)

Eurobarometer, 2005 *Europeans, Science and Technology*, Wave 63.1 (Commission of the European Communities, Brussels)

European Commission, 2000 *Science, Society and the Citizen in Europe* (Brussels: Commission of the European Communities)

European Commission, 2004 *Towards a European Strategy for Nanotechnology* (No. COM[2004]) (Brussels: Commission of the European Communities)


Fleck L, 1979 *Genesis and Development of a Scientific Fact* (Chicago University Press, Chicago)

Hacking I, 1992, ”‘Style’ for historians and philosophers” Studies in the History and Philosophy of Science 23(1) 1-20
Irwin A, 2006, “The politics of talk: coming to terms with the ‘new’ scientific governance” Social Studies of Science 36(2) 299-330
Joy B, 2000, “Why the future doesn’t need us” Wired 8(4) 238-262
Kearnes M, 2007, ”(Re)making matter: design and selection” Area 39.2 143–155
Macnaghten P, 2004, “Animals in their nature: a case study of public attitudes on animals, genetic modification and ‘nature’” Sociology 38(3) 533-551
Macoubrie J, 2006, “Nanotechnology: public concerns, reasoning and trust in government” Public Understanding of Science 15 (2) 221-241
MORI, 2005 Science in Society: Findings from Qualitative and Quantitative Research (Department of Trade and Industry, London)
National Science and Technology Council (NSTC) and Interagency Working Group on Nanoscience, Engineering and Technology (IWGN), 1999 Nanotechnology—Shaping the World Atom by Atom Plan (National Science and Technology Council, Washington, DC)
National Science and Technology Council (NSTC), 2004 National Nanotechnology Initiatives Strategic Plan (National Science and Technology Council, Washington, DC)
Noble D, 1999 The Religion of Technology: The Divinity of Man and the Spirit of Invention (Penguin, New York)
Nordmann A, 2005, “Noumenal Technology: reflections on the incredible tininess of nano” Techné 8(3) 3-23
Novas C, Rose N, 2000, “Genetic risk and the birth of the somatic individual” Economy and Society 29 (4) 485-513
Selin C, 2007, “Expectations and the Emergence of Nanotechnology” Science, Technology and Human Values 32(2)1-25
Turney J, 1998 Frankenstein’s Footsteps: Science, Genetics and Popular Culture (Yale UP, New Haven)
Wynne B, 2006, “Public engagement as a means of restoring public trust in science: Hitting the notes, but missing the music?” Community Genetics 9(3) 211-220
COMMISSION RECOMMENDATION

of 07/02/2008

on a code of conduct for responsible nanosciences and nanotechnologies research
COMMISSION RECOMMENDATION

of 07/02/2008

on a code of conduct for responsible nanosciences and nanotechnologies research

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community, and in particular Article 211 thereof,

Whereas:

(1) In its Communication to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions "Towards a European research area" the Commission proposed in January 2000 the creation of a European Research Area with a view to consolidating and structuring European research policy. In May 2007, in the Green Paper "The European Research Area: New Perspectives", the Commission re-launched a broad institutional and public debate on what should be done to create a unified and attractive European Research Area that would fulfil the needs and expectations of the scientific community, business and citizens.

(2) The Commission adopted in February 2000 a Communication on the precautionary principle, aiming to build a common understanding of how to assess, appraise, manage and communicate risks that science is not yet able to evaluate fully.

(3) In March 2000 the Lisbon European Council set for the Community the objective of becoming in the next decade the most competitive and dynamic knowledge economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion.

(4) In 2004, with its Communication “Towards a European strategy for nanotechnology”, the Commission identified actions aimed at creating the Community added value necessary to remain competitive in this sector while ensuring its responsible development. In its conclusions of 24 September 2004, the Council (Competitiveness) welcomed the proposed integrated, safe and responsible approach and the Commission’s intention to draw up an Action Plan for nanotechnology.

(5) Taking into account the results of a public consultation, the Commission drew up in 2005 a Nanotechnologies Action Plan which sets out coherent and interconnected actions for the immediate implementation of an integrated, safe and responsible strategy for nanosciences and nanotechnologies based on the priority areas identified in the Communication “Towards a European strategy for nanotechnology”. Both Communications explicitly acknowledged that

5 Doc. 12487/04
environmental, human health and safety aspects need to be integrated in all nanosciences and nanotechnologies research.


(7) Following comments made during a public consultation on a previous opinion, the Scientific Committee on Emerging and Newly Identified Health Risks adopted in March 2006 a Modified Opinion on the appropriateness of existing methodologies to assess the potential risks associated with engineered and adventitious products of nanotechnologies.

(8) In June 2006 the European Council adopted a revised sustainable development strategy fine-tuning the Community sustainable development strategy launched at the Gothenburg Summit in June 2001 that centred on objectives of environment and health protection and poverty eradication.

(9) In its conclusions of 23 November 2007, the Council (Competitiveness) recognised the need to foster synergies and cooperation between all nanosciences and nanotechnologies stakeholders, including the Member States, the Commission, academia, research centres, industry, financial bodies, non-governmental organisations and society at large.

(10) A first report on the implementation of the Nanotechnologies Action Plan for Europe was presented by the Commission in 2007. In this report the Commission announced its intention to adopt a voluntary Code of Conduct for Responsible Nanosciences and Nanotechnologies Research.

(11) This Recommendation includes the Code of Conduct, aiming to promote integrated, safe and responsible nanosciences and nanotechnologies research in Europe for the benefit of society as a whole.

(12) The general principles and guidelines on actions to be taken outlined in this Recommendation benefited from a public consultation.

(13) This Recommendation provides Member States with an instrument to undertake further initiatives to ensure safe, ethical and sustainable nanosciences and nanotechnologies research in the European Union.

(14) This Recommendation also aims at contributing to proper coordination between Member States with a view to optimise synergies between all nanosciences and nanotechnologies research stakeholders at European and international levels.

HEREBY RECOMMENDS:

1. That Member States be guided by the general principles and guidelines for actions to be taken, set out in the Code of Conduct for Responsible Nanosciences and Nanotechnologies Research, in the Annex, as they formulate, adopt and implement their strategies for developing sustainable nanosciences and nanotechnologies (hereinafter N&N) research, in line with the Commission Nanotechnologies Strategy and Action Plan.

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8 SCENIHR/002/05, 10 March 2006.
9 Doc. 14865/07.
2. That Member States endeavour to follow these general principles and guidelines when implementing their national regulatory research and development strategies or developing sectoral and institutional research and development standards, taking into account pre-existing applicable N&N guidelines, good practices or regulations.

3. That Member States consider such general principles and guidelines on research to be an integral part of institutional quality assurance mechanisms by regarding them as a means for establishing funding criteria for national/regional funding schemes, as well as adopting them for the auditing, monitoring and evaluation processes of public bodies.

4. That Member States encourage the voluntary adoption of the Code of Conduct by relevant national and regional authorities, employers and research funding bodies, researchers, and any individual or civil society organisation involved or interested in N&N research and endeavour to undertake the necessary steps to ensure that they contribute to developing and maintaining a supportive research environment, conducive to the safe, ethical and effective development of the N&N potential.

5. That Member States cooperate with the Commission in order to review this recommendation every two years, as well as to monitor the extent to which relevant stakeholders have adopted and applied the Code of Conduct.

6. That the criteria for measuring such adherence to and application of the Code of Conduct be established and agreed with the Member States in relation to similar work undertaken at Community level.

7. That Member States, in their bilateral agreements on research strategies and activities with third countries and in their role as members of international organisations, take due account of this Recommendation when proposing research strategies and taking decisions, and duly coordinate with other Member States and the Commission.

8. That this Recommendation also be used as an instrument to encourage dialogue at all governance levels among policy makers, researchers, industry, ethics committees, civil society organisations and society at large with a view to increasing understanding and involvement by the general public in the development of new technologies.

9. That the Member States inform the Commission by 30 June 2008 and annually thereafter of any measures they have taken further to this Recommendation, inform it of the first results of its application and provide good practices.

Done at Brussels, 07/02/2008.

For the Commission
Janez POTOČNIK
Member of the Commission
ANNEX

CODE OF CONDUCT FOR RESPONSIBLE NANOSCIENCES AND NANOTECHNOLOGIES RESEARCH

This Code of Conduct provides Member States, employers, research funders, researchers and more generally all individuals and civil society organisations involved or interested in nanosciences and nanotechnologies (N&N) research ("all stakeholders") with guidelines favouring a responsible and open approach to N&N research in the Community.

The Code of Conduct is complementary to existing regulations. It does not limit or otherwise affect the possibilities of Member States to grant a wider measure of protection with regard to N&N research than is stipulated in this Code of Conduct.

Stakeholders who adhere to this Code of Conduct should also be inspired, where applicable, by the principles set out in the Charter of Fundamental Rights of the European Union.

The Code of Conduct will be regularly monitored and revised every two years by the Commission in order to take into account developments in N&N worldwide and their integration in European society.

1. SCOPE AND AIM

The Code of Conduct invites all stakeholders to act responsibly and cooperate with each other, in line with the N&N Strategy and Action Plan of the Commission, in order to ensure that N&N research is undertaken in the Community in a safe, ethical and effective framework, supporting sustainable economic, social and environmental development.

The Code of Conduct covers all N&N research activities undertaken in the European Research Area.

The Code of Conduct is voluntary. It offers a set of general principles and guidelines for actions to be taken by all N&N stakeholders. It should facilitate and underpin the regulatory and non-regulatory approaches outlined in the 2005-2009 N&N Action Plan for Europe, improving the implementation of current regulation and coping with scientific uncertainties.

The Code of Conduct should also be a European basis for dialogue with third countries and international organisations.

2. DEFINITIONS

For the purpose of the Code of Conduct, the following definitions apply:

a) Nano-objects: In the absence of recognised international terminology the generic term of 'nano-object' is used all throughout the Code of Conduct to designate products resulting from N&N research. It includes nanoparticles and their aggregation at nanoscale, nano-systems, nano-materials, nano-structured materials and nano-products.

b) N&N research: In the broadest sense understood here, N&N research encompasses all research activities dealing with matter at the nanometric scale (1 to 100 nm). It includes all man-made nano-objects be they engineered or involuntarily generated.
Naturally occurring nano-objects are excluded from the scope of the Code of Conduct. N&N research encompasses research activities from the most fundamental research to applied research, technology development and pre and co-normative research underpinning scientific advice, standards and regulations.

c) N&N stakeholders: Member States, employers, research funders, researchers and more generally all individuals and civil society organisations engaged, involved or interested in N&N research.

d) Civil society organisations: In the context of the Code of Conduct, civil society organisations are considered to be any legal entity that is non governmental, not-for-profit, not representing commercial interests, and pursuing a common purpose in the public interest.

3. GENERAL PRINCIPLES

This Code of Conduct is based on a set of general principles which call for actions aimed at guaranteeing their respect by all stakeholders.

3.1 Meaning

N&N research activities should be comprehensible to the public. They should respect fundamental rights and be conducted in the interest of the well-being of individuals and society in their design, implementation, dissemination and use.

3.2 Sustainability

N&N research activities should be safe, ethical and contribute to sustainable development serving the sustainability objectives of the Community as well as contributing to the United Nations' Millennium Development Goals. They should not harm or create a biological, physical or moral threat to people, animals, plants or the environment, at present or in the future.

3.3 Precaution

N&N research activities should be conducted in accordance with the precautionary principle, anticipating potential environmental, health and safety impacts of N&N outcomes and taking due precautions, proportional to the level of protection, while encouraging progress for the benefit of society and the environment.

3.4 Inclusiveness

Governance of N&N research activities should be guided by the principles of openness to all stakeholders, transparency and respect for the legitimate right of access to information. It should allow the participation in decision-making processes of all stakeholders involved in or concerned by N&N research activities.

3.5 Excellence

11 The United Nations Millennium Declaration, General Assembly resolution 55/2, 8.9.2000
N&N research activities should meet the best scientific standards, including standards underpinning the integrity of research and standards relating to Good Laboratory Practices.\(^{12}\)

3.6 Innovation

Governance of N&N research activities should encourage maximum creativity, flexibility and planning ability for innovation and growth.

3.7 Accountability

Researchers and research organisations should remain accountable for the social, environmental and human health impacts that their N&N research may impose on present and future generations.

4. GUIDELINES ON ACTIONS TO BE TAKEN

The guidelines set out in this point are based on the set of general principles described in point 3. They are meant to give guidance on how to achieve good governance, due respect for precaution, as well as wide dissemination and good monitoring of the Code of Conduct. The main responsibilities for action are indicated below, but all N&N stakeholders should contribute to their implementation as much as possible within the scope of their own remit.

4.1 Good governance of N&N research

*Good governance of N&N research should take into account the need and desire of all stakeholders to be aware of the specific challenges and opportunities raised by N&N. A general culture of responsibility should be created in view of challenges and opportunities that may be raised in the future and that we cannot at present foresee.*

4.1.1 Member States should cooperate with the Commission in order to maintain an open and pluralistic forum for discussion on N&N research at Community level as a means to stimulate the societal debate about N&N research, encouraging the identification and discussion of concerns and hopes and facilitating the emergence of possible initiatives and solutions. Accordingly, Member States should enhance communication on benefits, risks and uncertainties related to N&N research. Specific attention should be paid to the younger and older members of the population.

4.1.2 With due respect for intellectual property rights, Member States, N&N research funding bodies, research organisations and researchers are encouraged to make easily accessible and understandable by lay people as well as by the scientific community all N&N scientific knowledge as well as related information such as relevant standards, references, labels, research on impacts, regulations and laws.

4.1.3 Member States should encourage private and public sector laboratories to share best practices in N&N research, with due respect for the protection of intellectual property.

4.1.4 N&N research organisations and researchers should ensure that scientific data and results are duly peer-reviewed before being widely disseminated outside the scientific community in order to ensure their clarity and balanced presentation.

4.1.5 Given its potential, Member States and N&N research organisations should ensure that N&N research is conducted at the highest level of scientific integrity. Questionable N&N research practices (not limited to plagiarism, falsification and fabrication of data) should be fought as they may entail risks for health, safety and the environment, raise public distrust and slow down the dissemination of benefits from research. Individuals signalling impropriety in research should be protected by their employers and national or regional laws.

4.1.6 Member States should ensure that appropriate human and financial resources are dedicated to the application of existing laws and regulations applicable to N&N research. Organisations performing N&N research activities should demonstrate transparently that they comply with relevant regulations.

4.1.7 National and local ethics committees and competent authorities should evaluate the manner of applying ethical review requirements to dual-use nanotechnology research. They should notably address the fundamental rights implications of any possible restrictions on informed consent and on publication of research results related to human health.

Favouring an inclusive approach

4.1.8 The broad directions of N&N research should be decided in an inclusive manner, allowing all stakeholders to enrich the preliminary discussions on these directions.

4.1.9 Member States, N&N research funding bodies, research organisations and researchers are encouraged to consider, at the earliest stages and through participatory foresight exercises, the future implications of technologies or objects being researched. This could allow the development of solutions to meet potential negative impacts caused by the use of a new object or technology at a later stage. Consultations with relevant ethics committees should be part of such foresight exercises as appropriate.

4.1.10 N&N research itself should be open to contributions from all stakeholders who should be informed and supported so that they can take an active part in the research activities, within the scope of their mission and mandate.

Key priorities

4.1.11 Research authorities and standardisation bodies should endeavour to adopt N&N standard terminology to facilitate the communication of scientific evidence. They should encourage standard measurement procedures as well as the use of appropriate reference materials in order to improve comparability of scientific data.

4.1.12 N&N research funding bodies should devote an appropriate part of N&N research to the development of methods and tools for risk assessment, the refinement of metrology at nano-scale and standardisation activities. In this context, particular attention should be paid to developing methods to assess the risk of second-generation, active nano-structures.

4.1.13 Member States, N&N research funding bodies and organisations should encourage fields of N&N research with the broadest possible positive impact. A priority should be given to research aiming to protect the public and the environment, consumers or workers and aiming to reduce, refine or replace animal experimentation.
4.1.14 N&N research funding bodies should carry out and publish balanced assessments, based on best available scientific data, of the potential costs, risks, and benefits of research areas eligible for funding.

Prohibition, restrictions or limitations

4.1.15 N&N research funding bodies should not fund research in areas which could involve the violation of fundamental rights or fundamental ethical principles, at either the research or development stages (e.g. artificial viruses with pathogenic potentials).

4.1.16 N&N research organisations should not undertake research aiming for non-therapeutic enhancement of human beings leading to addiction or solely for the illicit enhancement of the performance of the human body.

4.1.17 As long as risk assessment studies on long-term safety is not available, research involving deliberate intrusion of nano-objects into the human body, their inclusion in food (especially in food for babies), feed, toys, cosmetics and other products that may lead to exposure to humans and the environment, should be avoided.

4.2 Due respect for precaution

Given the deficit of knowledge of the environmental and health impacts of nano-objects, Member States should apply the precautionary principle in order to protect not only researchers, who will be the first to be in contact with nano-objects, but also professionals, consumers, citizens and the environment in the course of N&N research activities.

4.2.1 Students, researchers and research organisations involved in N&N research should take specific health, safety and environmental measures adapted to the particularities of the nano-objects manipulated. Specific guidelines on the prevention of pathologies induced by nano-objects should be developed in line with the Community Strategy 2007-2014 on Health and Safety at Work.\(^\text{13}\)

4.2.2 N&N research organisations should apply existing good practices in terms of classification and labelling. In addition, as nano-objects might present specific properties due to their size, they should undertake research on systems (including e.g. the development of specific pictograms) aiming to inform researchers and more generally people likely to come into contact with nano-objects in research premises (e.g. security and emergency staff) so that they may take the necessary and appropriate protection measures in the course of their duties.

4.2.3 Public and private N&N research funding bodies should request that a risk assessment be presented along with each submission of a proposal for funding for N&N research.

4.2.4 N&N research funding bodies’ programmes should include monitoring of the potential social, environmental and human health impacts of N&N over a relevant period of time.

**Application of the precautionary principle should include reducing the gaps in scientific knowledge, and therefore undertaking further actions in research and development such as the following:**

4.2.5 Research funding bodies should devote an appropriate part of N&N research to understanding the potential risks, notably to the environment and human health, induced by nano-objects, encompassing their whole life-cycle, from their creation up to their end of life, including recycling.

4.2.6 N&N research organisations and researchers should launch and coordinate specific N&N research activities in order to gain a better understanding of fundamental biological processes involved in the toxicology and ecotoxicology of nano-objects man-made or naturally occurring. They should widely publicise, when duly validated, data and findings on their biological effects, be they positive, negative or null.

4.2.7 N&N research funding bodies should launch and coordinate specific research activities in order to gain a better understanding of ethical, legal and societal impacts of the new fields opened by N&N. Information and communication technologies and biotechnology should receive particular attention as well as the convergence between these fields and cognitive sciences and N&N.

4.3 Wide dissemination and monitoring of the Code of Conduct

4.3.1 Member States should support the wide dissemination of this Code of Conduct, notably through national and regional public research funding bodies.

4.3.2 In addition to the existence of this Code of Conduct, N&N research funding bodies should make sure that N&N researchers are aware of all relevant legislation, as well as ethical and social frameworks.

4.3.3 As the application of the Code of Conduct should be monitored across the Community, Member States should cooperate with the Commission in order to devise adequate measures to carry out such monitoring at national level and guarantee synergies with other Member States.