

Reconfiguring Responsibility:

Deepening Debate on Nanotechnology

**A research report from the DEEPEN
project**

Sarah Davies, Phil Macnaghten and Matthew Kearnes have acted as rapporteurs for Part 1 of this report, in partnership with Antonio Carvalho, Arianna Ferrari, Ângela Marques Filipe, Alfred Nordmann, João Nunes, Arie Rip, and Clare Shelley-Egan.

It should be cited as: Davies Sarah, Macnaghten Phil, and Kearnes Matthew (ed.) 2009. *Reconfiguring Responsibility: Lessons for Public Policy (Part 1 of the report on Deepening Debate on Nanotechnology)*. Durham: Durham University.

Arianna Ferrari and Alfred Nordmann have acted as rapporteurs for Part 2.

It should be cited as: Ferrari Arianna and Nordmann Alfred (ed.) 2009. *Reconfiguring Responsibility: Lessons for Nanoethics (Part 2 of the report on Deepening Debate on Nanotechnology)*. Durham: Durham University.

These documents are products of the DEEPEN (Deepening Ethical Engagement and Participation with Emerging Nanotechnologies) project. DEEPEN is a three year project (2006-2009) funded by the European Commission's Framework Programme 6. We wish to gratefully acknowledge the support of the European Commission and, in particular, the involvement of René von Schomberg.

Electronic versions of these documents are available from www.geography.dur.ac.uk/projects/deepen or from:

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Contents

Note on the structure of the report

Part 1: Lessons for public policy

Executive Summary

- 1 Introduction
- 2 Engaging with nanoscience and industry
- 3 Understanding European publics
- 4 Understanding the governance challenge
- 5 Re-shaping public debate on nanotechnology
- 6 Conclusion

Part 2: Lessons for nanoethics

Executive Summary

- 1 Introduction
- 2 Analysis: Nanoethics in the real world
- 3 New perspectives for nanoethics
- 4 Final observation

Select bibliography

Note on DEEPEN project participants

Note on the structure of the report

This report brings together two documents. Both draw on the activities of the DEEPEN (Deepening Ethical Engagement and Participation with Emerging Nanotechnologies) project and make recommendations for policy and research on nanotechnology.

Part 1, reported by Davies, Macnaghten and Kearnes, takes the findings of the DEEPEN project as a whole and explores their implications for public policy. It critically examines the world of nanoscience and industry, research into public perceptions and participation, and the governance of nanotechnology. Its intended audience is those involved in policy in these areas, and its recommendations are shaped accordingly.

Part 2 is reported by Ferrari and Nordmann and draws on the philosophical analysis carried out by the DEEPEN project. It discusses the field of 'nanoethics' and recommends new directions and approaches for this. While relevant to those involved in policy, it is also directed more generally at funding agencies, research institutes, and academic researchers involved in the philosophical, ethical and social study of nanotechnology.

We hope that you enjoying reading the products of what we have found a fascinating and fruitful three year project.

The DEEPEN project team, September 2009

Part 1

Lessons for public policy

Executive Summary

Background

- From its beginnings in the late 1990s, the development of nanotechnologies has been accompanied by experiments in governance. New mechanisms for the ‘responsible development’ of nanotechnology have emerged which respond to a striking – if not new – dilemma: how can policymakers regulate in such a way as to enhance innovation, but remain sensitive to public concerns and potential risks to the environment and human health?
- This report responds to this key problematic of responsible development. It brings together findings from a three year European research project (‘DEEPEN’) – involving researchers from ethics, philosophy and the social and political sciences – which aimed at deepening understanding of the ethical dimensions of emerging nanotechnologies, and their significance for civil society, governance and scientific practice.

The project

- The objectives of the study were as follows:
 - To examine how ethics and responsibility are understood within the nanoscience community and to explore ways of enhancing ethical reflexivity;
 - To understand how lay publics view the ethical import of emerging nanotechnologies and to develop methodologies aimed at better characterisation of public views;
 - To organise deliberative fora aimed at bringing together stakeholders and publics in the discussion of emerging nanotechnologies and their ethical and governance implications;
 - To deepen understanding of ethical issues associated with nanotechnologies;
 - To develop recommendations for ethical deliberation in nanoscience and governance communities.
- In sum, the DEEPEN project has found that current efforts in ‘responsible development’ – whether in ethical analysis, public engagement, or new forms of governance – while impressive, are still dominated by limited and limiting modes of thought. They will require reconfiguration in order to fulfil the promise of socially responsible nanotechnology.

Lessons for public policy

Engaging with nanoscience and industry

- The DEEPEN project examined how nanoscientists and industrialists understood the responsible development of nanotechnology. The research found that standard justifications and divisions of moral labour remain prevalent – particularly the repertoire that scientists do science, while society and ethicists deal with any ethical or social implications.
- To enable critical reflection, by the enactors themselves as well as others, it is important that these standard repertoires are opened up. Codes of conduct for nanotechnology aimed at the responsible development of nanotechnology represent an important opportunity to reconsider and modify such repertoires. In addition, there are opportunities for third parties such as funding bodies to ‘open up’ standard repertoires by requiring action on the social robustness of the research they fund.

Understanding European publics

- Drawing upon a series of discussion groups in the UK and Portugal, DEEPEN project research sought to characterise public responses and to understand how these are resourced. The research found that public responses to nanotechnology can be understood as being structured by five key cultural narratives, each of which represent archetypal stories deeply embedded in European culture. These are: ‘Be careful what you wish for’; ‘Opening Pandora’s box’; ‘Messing with nature’; ‘Kept in the dark’; and ‘The rich get richer and the poor get poorer’.
- A technoscientific vision of technology driving inexorably forward and bringing with it inevitable social benefits is thus rejected by lay publics. Public narratives instead emphasise that technoscience involves risk and uncertainty, and that perceived ‘benefits’ may turn out not to be beneficial at all.
- These findings suggest that lay responses to nanotechnology are complex, and that more thought needs to be given to the way in which public attitudes are understood and measured.
- In addition, public concerns and enthusiasms cannot be categorised as ‘pro’ or ‘anti’ but encompass anything from the dangers of perfection to the problematic nature of controlling life. Policymakers need to acknowledge the strength of feeling around these issues and seek to integrate more thoroughly the values they convey into nanotechnology research programmes.

Understanding the governance challenge

- Responsible development initiatives often involve forms of voluntary self-regulation and ‘soft-law’. Such initiatives attempt to intervene at earlier stages in the development of nanotechnology so as to ensure international best practice and a more socially robust governance framework.
- The DEEPEN project has mapped the different domains of uncertainty that policymakers must confront, and characterised an emergent governance landscape.

- We recommend that policy makers and regulators address the democratic and political challenge and move the focus of debate beyond technical questions of risk and scientific uncertainty – important though these issues are – and towards more collective discussion and experimentation about the direction, application and governance of innovation systems.

Re-shaping public debate on nanotechnology

- Public participation and deliberation is viewed as a key element of ‘responsible development’, but the current proliferation of public engagement activities is marked by mixed motives and confused practices.
- We suggest the time has come to move away from open-ended conversation on what nanotechnology may provide for our society, and to promote concrete deliberation on possible developments of nanotechnology.
- Instead of identifying concerns regarding speculative futures, public engagement exercises should focus on current or emerging research directions and technological developments in order to critically assess their possible impacts and their normative implications.
- To meet these challenges new methods and formats for deliberation need to be created. Popular formats for deliberation – often based on ‘ideal’ definitions of deliberation derived from theoretical accounts – all too often hinder rather than help engagement. The introduction of innovative techniques will allow diverse forms of interaction and debate to take place.

Conclusion

- The discourse of ‘responsible development’, with its emphasis on safe and beneficial innovation, lies at the heart of current thinking on the governance of nanotechnology. This offers a new space to discuss wider social and ethical questions, but it remains unclear how this is being understood by actors and how it will operate in practice.
- There is thus an urgent need for industry and government to open the politics of ‘responsible development’ up to wider deliberation and scrutiny. If responsible development is to succeed in opening up debate on nanotechnology, it needs to be substantially rethought.
- In particular, if the growing field of ‘nanoethics’ is to be of use in promoting new ways of thinking about responsible development, it cannot continue to operate in the currently predominant manner of generating and cataloguing concerns regarding potential impacts and applications of nanotechnology.
- Finally, we urge policymakers to develop a healthy scepticism about the rhetoric of the win-win situation characteristic of much discourse on nanotechnology. However seductive the vision of untrammelled technological development with no negative consequences is, thinking in these terms is hindering, not helping, debate on the responsible development of nanotechnology.

Reconfiguring responsibility: 10 lessons for public policy

1. Critically reflect on the standard repertoires of nanoscience and industry
2. Understand the complexity of public 'attitudes'
3. Engage with enduring public narratives
4. Shift governance from reactive to integrative forms of innovation management
5. Move public debate on nanotechnology from 'conversation' to 'deliberation'
6. Be aware of the challenges of deliberation
7. Develop innovative methods for engagement
8. Move away from speculative debate
9. Return 'ethical concerns' to the sphere of politics
10. Open up the politics of responsible development

1

Introduction

Nanotechnology – the understanding and control of matter at molecular levels – has attracted much attention. Its proponents claim it could result in a new industrial revolution, and point to enormous economic potential as well as the possibility of applications in everything from medicine to materials to space travel. Others point to nanotechnology's potential to pose new risks to human health and the environment, and warn that since these applications offer the ability to radically transform the quality and texture of everyday life, their ethical and social significance must be thoroughly considered in real-time.

Over the last decade, a consensus has emerged in the international policy community around the importance of such social and ethical consideration. As UK government minister Ian Pearson noted in a speech in 2008, there is much at stake. Nanotechnology's development, he suggested, is 'an ethical as well as a scientific question, and the public's voice should be heard in answering it'.¹ Since its inception in European and national research programmes, scientific research on nanotechnology has been accompanied by interest in characterising its ethical implications, understanding public responses to it, and making its governance more robust.

This awareness of the importance of public views, and of the need for thoughtful consideration of nanotechnology's implications for society, is an important part of the broader context of contemporary technoscientific governance. Over the last five years an international policy debate has emerged concerning the appropriate mechanisms for the governance and regulation of nanotechnology. At the heart of this debate is a striking – if not new – dilemma: how can policymakers regulate in such a way as to enhance innovation, but remain sensitive to public concerns and to potential risks to the environment and human health?

The challenges involved in developing such 'anticipatory' governance are far from inconsiderable. Most people are unfamiliar with nanotechnology, and have little to no factual knowledge of what it is or what it can be. Most nanotechnologies remain at an early or premarket stage of development, existing largely in terms of their future-oriented promises. Most experts seem to agree that there is considerable uncertainty about the kinds of environmental and toxicological effects that might be expected. And nanotechnologies are not only unbelievably small, operating at dimensions of roughly 1 to 100

¹ http://www.dius.gov.uk/news_and_speeches/speeches/past_ministers/ian_pearson/nanotechnologies

nanometres, but also tend to operate in ways that are fundamentally beyond human action, perception and causal control.

Nanotechnology is thus often cast as a test case for the classic dilemma of how to regulate and govern a technology that is 'in the making' and which is characterised by fundamental uncertainty. At the forefront of attempts aimed at dealing with this is a set of distributed and deliberative governance arrangements. This 'emerging governance landscape' of regulation and innovation policy on nanotechnology is marked by four overlapping sets of initiatives:

1. Debates about the possible toxicological effects of nano-particles and the publication of a number of 'regulatory reviews' concerning the sufficiency of existing regulations for new nanotechnology products.
2. The development of a number of voluntary mechanisms for reporting the presence of nanoparticles in current products, consistent with forms of governance built on soft-law and voluntary self-regulation.
3. The incorporation of 'Ethical, Legal, and Social Aspects' (ELSA) research and forms of public participation and deliberation into nanotechnology research programmes.
4. The proliferation of voluntary codes focussing on the 'responsible development' of nanotechnology, of which perhaps the most notable is the European *Code of Conduct for Responsible Nanosciences and Nanotechnologies Research*.

Such initiatives, as part of overall governance proposals, can be understood as speaking to the challenges of technological governance in being fundamentally designed to be 'enabling'. They are designed to operate in real-time and to draw together actors from science, policy, industry and civil society. They aspire to define new ways of governing emerging technologies in ways that are socially responsible, ethically robust, and publicly accountable.

Thus, for example, ethical and philosophical analysis has sought to elucidate the likely implications of nanotechnological applications: scholars have examined both particular substantive areas (such as the potential for new levels of surveillance, or for new forms of human enhancement) and transversal issues such as the necessity of justice and sustainability in nanotechnology's development. Sociological research has similarly been carried out on current public perceptions of nanotechnology and, given that public awareness is generally low, on the factors which may affect public attitudes. (European publics are, it seems, cautiously enthusiastic about nanotechnology's potential, though concerned about its regulation.) A number of 'upstream' public dialogue activities have also sought to make use of public views and values in shaping the direction of research. A further case is the use of soft-law forms of voluntary regulation of nanotechnology, consistent with the overall ambition to enable continued innovation in nanotechnology, while at the same time anticipating the need for more stringent approaches in the future. For the European Commission, for example, 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".²

We suggest, then, that a discourse of 'responsible development', with its emphasis on enabling safe and beneficial innovation, lies at the heart of current thinking on the governance of nanotechnology. It offers the possibility of opening up a space for debate and discussion of technological innovation in a way that has not been possible before. But it is not yet clear how this moment of opportunity – this chance to re-shape public debate, and re-direct technological pathways – will be taken up. Discussion of 'responsible development' may open up the governance of nanotechnology, but it could also close it down.

One key challenge is that it is often not clear what responsible development means in practice. Key notions of success, responsibility, safety, being socially acceptable – all of which are commonly applied to nanotechnology – are unclear: there is no settled consensus on the meaning of these terms nor of how they should be applied in real-world circumstances. And there is even less agreement on how these terms might provide useful guides in debates about the appropriate governance of nanotechnology. Definitions, of course, do exist; the following – featured in the mid-term evaluation of the US National Nanotechnology Initiative – is illustrative:

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.³

The text is striking in its lack of detail on the practice of responsible development. How is 'balancing' to be achieved when applications and implications are as yet unclear? Who decides what are the most pressing human needs? How are potential implications to be determined? In addition, from the perspective of ethics it draws solely upon consequentialism (moral theories that hold that the consequences of a particular action form the basis for any valid moral judgment about that action), ignoring other positions such as deontology (moral theories that hold that decisions should be made solely or primarily by considering one's duties and the rights of others) or virtue ethics (the search for a life that is up to an ideal of excellence). For many people, such arguments are dangerously incomplete.

The move towards 'responsible development' of nanotechnology, then, offers a key opportunity to develop a science that is truly in step with society. But current efforts towards this – whether in ethical analysis, public engagement, or new forms of governance – while impressive, require continual

² See European Commission. 2008: *Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee: Regulatory Aspects of Nanomaterials, COM(2008) 366 final* Brussels: Commission of the European Communities, p. 3.

³ Committee to Review the National Nanotechnology Initiative. 2006. *A Matter of Size: Triennial Review of the National Nanotechnology Initiative*. Washington DC: The National Academies Press

rethinking. In fact, it is the thesis of this report that in many respects the debate needs to be entirely reconfigured. That there is a public and policy debate on nanotechnology in its upstream stages is an enormous achievement; this debate, however, has not yet fully come to terms with the elusive nature of nanotechnology. It requires subversion and deconstruction in order for its taken-for-granted assumptions and failings to be brought to light.

The rest of this report starts from this point. Drawing on the findings of the DEEPEN (Deepening Ethical Engagement and Participation with Emerging Nanotechnologies) project – a three year research project involving academics in philosophy, ethics, and social and political science from across Europe – it explores a number of ways in which the notion of ‘responsible development’ can be interrogated and developed. We present headline findings from the project and suggest key lessons for policy on nanotechnology that the research process has thrown up. In discussing these lessons we focus on a number of substantive areas: nanoscience and industry, European publics, governance processes and, finally, the public and policy debate as a whole. In the following sections we describe some of the ways in which both policy activities and social science analysis need to become more thoughtful, reporting on key findings on the world of nanoscience and industry (Section 2), European publics (Section 3), and the challenges of governance of nanotechnology (Section 4). Section 5 provides a commentary on the need to re-shape public debate on nanotechnology and focuses on notions of deliberation and participation. Finally, we conclude by reflecting on the urgency of opening up the politics of responsible development (Section 6).

Before moving on to discuss these different areas and the challenges they hold, a word on both our findings and our position. This report contains a serious challenge for policy on emerging technologies. The findings discussed make strong and often critical points: based on these, we maintain that current activities in ‘responsible development’ are in many ways simply not adequate and need to be rethought. In making recommendations as to how this process can be begun, we – the DEEPEN project team – are not solely taking the traditional social science role of describing sections of society. We are also simultaneously evaluating the activities and processes that we describe. We take a stance on what we find about the practices and discourse of nanoscientists, publics, policymakers. This, of course, is what makes our recommendations powerful.

While we make strong points, we also attempt to steer a course away from being overly didactic. It is important to keep in mind that the development of nanotechnology is currently uncertain in multiple ways. New issues may emerge, and debate may shift in unexpected directions: the responsible development of nanotechnology is poised at a moment of opportunity precisely because it remains flexible and open. It is important, then, that the findings discussed in this report, and the recommendations derived from them, should not be reified or used as a way of solidifying particular practices. They are not ‘once and for all’. Rather, they should be seen as the start of a process in which new challenges and surprises will continually emerge, and where policy practices can adapt to these. We would urge policymakers and researchers alike to engage in this process.

The DEEPEN Project

The DEEPEN project (Deepening Ethical Engagement and Participation with Emerging Nanotechnologies), a European Commission FP6 project, has been 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 for Hazard and Risk Research at Durham University (UK). 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, as its name suggests, has had as its specific focus to deepen and develop what has gone before. The project has sought to critically reflect upon the current state of the art in social and ethical analysis, unravelling the challenges and hidden assumptions within the governance of nanotechnology and interrogating how the current language of 'responsibility' and 'upstream engagement' are worked out in practice. DEEPEN has also been an experimental project, testing new methods of engagement and analysis on a number of different levels.

The overall aim for the DEEPEN project is as follows:

- To deepen ethical understanding of issues related to emerging nanotechnologies through an interdisciplinary approach utilising insights from philosophy, ethics, and the social sciences.

In addition, there are a number of specific DEEPEN objectives:

- Map the ways that ethical and normative commitments are embedded in the development of nanotechnology research practices and develop ways of enhancing ethical reflexivity within the nanoscience community;
- Instigate a programme of cross-European empirical research aimed at unravelling the 'lay ethics' and values that a diverse European public use to understand and make sense of emerging nanotechnologies;
- Organise a series of deliberative fora in which citizens, stakeholders, experts and decision-makers can develop convergent and divergent understandings of the social and ethical ramifications of nanotechnology;
- Develop recommendations for articulating and deliberating ethical reflection in nanoscience practice and governance processes.

More information can be found at www.geography.dur.ac.uk/projects/deepen.

2

Engaging with nanoscience and industry

In the world of the practice – rather than the policy – of nanoscience and industry, the notion of ethics is rarely a key concern. Of course, those working within nanoscience and industry have views on issues such as the promises and risks of nanotechnology, the possibility of moratoria, responsible development, and the roles of themselves and others within these developments. But while such views can be linked to ethical stances by external analysts, they are primarily concerned with what one is to do in particular situations, rather than with articulating the ethical justification of courses of action. Strong positions may be held, but these tend to be justified in terms of an actor's roles and responsibilities as an industrialist, scientist, or policymaker. This also explains why interactions between different actors (discussions, dialogues, workshops) often look like a role play. Indeed, DEEPEN research was able to reconstruct a set of standard repertoires that are employed in industry and by scientists.

The DEEPEN project interacted with two main groups of people 'inside' nanoscience – industrialists and scientists – in order to learn about their positions on nanotechnology and its responsible development. What did they have to say?

When the topic is the development of nanotechnology, one particular stance is dominant: the importance of progress in general, and of progress through further development of nanotechnology in particular. Such stances are common in modern society. It is, after all, common to hear the claim that progress cannot be stopped. DEEPEN project research has found that people working in the world of nanoscience and industry are often also those who invest in or identify with such further development of nanotechnology and see it as unproblematically good. These perspectives are justified by reference to progress in general, and the specific benefits derived from new products and processes.

For industrialists, responsibility is discussed in terms of 'responsible innovation'. Many companies show a sense of self-interest in investing time and resources into responsible innovation in nanotechnology. They sometimes position it as a further step in Corporate Social Responsibility (CSR). This is tied up with the importance of being a 'good' firm. Companies talk about responsible innovation in terms of transparency and are concerned about lack of trust in industry. They see calls for a moratorium on nanotechnology product development as an example of lack of trust, and argue against it.

For scientists, the discussion is broader. Responsibility and accountability are discussed in terms of producing good students, making responsible promises and predictions, the status of ethics, and the

division of moral labour in science. Scientists have difficulty linking issues of responsibility with their own research. A grey area exists with regard to how far the responsibility of the scientist should extend, for applications enabled by their research, as well as for the wider impact of these applications. This is an age-old question and scientists tend to say that other actors should look after such broader issues – while at the same time wanting to take credit for beneficial applications.

Engaging with nanoscience and industry: methods

A number of different sources of data were used to explore the ethical repertoires prevalent in each of the groups selected for study (industrialists, policymakers and nanoscientists). These included documents, participant observation at meetings, and dedicated interviews. Informal discourse analysis was used to interpret the data. The research focused on ethical stances and patterns of moral argumentation, eliciting justifications for ethical stances, and how participants understand ‘ethical issues’.

(Extract from *Diagnosis Report: Ethics in the Real World*, 2008, Arie Rip and Clare Shelley-Egan)

Lesson one: Critically reflect on the standard repertoires of nanoscience and industry

Our research has found that standard repertoires of justification of nanotechnological development are prevalent in the ways that scientists and industrialists discuss their work. These standard repertoires build on present divisions of moral labour – the idea that scientists do science, while society and ethicists deal with any ethical or social implications – and allow the actors to continue to play their roles. While some division of moral labour is necessary, one should not assume that the present division, with its roots in the past, is still adequate. The repertoires of scientists and industrialists reflect a specific perspective: that the promises of nanotechnology must be pushed and that ethics is a brake on progress. To enable critical reflection, by the enactors themselves as well as others, it is important that standard repertoires are opened up.

Current activities around responsible development are thus an important opportunity to reconsider and modify repertoires and divisions of moral labour. At the moment, we find recourse to traditional roles, and a focus on concrete issues such as transparency and risks rather than the background repertoires and divisions of labour that shape the debate on such issues. But there are opportunities to do better.

First, recent initiatives for codes of conduct for nanotechnology, and receptivity to these initiatives in terms of willingness to discuss such codes seriously, provide an opportunity for the opening up of standard repertoires. A code of conduct is a self-binding action. (A particularly striking and authoritative example of this self-binding is the broad definition of scientific responsibility in the Code of Conduct proposed by the European Commission.) A key feature of such codes is that they assume, and thus create, a public space where a subscriber to the code can be called to account by other actors referring to the code. This is reflected in the reluctance of industry and other actors to subscribe to broad

circumscriptions in codes that open up the possibility of (unexpected, risky) critical calls for being held to account. On the other hand, such public spaces allow for deliberation and can be used for learning by all parties.

Second, there are third parties who do not develop nanotechnology themselves but exert leverage on developments through their actions. Funding agencies, for example, may require particular kinds of activity relating to responsible development of those whom they fund. If we are interested in ‘opening up’ standard repertoires, one entrance point is through these third parties. Increasingly, third parties such as funding agencies (for science) and venture capitalists and insurance companies (for industry) are requiring action on the social robustness of the nanotechnological research they fund. Under such imperatives, those within nanoscience and industry must develop relevant competencies, and act upon them – again, presenting an opportunity for discussion and debate on the nature of responsible development and on the repertoires these actors use.

Codes of Conduct and proactive third parties are so-called ‘soft’ (non-binding) governance structures. However, what is important here is not whether they are effective or not, but whether they stimulate critical reflection on background issues, and thus openings for long-term changes. We would suggest that they are a key part of nanotechnology’s moment of opportunity, and present an opportunity for those within nanoscience to develop new ways of understanding and justifying their activities.

From the data: Industrialists and responsible development

We asked interviewees whether their company’s stance towards responsible innovation in nanotechnology was part of their overall corporate social responsibility strategy or additional to it; we wanted to find out if industrialists considered nanotechnology to be ‘ethically special’.

All respondents answered that responsible innovation in nanotechnology was a normal part of their corporate social responsibility. Responses included:

“That’s part of our DNA.”

“It’s part of the total philosophy... it’s a total attitude – you can’t just split parts of it... it’s part of the total way we do business. “

(Extract from *Diagnosis Report: Ethics in the Real World*, 2008, Arie Rip and Clare Shelley-Egan)

3

Understanding European publics

Research into public attitudes to nanotechnology has been gathering apace over the last eight years. Survey research has identified low public awareness, alongside a cautious enthusiasm, while qualitative research has found a more marked ambivalence. A review of findings from UK deliberative processes – published by the Nanotechnology Engagement Group in 2007 – noted that lay participants emphasised the need for social, rather than ‘consumption’ benefits from the technology, were concerned about existing uncertainties and lack of regulation, and felt there was a need for greater openness, transparency and public engagement. Similar findings have emerged from across Europe and North America. However, despite this mapping of public attitudes to nanotechnology, relatively little work has examined in detail the ways in which responses to the technology are created and maintained. A number of questions remain – including exactly what underpins lay responses to nanotechnology.

The DEEPEN project has started to answer such questions through a series of discussion groups held with laypeople in the UK and Portugal. We have found that in both national contexts, laypeople’s excitements and anxieties about nanotechnology can be understood as being structured by five key cultural narratives. These narratives are familiar stories that are deeply embedded in European culture and which provide foundation and strength to a more broadly applicable type of imagination. Concerns about nanotechnology, in other words, form part of a larger context of concerns about technological society in general, and general cultural storylines can be applied to them. The five key narratives we have identified as providing ‘archetypal’ stories in response to the issues posed by nanotechnology are:

1. ‘Be careful what you wish for’
2. ‘Opening Pandora’s box’
3. ‘Messing with nature’
4. ‘Kept in the dark’
5. ‘The rich get richer and the poor get poorer’

The names of the five narratives indicate, in shorthand, their storylines. Indeed, their very familiarity is a sign that they are deeply rooted within contemporary culture, and can be understood as mythic cultural tropes. Thus, the ‘be careful what you wish for’ narrative builds on the age-old notion that getting

exactly what you want may not ultimately be good for you, and may, inadvertently, lead to unforeseen disaster and catastrophe. This narrative was especially potent in structuring public resistance to the seductive and apparently boundless promises provided by nanotechnologies. 'Opening Pandora's box' draws on the Pandora's box myth to provide a repertoire for articulating public unease about the hubris of meddling with things that should be left alone, of the danger of proceeding without limits, and of the likely subsequent release of a whole range of human evils. 'Messing with nature' is a further narrative deployed to express public concerns over nanotechnology's potential to disrupt long standing distinctions and boundaries – such as 'sacred' distinctions between the living and the non-living – in the face of the possibility of redesigning nature to our own needs. The 'kept in the dark' narrative expresses participants' sense of powerlessness in the face of nanotechnology's troubling but inevitable development, while 'the rich get richer and the poor get poorer' draws on how real-world drivers of commerce and consumption were seen as likely to further exacerbate injustice and inequality. Ultimately, the story goes, promises of green or socially relevant technology are likely to result only in the rich – big business and the already-powerful – benefiting, while the poor or excluded remain so.

Importantly, all five narratives can be understood as resisting the key Enlightenment narrative embedded in the perspectives of actors within nanoscience highlighted in the previous section: that technological progress will inevitably lead to social betterment. This vision of technology driving inexorably forward, bringing with it social benefits, is rejected by lay publics. Public narratives instead emphasise that technoscience involves risk and uncertainty, and indeed that perceived 'benefits' may turn out not to be beneficial at all.

Lay narratives: A philosophical perspective

The narratives DEEPEN research has identified emerged through analysis of empirical data with lay publics. Their characterisation is thus grounded in the methods of social science. It is clear, however, that they can be analysed and interpreted using a variety of intellectual resources, and one feature of the DEEPEN project was an interplay between philosophical and social science approaches. Below we quote from a DEEPEN paper in which Jean-Pierre Dupuy discusses the five narratives from a philosophical perspective.

The DEEPEN project has come up with five narratives that purport to be 'arche' stories as regards the deeply embedded cultural resources which laypeople utilise to discuss the ethics of [nano]technology.

I submit that:

- *Those five narratives draw up a semantic and pragmatic space that may be assumed, as least as a first approximation, to be consistent and complete. It is an important result of the DEEPEN project to have disclosed this structure;*
- *Those narratives are not independent of one another and they must be grouped in two meta stories;*
- *Those two meta stories belong to two very distinct worlds, which it may be convenient to dub "ancient" and "modern";*

- *The ancient meta story unites narratives “Be careful what you wish for”, which I prefer to call Desire; “Pandora’s box”, which I prefer to call Evil; and “Messing with nature”, which I prefer to call The Sacred. The contents of the interviews conducted by the Durham and Coimbra teams do not justify, in my opinion, to keep those three narratives separate: they tell the same story, a very ancient story at that.*
- *The modern meta story conjoins narratives “Kept in the dark”, which I prefer to call Alienation, and “The rich get richer, the poor get poorer”, which I prefer to call Exploitation. Although distinct, those two narratives belong in the same category, far removed from the ancient meta story. They concern a world in which the problem of evil has become a purely human story.*

(Extract from *The Narratology of Lay Ethics*, Jean-Pierre Dupuy, 2009)

Lesson two: Understand the complexity of public ‘attitudes’

The DEEPEN project’s surveys of the real world of nanotechnological development – in governance, policy, science and industry – has indicated the importance of ‘the public’. They (or rather, we) are seen as having a key part to play in nanotechnology’s responsible development. Through processes of public engagement and deliberation, publics will become involved in nanotechnological research programmes and make them more robust. As framed by the European Code of Conduct, for example, it is essential that research and development in nanotechnology is comprehensible, inclusive and accountable to European publics.

This emphasis helps explain the current enthusiasm for research and policy-oriented activities which seek to better understand public views on nanotechnology. Surveys have attempted to measure public attitudes to the technology, and to identify where these derive from, while public engagement processes have been used to gain a sense of public evaluations of nanotechnology’s risks and benefits. The empirical work that the DEEPEN project has carried out similarly speaks to this interest in ‘the public’ and their attitudes. It also, however, challenges the focus of this interest.

A key finding from our analysis is – very simply – that lay reactions to nanotechnology are complex. Public responses to the technology, or even to particular applications, are not simply either positive or negative; rather, pros and cons are seen as intermingled and often inseparable. Laypeople are also not content with weighing up risks and benefits. Their concerns and enthusiasms go beyond this narrow framing to encompass anything from the dangers of perfection to the problematic nature of controlling life. This is further implied by our reading of public responses to nanotechnology as structured by deeply rooted cultural narratives: such narratives represent contemporary dilemmas and questions, simultaneously acknowledging that these have no easy answers. They suggest contradictory and powerful pulls on our hopes and desires: yes, of course we long for better medical technologies, but at the same time are anxious about the implications they will have for what it means to be human. We want more equitable access to technology, but at the same time know that, often, we are the ‘rich’ for whom consumer technologies are designed.

A key implication of these findings on the complexity of public ‘attitudes’ is that both social scientists and policymakers need similar sophistication in understanding and acting upon them. Our methodologies should not box in and over-simplify laypeople’s thinking on nanotechnology’s implications. We must move beyond the language of ‘pro or anti’, and ‘risks versus benefits’, and acknowledge that the judgements about nanotechnology that all of us make – whether layperson, scientist, or policymaker – are not easily encapsulated in tick box surveys. We recommend, then, that more thought is given both to the way in which public opinions are measured and to the ways in which publics are understood and involved in engagement activities. Both of these processes, we suggest, need to grapple further with how complex public concerns can be represented and included in policy.

New methods for public research

Public engagement with emerging technologies – which are unfamiliar to most people – present important methodological challenges. How to introduce the technology, and enable participants to consider their ethical implications?

DEEPEN project research drew upon group performance and theatrical techniques, including the work of the Brazilian dramatist Augusto Boal on the ‘Theatre of the Oppressed’, to respond to this challenge. The ability of theatrical techniques to harness unexamined, affective and intuitive ethical responses, and to provide insight into the social dynamics and the perceived moral orders driving those responses, makes them a productive method for accessing the tacit narratives we aimed to explore. Through them it is possible to examine the shaping of ethical narratives and the resources that people bring to bear on this process.

In the UK, the research involved six groups (of six to eight individuals), covering standard demographic criteria, and selected around commonalities likely to have relevance to negotiations of the ethical issues nanotechnology presents. The groups were: a church group; a student environmental and social justice group; a group of (female) users of organic products and alternative therapies and a group of (male) confident supporters of technology; a group with interests in local community involvement; and a group who saw themselves as having authority in their workplaces. In Portugal, four groups of participants were constituted on the basis of their commitment to specific concerns that were expected to be relevant for their stances towards nanotechnologies. The groups included those involved in patient organisations, environmental issues, consumer rights, civil and human rights, and social justice issues.

In both countries, each group met twice, for an evening focus group, and then, in conjunction with another group, for a Saturday workshop. Focus groups lasted approximately three hours and involved an initial discussion of the role technologies played in participants’ lives, and a fuller discussion around stimulus material introducing nanotechnology and the visions around it. The workshop gave participants the opportunity to reflect further on and act out futures where aspects of nanotechnology had become reality. Working separately in the morning, the groups discussed what they felt was the most pressing concern for the future which their research and the previous meeting had thrown up; they then developed a performance or presentation based around this. In the afternoon the groups presented their performances

to one another and discussed, together, the issues depicted, the changes that could be made, and the implications for those controlling nanotechnology.

For further details see *Working Paper: Comparative Analysis of Lay Ethics in Two European Nations*, 2008, Durham and Coimbra DEEPEN research teams

Lesson three: Engage with enduring public narratives

The next point follows on from that which we have just discussed: once we take the complex nature of public opinion seriously, we need to start to deal with the content of lay concerns more thoroughly. We cannot brush these off as ‘irrational’ or as irrelevant. Rather, our recommendation is that policymakers acknowledge the strength of feeling around these issues and seek to more thoroughly integrate the values they convey into nanotechnology research programmes.

The lay narratives we have identified express dilemmas and dynamics which run as patterns through European society, but which will wax and wane as contemporary circumstances change. These narratives thus act as an expression of important currents within lay culture which resist the trends that nanotechnology is seen as imposing; it is important, then, to understand public responses to nanotechnology as part of a much wider sense of anxiety around technology’s effects on our lives and, ultimately, what it means to live within contemporary technological society. For example, take the ‘opening Pandora’s box’ narrative we have identified. The story of Pandora’s box is a familiar one: a temptingly closed but prohibited box, when opened, releases all human ills. The storyline thus incorporates ideas of uncertainty, of hubris and meddling with things that should be left alone, and of danger and disaster. These notions are familiar ones that resonate with wider societal concerns and experiences, from Bhopal to Three Mile Island to thalidomide. The narrative draws together ideas of escape and technology out-of-control, as well as an uncertain potential for good. Its use in response to nanotechnology pins down the technology as being understood, by lay publics, as part of much bigger trends: it is part of a continuum that runs – we might speculate – from Icarus to Chernobyl.

The other narratives we find used in public responses to nanotechnology similarly have broad resonance. ‘Kept in the dark’ expresses a widely felt sense of disempowerment in everyday life, while ‘the rich get richer and the poor get poorer’ refers to what are seen as entrenched local and global inequalities. ‘Messing with nature’ encapsulates anxiety about a blithe interference with some of the most fundamental boundaries of human experience – life and death, human and machine, natural and unnatural. And ‘be careful what you wish for’ can be seen as expressing a fundamental dilemma of contemporary life in the tension between our desires and our moral, relational or social health. Do we give in to what we want, or think of the bigger picture and resist? These narratives, then, express some of the most troubling and profound questions of our society. At the very least they point to an enduring sense that the essential reasoning of technoscience – the twinning of science and social progress – is one that is flawed. Their use in response to nanotechnology indicates that there is much at stake in the technology’s development: it is not simply a question of whether risks outweigh benefits or not, but that

nanotechnology will re-shape our entire experience of living in the world. The challenge for those involved in shaping nanotechnology's (responsible) development is both to acknowledge this, and thus to resist the false humility that suggests that nothing new is being undertaken, and to find ways of incorporating these questions, concerns and excitements into emerging research programmes.

4

Understanding the governance challenge

The call for more or better regulation of nanotechnology is a familiar one. As we noted in the Introduction, there has recently been a high degree of attention given to the challenges – and best ways forward – of governing nanotechnology.

Concern has been raised about the possible eco-toxicity of nanomaterials, together with the broader socio-economic and ethical dimensions of nanotechnologies. Regulatory attention has also 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. One notable feature of current governance initiatives has been the development of governance structures that incentivise forms of ‘responsible development’, particularly through forms of voluntary self-regulation and soft-law. Policy makers have begun to consider how governance initiatives might usefully intervene at earlier stages in the development of nanotechnology so as to ensure international best practice.

The key dilemma facing policy makers is therefore how suitable to nanotechnology current governance initiatives and notions of responsible development are, given the uncertain nature of both the possible risks of the technology and the possible pathways that developments will take.

In the DEEPEN project we have suggested that there are three areas of uncertainty that policy makers must confront when thinking about the governance and regulation of nanotechnology:

1. **Knowledge uncertainties** – the limited current knowledge of possible eco-toxicological effects of nanomaterials. Despite some early warnings many authors have stressed the limited state of current knowledge regarding the ecological and health effects of nanomaterials.
2. **Commercial uncertainties** – the simple fact is that though nanotechnology is seen as heralding great promise in a number of commercial sectors, many of these potential innovations are a long way from full realisation. The particular paths that developments enabled by nanotechnology will take remains unclear. Aside from the modest advances that nanotechnology has made in a range of nano-enabled products it is not clear what directions nanotechnology will take in the medium term.

3. **Public uncertainties** – concern has been expressed regarding the public acceptability of particular nanotechnologies, and a number of public attitude studies have been commissioned to examine these issues (see Section 3). However, DEEPEN findings indicate that, given the complexity of lay reactions to nanotechnology, it is currently unclear how nanotechnology will be regarded by diverse European publics.

These three areas of uncertainty have been the impetus for a range of proposals for new forms of governance. We have characterised this overlapping range of initiatives as a ‘governance landscape’. A striking feature of the nanotechnology governance landscape is that the governance and regulation of nanotechnology are being considered concurrently with the development of nanotechnology research programmes. In this sense, governance and regulation have moved ‘upstream’. For example, a number of recent governance initiatives seek to shape the development trajectory of nanotechnologies by intervening at the research and development stage of nanotechnologies. In particular a number of ‘codes of conduct’ have been published by government, commercial bodies, industry associations, and NGOs. These forms of voluntary self-regulation have sought to address the responsible development of nanotechnology by requiring signatories to conduct risk research and life-cycle analysis, stakeholder and public engagement and to consider the wider ethical and societal dimensions of nanotechnology.

The recently released *Code of Conduct for Responsible Nanosciences and Nanotechnologies Research* developed by the European Commission is one code that is voluntary, but which has originated in a political sphere and which demands a higher level of accountability. The approach taken in this code is indicative of a wider set of voluntary initiatives. For example, the code is based on seven general principles – *meaning, sustainability, precaution, inclusiveness, excellence, innovation and accountability* – and operates as a recommendation that ‘member states be guided by the principles ... as they formulate, adopt and implement strategies for developing sustainable nanosciences and nanotechnologies’. As such the code seeks to intervene at an earlier stage in the development cycle of nanotechnologies, embedding principles of responsibility at the research stage.

Considering the governance challenges of Eastern and Central Europe

In order to consider the governance challenges posed by the responsible development of nanotechnology in Eastern and Central Europe the DEEPEN project hosted a High Level Workshop on ‘The Responsible Development of Nanotechnology: Governance Challenges’ in Budapest in April 2009.

This workshop was designed to critically evaluate emerging policy debates on the responsible development of nanotechnology and to consider the governance challenges posed by this, particularly for new accession and Eastern European nations. Workshop participants included representatives from Hungary, Ukraine, Russia and Poland, and were asked to prepare country reports on both the situated challenges and opportunities posed for improving the responsible development of nanotechnology in national contexts.

A workshop report was prepared by the Workshop Rapporteur Imre Hronszky, who suggested that rather than merely being geographically linked, Eastern European countries share a common socialist heritage and parallel (but not equivalent) transitions to democratic market societies. It is this political context that constitutes the key challenge to engaging in the responsible development on nanotechnology in Eastern European countries, given that the transition from State-oriented economic systems has not fully been realised in individual national contexts. Further, a legacy of authoritarian political systems in post-Socialist contexts, in which linear models of technoscientific progress are presumed, limits the potential for effective public and stakeholder engagement. In the nations surveyed, this legacy has resulted in relatively weak notions of democracy, civil society and public participation and a largely uncritical belief in beneficence of science and technology.

However, workshop participants also reported on some processes that signal the possible development of more participatory models of technological development. These are, however, limited to particular application areas, and have yet to effect a broader change in the governance of technological development.

For further details on the workshop, and its associated report, see *Contributing Report: Governance and Regulation of Nanotechnologies in Europe*, 2009, Matthew Kearnes and Arie Rip.

Lesson four: Shift governance from reactive to integrative forms of innovation management

A recent report by Royal Commission on Environmental Pollution characterised contemporary changes in governance practice as a shift from risk-based modes of regulation to forms of innovation governance. The report stated that:

Ultimately, however, many of the questions raised by developments like those in the field of novel materials are trans-scientific in nature. They extend beyond the (important) issues of risk and risk management to questions about the direction, application and control of innovation. ... The more substantive challenge, therefore, is to find the means through which civil society can engage with the social, political and ethical dimensions of science-based technologies, and democratise their 'licence to operate'. It has been characterised as a challenge of moving beyond the governance of risk to the governance of innovation.⁴

Clearly, many contemporary governance initiatives are seeking to intervene at earlier stages in the development of nanotechnology – before risks become apparent – to ensure that responsible action is taken in the R&D phases of nanotechnology innovation. Given the current state of uncertainty regarding both the possible toxicological effects of nano-materials and development pathways we endorse this diagnosis. We further recommend that policy makers and regulators address the democratic and political challenge posed by moving from reactive forms of risk governance to more integrative forms of innovation governance. Initiatives such as the *Code of Conduct for Responsible Nanosciences and*

⁴ Royal Commission on Environmental Pollution. 2008: *Novel Materials in the Environment: The Case of Nanotechnology*. London: HMSO.

Nanotechnologies Research represent an opportunity to open up and democratise nanotechnology's 'licence to operate'. This opportunity must be taken.

This is an important shift in thinking, and will undoubtedly have lasting impacts on the governance and regulation of future emerging technologies. In order to bring this into effect we recommend, therefore, that governance arrangements should be reflexively monitored for their capacity to orient nanoscience research in democratically acceptable and desirable directions.

A further key feature of debates about the governance and regulation of nanotechnology is the emergence of notions of the 'responsible development' of nanotechnology. The twin goals here are to stimulate innovation in nanotechnology while at the same time 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. However, it is striking that there is very little consensus as to the meaning of responsibility – aside from the generic desire to 'enable' the successful development of nanotechnology. We recommend that further and more explicit debate be fostered in order to more fully articulate the meaning of the 'responsible development' of nanotechnology.

5

Re-shaping public debate on nanotechnology

In the previous sections we have described DEEPEN project findings in specific arenas, and discussed their implications for policy in terms of the opportunities these spaces present for opening up the discourse and praxis of ‘responsible development’. In this section we continue by focussing on an aspect of responsible development that has been emphasised both within governance processes and by lay publics: the move towards deliberative public debate that will help shape research policy.

Public participation and deliberation might in fact be regarded as a key element of current nanotechnology governance. We are witnessing the emergence of a new set of such governmental technologies in the governance and regulation of nanotechnology – principally public deliberation, ethics and foresight – built into technological development at upstream stages. However, within this, public engagement is frequently represented as a mechanism through which to restore public trust by increasing the transparency and accountability of scientific governance and policy development. Though 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.

DEEPEN project research has also indicated just how ingrained are the challenges to processes of public participation. Public engagement initiatives are often defined as deliberative exercises, requiring that participants meet on an equal basis, without being subject to coercion, manipulation or deception. These conditions are hard to meet in practice: power relations or inequalities associated with class, gender, sexual orientation, race, ethnicity, or literacy are almost impossible to erase. In addition, a strict definition of rational argument as the sole legitimate mode of engaging other participants tends to give an advantage to those who have mastered the communication skills associated with this kind of argument (as opposed to, say, storytelling, polemic, or personal biography). This is often the case for scientists, and these participants in a deliberative process are thus more likely to frame and dominate the debate. In practice, it is easy to recreate the kind of hierarchical relationship between ‘experts’ and ‘laypeople’ which deliberative fora were supposed to overcome.

The current proliferation of public engagement activities are, we suggest, marked by mixed motives and confused practices. Though viewed as a key element of ‘responsible development’, it is often not clear

what their purposes are and how they will be used within nanotechnology policy and research and development. DEEPEN project research in this area – which has fused both social scientific and philosophical analysis – has indicated that these challenges are a hallmark of ‘public engagement’, rather than an unfortunate by-product of particular kinds of processes. The emphasis on lay perspectives and democratic accountability in ‘responsible development’ is laudable, and certainly presents an opportunity for a new form of collective science – but, as it is currently constituted, the framing of public debate needs to be rethought.

Experimental deliberative processes on nanotechnology: findings from Portugal

On the 7th March 2009, a Deliberative Forum organised by the project DEEPEN – Deepening Ethical Engagement and Participation in Emerging Nanotechnologies – took place at the Centre for Social Studies, University of Coimbra. Recommendations included:

Research

Investment in research which takes into account sustainable development. Information should be made available on research and in European projects on nanotechnologies, through websites allowing public access to progress and results.

Information

Information should include the explanation of what are nanotechnologies and of their diversity, in such a way that citizens do not create resistance. Incentives should be created for media to broaden their coverage of questions related to science, technology and society; training and updating of information for journalists in this field should be reinforced.

Education

As far as education is concerned, and in connection with information, public actions should be carried out in schools for the promotion of science in schools, and the topic of nanotechnologies should be introduced into school curricula (primary and secondary). New tools must be developed for schools, opening the school to the community. Different strategies of education and citizenship must be mobilized. The body in charge of this may be, at the national level, the program “Ciência Viva” and science centres and museums.

Regulation and Certification

Civil society and regulation must be present through all the steps of nanosciences and nanotechnologies, possibly through the involvement of laboratories and a reinforced European observatory of nanotechnologies, whose model could be replicated at the national level. There is the possibility of applying to other domains the procedures of evaluation and regulation developed for the field of health, always taking into account the diversity and specificity of nanotechnologies and of their life cycle – for instance, broadening to the military domain mechanisms of regulation used in other fields. The certification of products and material is advised, since people will tend to avoid products which are not

certified. A procedure and a body for certification should be created, in connection with regulatory processes, to be designed by public entities, acknowledging that different levels of risk in diverse areas imply different levels of certification. The instruments and processes of regulation and certification could be articulated to networks of laboratories; observatories of emerging technologies and nanotechnologies; existing ethics commissions, eventually reformulated to be inclusive of the diversity of new issues; and all the platforms for debate, existing or to be created, always including representatives of civil society.

(Extract from the Public Report of the deliberative event organised by the Coimbra DEEPEN team, available from www.geography.dur.ac.uk/projects/deepen.)

Lesson five: Move public debate on nanotechnology from ‘conversation’ to ‘deliberation’

In spite of the extensive use of the label ‘deliberative’ to describe public engagement with nanotechnology activities, it is not always the case that these exercises have a concrete effect on decision-making. In fact, most are of a consultative kind – at best contributions to more informed and robust decision-making that remains the province of elected politicians, officials or experts. While the arguments around whether public participation processes should be binding or consultative are complex, we would like to make a general point about the purpose of public engagement. Engaging people – publics and stakeholders – in an unending conversation on the possible implications and visions embedded in nanotechnologies is not sufficient. We see a strong need to remain not merely at the level of a general conversation on what nanotechnology may provide for our society, but to promote concrete deliberation on possible developments of nanotechnology. In other words, in order for public engagement to not be merely a pleasant, and unending, conversation on the possible implications of nanotechnology, collecting a set of different opinions but taking these no further, the role of the public should be conceived as part of a space of concrete decision-making.

In particular, of course, concepts such as ‘sustainability’ and ‘responsible development’ are not discussed in terms of precise deliberations, statements and decisions, but instead remain vague and unfocussed. This is not to suggest that all public engagement processes need to result in concrete programmes which are then binding for policymakers. The governance context is too complex for any one method to be appropriate, and we would like to emphasise the importance of diversity in the ways that publics are brought into the debate on nanotechnology’s development. At any one time there will be numerous processes that involve publics – deliberative events, consultations, web-based interaction, or science communication activities, to name a few – and these will interact with each other and with policy making in different ways. But the broader point remains: public debate, whatever its exact form, must take place in a space that takes the issues that arise seriously, and acts upon them. ‘Deliberation’ in this sense might focus on such questions as the possibly excessive and environmentally problematic use of anti-bacterial nanosilver in consumer products; the incorporation of biological properties (such as viral properties) in the construction of new materials; or, on the level of governance, the mandate a European Observatory of nanotechnology should have.

Lesson six: Be aware of the challenges of deliberation

Unlike procedures for the assessment of existing technologies, whose effects or consequences may be scrutinized, ‘upstream’ public engagement with emerging technologies such as nanotechnology requires participants to deal with scenarios and implications of scientific and technological developments that may not currently exist. Emerging technologies therefore raise unique challenges for public debate: how, for example, to enable an informed discussion on a technology that remains in the making? Or how to engage with technological futures without indulging in fruitless speculation?

DEEPEN project activities have indicated that it is exceptionally difficult for groups of stakeholders and laypeople to discuss diverse aspirations and concerns in the context of an emerging technology. Challenges include the lack of common ground, the replication of external power relations, uncertainty as to what actions and decisions can or should be taken, and the difficulty of discussing ‘nanotechnology’ when there are hundreds of very different applications. These challenges need to be more frequently acknowledged and innovations designed to take them into account. The blithe reproduction of existing formats for public engagement is not productive. Instead, those on an increasingly professionalised bandwagon of deliberation and dialogue around nanotechnology need to acknowledge that any process which seeks to collectively explore the promises, concerns and fears associated with emerging technologies and influence research policy will inevitably be hard work, and at times intensely uncomfortable, for all involved.

We offer two suggestions of what this might mean in practice if these exercises are to reach their potential as pathways to new ways of collaboratively imagining and shaping possible futures. First, the sense of inevitability, often evident in public discourse, of the irreversibility of certain technological paths should be critically addressed. Is technological progress genuinely inevitable? At what stage in the R&D cycle should deliberation take place in order to disrupt this ‘inevitability’? What stakes do different actors have in any deliberation process? These questions should be opened up to public discussion. Second, a distinction should be made between speculation over what may or may not be feasible in the future, on the one hand, and thinking through the prospects and implications of current research and development on the other. Public engagement exercises should focus on current or emerging research directions and technological developments (such as existing forms of ethical scrutiny and regulation for emerging technologies), in order to assess critically their possible impacts and their normative implications. But they should also open up new spaces for the emergence of a healthy scepticism over the promises and fears associated with nanotechnologies.

Experimental deliberative processes on nanotechnology: some quotes from the UK

The Durham DEEPEN team ran a deliberative event focussed on nanotechnology’s responsible development over a day and a half in February 2009. The event brought together policymakers, laypeople, scientists, and representatives from civil society. Below are some quotes from participants illustrating the concerns and excitements that were brought to the table.

“...there was a concern as well about whether there was kind of an ethical framework in existence to discuss these things at the moment. Is it moving quicker than an ethical framework can be set up?” (Policymaker)

“...the greatest excitement for nano was to do with the implications for energy, for generating energy. Specifically for renewable energy, the possibilities there are very very interesting...” (Layperson)

“...sometimes it just has to be taken right back to the level of communication, so that it says, we all know what we’re talking about ... I know it doesn’t stop things going wrong. But it means that people will feel more empowered...” (Layperson)

“I suppose the worry I have in this context is the issue of who actually does look after the longer term in a world where everybody's kind of making small decisions about how to maximise their own benefit over the short term. Who is really thinking, you know, in a big way about what society's going to look like in 20 or 30 years?” (Scientist)

“...the complexity of the whole issue is a problem, and it has to be addressed in that complex way. There’s more than one solution and answer, but everyone has to play a role in the development of end technology in nano.” (Policymaker)

(Extracted from the Public Report of the deliberative event organised by the Durham DEEPEN team, available at www.geography.dur.ac.uk/projects/deepen.)

Lesson seven: Develop innovative methods for engagement

This lesson follows on from the last: if deliberation and engagement is difficult, riddled with the remnants of inequalities and a lack of common ground, then new methods should be developed in order to respond to these challenges. Popular formats for deliberation – often based on ‘ideal’ definitions of deliberation derived from theoretical accounts – all too often hinder rather than help engagement. Deliberation may or may not occur within a particular ‘deliberative’ setting, and clashes between rational argument, storytelling, confrontation and negotiation are common. The introduction of innovative techniques will allow diverse and often conflicting forms of interaction and debate to be openly displayed.

New formats for engagement will therefore broaden the range of acceptable means of expression and of ways of working through differences, disagreements and misunderstandings. We would also suggest that specific fora should be organized for different types of participants or configurations of participants. For example, DEEPEN project research with focus groups, and their comparison with deliberative fora carried out in the UK and in Portugal, suggests that such small groups may provide a different model for the collaborative production of recommendations by participants. One of the features of these exercises was the absence of those working in nanoscience and industry, allowing participants to define concerns and questions on their own terms and without being constrained by the more rigid formats associated with deliberation. Participants were able to draw on their own experiences and skills to build scenarios

and create arguments less constrained by what those working within nanoscience view as the pertinent issues.

Rather than relying solely on formats of public engagement that bring together scientists, stakeholders and citizens, then, the full range of possible fora, with different formats and compositions, should be explored. Importantly, this means that public engagement must be understood as sets of initiatives, rather than as one-off events – creating a public debate that is both flexible and diverse.

<i>Lesson eight: Move away from speculative debate</i>

Nanotechnologies, as emerging technologies, inevitably offer us visions of the future. The field has been marked by speculation and hype from its inception, and this has impacted public as well as technical discussion of the technology. At the same time nanotechnologies are already present: research is taking place on them, and particular visions are embedded in the practice of this research. As such they are a present reality as well as an imagined future. Research programmes are driven by existing assumptions and practices, and these will also impact how technologies will be imagined and perceived as they emerge into the public domain.

Public debate therefore needs to engage with what is happening now in nanotechnological research, as well as with expectations of nanotechnology's future development. Empirical findings from the DEEPEN project suggest that much of what is perceived to be at stake in nanotechnology is similar to the questions and concerns which have emerged in connection with other past technologies (such as, for example, concerns regarding human relationships with nature, or around technoscience's propensity for catastrophic failure). Reference to past experiences of debate and deliberation on technologies should therefore play an important role in reflecting on the visions driving nanotechnology.

While not ignoring the future, and what it promises, we most urgently need to consider the present situation of scientific research and development, as well as governance regimes and the economic context of nanotechnologies. We also need to engage with, and learn important lessons from, past experiences of technology. In moving away from speculation about possible but remote futures, we can recover a sense of the novelty and peculiarity of nanotechnology, which consists precisely of an 'intensification' of already existing technological pathways and concerns about these.

Ultimately, the notion of responsible development of nanotechnology must be held to a higher standard than that of inclusiveness. Promoters of nanotechnology need to be held responsible for the claims they make – in the case of exaggerated technical visions, their truth must be challenged; whereas in the case of societal promises, they must be measured against these.

6

Conclusion

In the introduction to this report we suggested that nanotechnology is poised at a key moment of opportunity and uncertainty. Recent moves in scientific governance are being tested in the technology's regulation and control, and new initiatives – in particular a move towards emphasising 'responsible development' – offer key opportunities to open up public debate on innovation in nanotechnology. But the extent to which this opportunity will be taken up remains unclear. Will new spaces for debate on nanotechnology open up, or will public discussion continue to be constrained by outdated policy frameworks and the assumptions of the technoscientific project?

In the preceding sections we have discussed this question in the light of DEEPEN project research. We have explored analysis of the language of those working in nanoscience, of European public responses to nanotechnology, of contemporary governance practices, and of the current emphasis on public deliberation and debate. We have made specific recommendations – the 'lessons' of our research – in each of these areas. To recap, these lessons are:

1. *Critically reflect on the standard repertoires of nanoscience and industry*
2. *Understand the complexity of public 'attitudes'*
3. *Engage with enduring public narratives*
4. *Shift governance from reactive to integrative forms of innovation management*
5. *Move public debate on nanotechnology from 'conversation' to 'deliberation'*
6. *Be aware of the challenges of deliberation*
7. *Develop innovative methods for engagement*
8. *Move away from speculative debate*

These recommendations are nothing if not wide-ranging. They also, inevitably, make for uncomfortable reading for anyone involved in research and policy making on nanotechnology's social and ethical significance. They suggest that there are, in fact, no straightforward prescriptions, but that policymakers must engage in a balancing act between maintaining a public debate that is open enough for new issues to spontaneously emerge, but which is able simultaneously to make concrete decisions. Drawing on a

contemporaneous report from the European Commission MASIS (Monitoring Policy and Research Activities on Science in Society) Expert Group, we might describe this as dynamic governance. Such governance will respond to emergent issues, opening up the policy process to continuing experimentation and encouraging public debate on nanotechnology's role in society.

Even more fundamentally, this set of recommendations reflects what must be seen as entrenched failings in the current policy and governance environment of nanotechnology. Those within nanoscience and industry rely on standardised repertoires which may no longer be relevant to the messy world of 'mode 2' science. Public narratives of technoscientific failure are subsumed by banal calculations of 'risks vs. benefits'. Technological governance promotes 'responsible development' but fails to expand on what this means in practice. And public engagement processes limit public debate through flawed methods and misleading foci. It is these limitations that give us the sense that, if responsible development is to succeed in opening up debate on nanotechnology, its nature needs to be substantially rethought.

The eight lessons start to point to how this can be done. By engaging with these challenges we suggest that the existing poverty of debate can be turned into an opportunity; that, if new spaces for debate and deliberation open up (around Codes of Conduct, for example), and if they can be used to enable reflection on the very terms of the debate of which they are part, then nanotechnology may indeed become a more open, considered, and resilient technoscience. On this note we offer a final two lessons from the DEEPEN project, which draw together core challenges faced by those involved in nanotechnology policy making.

Lesson nine: Return 'ethical concerns' to the sphere of politics

'Ethics' has become a kind of lingua franca for everyone who engages with nanotechnologies. All – nanoscientists, publics, industrialists – agree that it is important, and that it should be a consideration in nanotechnological development. Promoters of nanotechnology confidently expect that 'this time we can get it right'; that nanotechnology can be 'safe by design'. The technology's development has been accompanied by a raft of initiatives to stimulate the formulation of ethical concerns – work which draws on 'ELSA' funding and tends to be delegated to committees of self-proclaimed experts. But work with lay publics has indicated a rather different sense of 'ethics'. For these groups, the promises of emerging realities of nanotechnology intensify ambivalence about technological change. In the context of such anxieties and of the dilemmas of contemporary technological life, much 'ELSA' work to a large extent misses the point. It operates under assumptions that fail to grasp the meat of the matter.

In particular, if the growing field of 'nanoethics' is to be of use in promoting new ways of thinking about responsible development, it cannot continue to operate in the currently predominant manner of generating and cataloguing concerns regarding potential impacts and applications of nanotechnology. Instead, a new kind of ethical thinking is needed. This is not only because the ethical repertoires used in the current discourse on responsible development are too narrow, framing the problems only in terms of risks and benefits, but also because public engagement has shown the importance of taking into

consideration past experiences and standard repertoires that are brought even to novel situations. This opening up of ethics, in which the terms of debate on ‘ethical issues’ are returned to the political arena, is a significant task. We start to consider these questions in more detail in Part 2 of this report, where we explore the implications of DEEPEN project findings for the emerging discipline of nanoethics.

Lesson ten: Open up the politics of responsible development

Discussion of responsible development of nanotechnology represents a moment of opportunity. On the one hand ‘responsible development’, and its embodiment in a range of contemporary governance initiatives, might be taken up in a way that opens up the development of nanotechnology to public and democratic debate and deliberation. On the other hand, notions of responsible development could be used strategically to close down debate and to ensure the perpetuation of technocratic modes of decision making.

It is necessary, then, to attend to what might be termed the ‘politics of responsible development’. Accepting that scientific and technical innovation must be infused with the values of precaution, sustainability, and accountability necessarily introduces political judgement and the necessity of widening the range of voices that determine the meaning of these values. Though current efforts at embedding notions of responsible development in research and commercial practice are to be commended, such initiatives have the potential to close down discussion by directing attention away from the taken-for-granted notions that constitute it. Indeed, we have found that contemporary debates are informed by a persistent and unexamined assumption that the meaning of ‘responsible development’ is shared collectively.

This assumption must be revisited in an effort to deepen our conceptions of responsible development. Further, it must be ensured that the current effort to embed the values of responsibility in contemporary research practice operates as a site for asking important questions: Who is this technology for? Who will it benefit? Who is looking after the long term? Who will be responsible if things go wrong?

Throughout this report we have offered two implicit responses to this challenge. Firstly, we have used metaphors of space, site and landscape to question whether current initiatives and proposals aimed at the ‘responsible development of nanotechnology’ will effect a democratic and deliberative transformation of the development of nanotechnology. Contemporary modes of democratic and deliberative politics are often said to be modelled on the ideals of the Athenian agora, which operated as both a physical place and a democratic ideal as the meeting place of a free citizenry. Indeed, it is classically assumed that political decision making is legitimatised by unhindered participation of citizens in such decisions. However, such ideals need to be qualified. In a recent paper, Sally Davenport and Shirley Leitch⁵ critically examine the ways in which classical notions of the agora have been borrowed in modern conceptions such that the agora has ‘been equated with discussions in public of major political

⁵ Davenport, S. and Leitch, S. 2005: Agoras, ancient and modern, and a framework for science–society debate. *Science and Public Policy* 32(2): 137-53.

and social issues'. Through a careful analysis they distinguish two separate spaces – the agora which served as a 'space for debate amongst citizens ... as a prelude to the decision-making processes that occurred in the related but separate Ekklesia'. There is an important lesson here: spaces for debate and deliberation and spaces of decision-making do not necessarily map onto one another. In tackling the challenges posed by the responsible development of nanotechnology, governance initiatives must foster debate and dialogue rather than simply new mechanisms for technocratic decision making. One might therefore conceptualise the challenges posed by nanotechnology as a 'regime of collective experimentation' – in which 'technological promises can – and should – be incorporated, but they should help, not lead'.⁶ A renewed capacity for European democracies to confront complex technoscientific issues is needed so that technoscientific developments are informed by democratic values and oversight.

The second element of our response has been to consider the implications of democratising the responsible development of nanotechnology. What do we need to do, and what ethical, cultural, and political issues require deliberation, if we accept the necessity of opening up nanotechnological innovation in this way? Here we have resisted giving easy prescriptions on the results of such democratisation. However we have offered some suggestions and recommendations.

We have, in particular, suggested that European science and technology policy needs to engage more thoroughly with the gravity of issues posed by nanotechnology for European publics. We have used a narrative approach to demonstrate that public concerns about nanotechnology do not simply concern the relative 'risks' or 'benefits' of particular nanotechnologies. Rather these narratives operate as storylines that enable lay publics to understand the cultural meaning of developments in nanotechnology. The results of public opinion surveys and public engagement projects have often been dismissed as not offering 'new insights' – as if in order to justify attention public concerns need to be 'nano-specific'. We have taken the opposite approach, by suggesting that developments in nanotechnology make salient a range of very old concerns. Indeed such storylines have the capacity to determine the ways in which European publics will engage with nanotechnology in years to come. We need therefore to grasp the seriousness of the issues at hand and to ensure that, through democratic input, European policy making responds to them.

⁶ Felt, U. and Wynne, B. 2007: *Science and Governance: Taking European Knowledge Society Seriously*. Report of the Expert Group on Science and Governance to the Science, Economy and Society Directorate, Directorate-General for Research, Brussels: European Commission

A final reflection:

Even win-win situations come at a cost

The rhetoric of nanotechnology is seductive. Who wouldn't want a technology that is 'safe by design', that can deliver clean water to billions, or enable consumption without negative effects on ourselves or our environment? But such visions tend to make opaque some important elements of nanotechnological development – such as the visions of nature and life embedded in these technologies, or their implicit conceptions of the social role of technologies.

We all hope for positive economic, ecological and social outcomes from nanotechnology. But the task for the moment is to find a way to balance the optimistic belief that we have a chance to make things right through technological development with the critical capacity that suggests that there can never be a pure win-win situation. Our past experience of technology must indicate that as well as benefits there have also been problems and negative impacts – this is, after all, a key theme that has emerged from research on public attitudes to technology of all kinds. To believe that nanotechnology will be unique in changing the world in unambiguously positive ways is to ignore that technologies are in a relationship with the political, social and economic context in which they are developed. They are shaped by, and will shape, these relationships. An awareness of this means that responsible development, and discussion of responsibility more generally, must be tied to a deeper and richer debate in which all actors – policymakers, scientists, members of the lay public, social scientists – reconfigure the terms of discussion and their own roles in it.

We therefore need to develop a healthy scepticism about the rhetoric of the win-win situation characteristic of much discourse on nanotechnology – including, and perhaps especially, those incorporating references to sustainability and responsibility. However seductive the vision of untrammelled technological development with no negative consequences is, thinking in these terms is hindering, not helping, debate on nanotechnology.

Part 2

Lessons for nanoethics

Executive Summary

- European publics, including those who are actively involved in the development of nanotechnology, rely on a repertoire of stories and themes that are not informed by the specifics of nanotechnology but by past experience with emerging technologies and societal innovation. They are less concerned about nanoparticles endangering their personal well-being than they are about the ways in which European societies might head down a wrong path.
- These findings about European publics are very important for the governance of nanotechnologies (see DEEPEN's *Lessons for Public Policy*). They will not deter toxicologists, who must still seek to understand how nanoparticles might endanger personal well-being. And they must not deter those who still need to understand the ethical questions that arise with the development of nanotechnologies. In both cases, more research is needed.
- At least six of the themes that have not yet received sufficient attention emerge only once one appreciates the problematic assumptions upon which the standard repertoire is based.
 1. In light of boundless promises of technical possibilities that await to be realized, how can these be balanced by an understanding also of long-term *limits of understanding and of technical control*?
 2. In addition to risk/benefit analysis and considerations of opportunities and costs, what is the *ambivalence of hope* for a nanotechnologically improved world and technical solutions to global problems?
 3. What assumptions inform pervasive ambitions to nanotechnologically reshape or design the material and human world, what is the logic, what the promise, and what are the limits of this *metaphysical program of design*?
 4. What are the sources, the grounds of legitimacy, and the operations of *power* in the development of nanotechnologies?
 5. As a precondition for addressing questions of global, social, and environmental justice, how can various nano-divides, the *winners and losers* of nanotechnological development be brought to light?
 6. What is the current *division of moral labour* and how might it be renegotiated through codes of conduct and other instruments of responsible innovation?
- If one wants more than sophisticated opinion-research but a real appreciation of how nanotechnologies reflect and advance a changing world and changing values, one needs to engage

in serious research about these aspects of nanotechnological development – here, ethical questioning meets up with cultural, historical, and philosophical studies.

1

Introduction

The overall aim of the DEEPEN project was to deepen ethical understanding of issues related to emerging nanotechnologies through an interdisciplinary approach utilising insights from philosophy, ethics, and the social sciences. With regards to this goal of understanding ethical issues more deeply, what was accomplished by the project?

The following report summarises what has been achieved and indicates what further research is required. The two parts of the report highlight that DEEPEN produced original insights in two profoundly different but complementary dimensions. Both share as their point of departure that ethics is part of the nanotechnology phenomenon. Even as disagreements persist regarding the precise scope and definition of ‘nanotechnology’, this much is for sure: Ethics has become a kind of *lingua franca* for everyone who engages with nanotechnologies. When many different stakeholders come together to talk about promises and expectations, policy and funding priorities, opportunities and risks, regulation and voluntary codes, hopes and fears, foresight and governance of nanotechnologies, their shared language revolves around public concerns, ethical issues, and common values like safety, well-being, transparency, accountability, and trust. Here, ‘ethical’ is just another word for what is valued or found good. One might say that ethics provides the platform or stage on which policy makers, consumer advocates, scientists, industry representatives, environmentalists come together. What is happening on that stage? It is here that the DEEPEN-project offers two complementary perspectives:

- On the one hand, we see the re-enactment of a classic morality play where deeply entrenched experiences and concerns come to the fore as nanotechnology intensifies our ambivalence about technological progress in general. These powerful concerns tend to be overlooked by those who focus on the novelty and specificity of ‘nanoethics’. They have been brought to light by the DEEPEN partners in Coimbra, Durham, and Twente who engaged in empirical work and elicited concerns from lay publics, from scientists and industry representatives. Section 2 will briefly summarize some of these findings.
- On the other hand, we see a contemporary problem-play full of uncertainty and indecision. Those who are re-enacting a classic morality play have to wonder whether it still speaks to the world we live in today. Where one does not even know for sure whether old assumptions can be

carried forward to confront the challenges of nanotechnology, research is needed to elucidate our current technological condition. Section 3 will sketch an agenda for the required research on ethical and political dimensions of nanotechnologies.

2

Analysis: Nanoethics in the real world

The Woodrow Wilson Center recently issued a statement on Nanotechnology Oversight which sets the goal for responsible development of nanotechnology in a fairy-tale universe:

Scientists have given and will continue to give us vast marvels, capable of producing technologies of great power. Each of these marvels, including nanotechnology, comes in a treasure chest of riches and a Pandora's box of evils. The challenge of the new century [...] is to use the treasure while keeping shut the lid on the Pandora's box. It is a daunting challenge, but one that can be met.⁷

This is a fair description of what stakeholders aspire to on that shared platform of ethics: Responsible development of nanotechnology consists in the effort to separate good from evil, riches from curses. And among those who are asked to engage with nanotechnologies, including European publics, some are more confident than others that this mythical, heroic, somewhat simple-minded feat can be accomplished. Promoters and enactors of nanotechnology join together with the expectation that 'this time we can get it right', that nanotechnology can be 'safe by design' and may thus prove to be the safest technology yet, that the benefits of nanotechnology are many and its risks manageable. Where DEEPEN has engaged lay publics in Portugal and the UK, it encountered more cautious attitudes that are informed by historical experience with technical and social change, with promises of liberation that created new dependencies, with technological benefits and risks that never seem to be quite evenly distributed. The analysis of these attitudes by Sarah Davies and Phil Macnaghten shows that the promises of emerging realities of nanotechnology intensify ambivalence about technological change: five classical themes reappear in nanotechnological guise.

1. The ancient ambivalence of desire is expressed by the theme 'be careful what you wish for' – in face of the seductive promise of nanotechnologies, it expresses the moral concern that getting exactly what we want may not be good for us in the end. For example, if we were to find a nanotechnological fix for the problem of global warming, might this not heighten our dependency on technology and patterns of consumption that maintain us on a course that remains unsustainable in the long run?

⁷ Davies, JC. 2008. Nanotechnology Oversight: An Agenda for the New Administration. Washington DC: Project on Emerging Nanotechnologies.

2. The fear of evil is conjured by the theme 'Pandora's Box' – in face of the temptation to imagine perfect technical control of molecules and societal problems alike, people warn of unsettling uncertainties, dangers, and even catastrophe. For example, the uncertainties regarding toxicological properties may lead to another asbestos-story or, worse yet, to catastrophically cascading environmental effects.
3. The notion of the sacred is invoked by the theme 'messing with nature' – in face of the possibility of re-designing nature according to our needs, it expresses the moral concern that one should not without due consideration disrupt an established order of the world with its sacred divisions, for example, of the living and the non-living, of organism and artefact.
4. The modern condition of alienation is given voice in the theme 'kept in the dark' – even in face of measures to assure inclusiveness and transparency, people still feel powerless, unaware of decision-making and the drivers of nanotechnological development. In particular, the very fact that it is difficult to see a dark side of nanotechnology suggests that there is a story that is not being told.
5. The critique of exploitation reappears in the theme 'the rich get richer' – in face of the pervasive notion that nanotechnology will open new worlds of consumption and even an age of global abundance, people are concerned about the realities of injustice and inequality that characterize our culture of commerce and consumption, globally and locally.

Close engagement by Clare Shelley-Egan and Arie Rip with industry and scientific stakeholders brings further themes to light. In particular, the following theme stands out:

6. The uncertainties of agency and accountability emerge in the process of 'responsible development' – in face of an open invitation to all societal actors that they can share in the responsibility for the development of nanotechnology, these actors begin to wonder what their scope of influence and agency really is: What does it mean to take responsibility when there are no clear assignments of accountability, when there is no clarity in decision-making processes, and a silent perpetuation of a division of moral labour between enactors of nanotechnology and those who provide ethical reflection?.

The first three and perhaps all six themes suggest that engagement with ethical dimensions of nanotechnology resembles a classic morality play. Accordingly, nanoethics is not at the present time another version of applied ethics along the lines of medical ethics, environmental ethics, neuro-ethics, bio-ethics, etc. As opposed to nanoethics, these established fields of applied ethics encounter conflictual situations and bring ethical principles to bear on them, determining, for example, whether some action is permissible or not. In contrast and as in a morality play, nanoethics is rather a way of casting our hopes and aspirations within the story-line of an accomplished life and a flourishing commonwealth. And as in a morality play, the moral point of view is rehearsed, reiterated, and reaffirmed in a somewhat ritualistic fashion by variation and repetition. By performing this play again and again, one becomes

habituated to a certain way of appreciating and evaluating the ambivalence towards nanotechnology and its promise of intensifying the role of technology in our daily lives and social world.

With these six storylines a narrative repertoire becomes visible which links current experience and classical themes. This finding resonates with Arie Rip and Tsjalling Swierstra's notion of NEST-ethics and with a criticism of extant nano-ethics that motivated the DEEPEN project in the first place. Rip and Swierstra identify certain patterns that reappear in the discussions of 'new and emerging science and technology (NEST)', for example the pattern of claiming radical novelty and insisting at the same time that the novel technologies are only more of the same. In their account of nanoethics, one shouldn't really expect anything but the reappearance of such familiar rituals – they allow publics to come to terms with emerging technologies, and when these rituals are performed well this facilitates the sound integration of nanotechnologies in society.

The claim that nanoethical discourse is patterned like a kind of ritual and not unlike the morality play described above is confirmed by the fact that nanoethical considerations appear to revolve around a rather small set of standard questions. These concern invasion and protection or privacy, safety from physical harm, the sacredness of 'life' and 'human nature', the threshold between maintaining and altering nature. The DEEPEN project began by asking whether this set of questions could possibly be adequate to nanotechnologies – and it is evident from the identification of the six themes that it conceives nanoethics far too narrowly.

What is the significance of the DEEPEN analysis so far?

First, public concerns deserve to be taken seriously even where they do not follow the lead of a science-based, "rational" identification of risk. They are not at all naïve but informed by historical experience with technological, economic, and social developments, they regard a changing world through the lens of deeply ingrained values that have withstood so far the test of time.

Second, it highlights that nanoethics is more than what is captured by checklists of rote concerns and that one need not exclusively hunt for novel and specific ethical issues – the promises of nanotechnology resonate with pervasive ethical and social sensibilities.

Third, nanotechnologies do not necessarily introduce radically discontinuous challenges but intensify ongoing trends, for example, by insinuating themselves ever more subtly and imperceptibly into our daily lives, by describing more and more social and biological processes in mechanistic and technological ways, by pushing ever further the boundless promise that to every problem there is a technological solution, or by fostering ever more powerfully the hope that if only we manage to survive long enough on this planet we might just be able to continue a nano-enabled life-style of consumption and waste forever.

Fourth, the analysis confirms what many believe, namely that underneath all the hype, nanotechnology is business as usual. Accordingly, the *lingua franca* of ethics serves the purpose mainly of bringing stakeholders together rather than that of discovering grave ethical concerns that might stand in the way

of the further development of nanotechnologies. As such, the DEEPEN-findings so far might be very useful for purposes of communicating nanotechnologies and of addressing citizens' concerns through thoughtful and transparent governance.

Fifth, the analysis suggests that nanoethics does not concern the identification, evaluation, and adjudication of conflicts of value. Indeed, as a *lingua franca* that attunes stakeholders to one another, 'ethics' only appears to assume a central position but is actually relegated to the background: It is part of the environment in which nanotechnology might flourish, it accompanies scientific and technological developments, and takes place entirely in a conversational mode as concerns are expressed in open-ended ways but no decisions need to be taken, no judgements need to be made, no conclusions need to be reached.

Raising the Stakes

So far, the DEEPEN-analysis has told only part of the story about nanoethics, though an important part it is.

If nanotechnologies intensify ongoing trends and thereby heighten ambivalence about technical and social developments, there ought to be a way to go beyond the identification and analysis of the six storylines or themes. It is quite possible, after all, that these trends have created the mess that nanotechnologies are supposed to clean up – paradoxically, by continuing them? So, how does one go beyond the identification of storylines and beyond a merely conversational mode of open-ended sharing of ethical concerns? And in particular, what role does philosophical reflection and critique have to play in this, what role social and political theory, what role the objectivity and normativity of ethical inquiry?

An example may serve to illustrate how the nanotechnological intensification of existing trends presents a larger challenge. For several decades, there have been many voices critical of the so-called 'medicalisation' of society. They refer to a general tendency to treat problems as if they were a disease or an affliction that has to be remedied. Behavioural differences, ageing processes, social and cultural phenomena are considered medical problems that require scientific and technological remediation. This is most notable in respect to newly defined conditions like attention deficit disorder, post-traumatic stress syndrome, or obesity. As in the therapeutic practice of modern medicine, social and psychological health and disease are viewed technologically in terms of perfect or defective functioning. Also, an increasingly consumerist orientation in health care contributes to an expansion of diagnostic categories. It is easy to see that medical nanotechnology will continue these trends as it allows for improved monitoring and measuring and as it thus provides more indicators of departure from perfect functioning. The medicalisation of society may well move into the hands of countless individual patients who nervously monitor and treat themselves for deviations from normalcy or optimality. – So, what follows from this? If nanotechnologies are seen to continue ongoing trends that have been observed for a long time, the challenge would be to look for the motives and ideas that support these trends, and so to ask what happens if nanotechnologies push them even further and perhaps to their limit.

Along similar lines, one can identify a trend towards 'ethicalisation' of technology and society. When issues of technological development are translated into questions of ethics, they appear to open up to a broad audience, allowing a multitude of considerations to be brought in. At the same time, however, they tend to lose their political character. Instead of provoking explicit negotiations among elected representatives, they move into ill-defined fora such as ethics committees, expert commissions, citizen panels. The findings of these bodies are open to interpretation. It remains unclear whether and how they are taken up by decision-makers especially when these have pre-conceived notions of what is a relevant ethical issue in the first place. Rather than simply play into and continue this trend, nanoethics needs to delineate and sharpen issues in such a way that they can return to the political arena.

Accordingly, what is required is a conception of nanoethics that does not operate in the service of ethicalisation and that is not oriented in a speculative fashion towards an indefinite future in which imagined technical applications might see the light of day. Instead of gazing only at what might come out of nanotechnological research, nanoethics needs to consider and evaluate what, concretely, goes into nanotechnological development – that is, it needs to look at funding priorities, research programs, technological visions, long-term trends like medicalisation or ethicalisation, old and new hopes, abstract and concrete fears.

However, to look at the assumptions that inform the development of nanotechnologies is not an easy task and requires that we go well beyond the themes that were identified so far. The various stories about desire, evil, and the sacred, the stories of alienation, exploitation, agency and responsibility are today's stories primarily in the sense that they are part of the repertoire of stories and themes that we are used to draw upon. However, we draw on this repertoire also when we confront ideas and technical processes that we do not comprehend as of yet, let alone genuinely understand. Ethical inquiry takes us to the point where the standard repertoire begins to fail us and where new questions need to be asked.

Jean-Pierre Dupuy shows, for example, that concerns about 'messing with nature' and the transgression of sacred boundaries between the living and the non-living fail to come to terms with nanotechnological ambitions. These consist primarily in a different way of thinking about technology: So far, engineering has always been based on the technician's ability to control nature, but now bottom-up engineering seeks to harness processes of self-organization that are autonomous, out of the immediate control of the engineer, and yet thought to advance design goals. This unfamiliar conception of engineering is reflected neither in the standard set of questions nor in the classical story-lines that are mobilized in discussions of nanotechnology. But it is this conception of engineering, for example, that requires close scrutiny and ethical inquiry. And if this conception of engineering proves to be a conceit that cannot be reconciled with our expectations of technology and if it eludes standard procedures for ascertaining the safety and reliability of its functioning, this would be a sign that it is time to leave the conversational mode and arrive at a resolution, one that should not exclude even a moratorium on certain kinds of nanoresearch.

If our present nanoethical narratives can be traced back to classic morality plays, this might also signal the helplessness of those who don't know better but to bring such mythical stories to bear on a new

kind of socio-technical complexity that challenges us to expand our ethical questioning. We are in a situation in which the actors do the best they can even as they do not know their way about.

The DEEPEN analysis of nanoethics in the real world has therefore shown not only what concerns there are and how these differ from the standard set of ethical concerns regarding emerging technologies. It has also shown that it is insufficient to rest content with ethics as a *lingua franca* for an open-ended exchange about issues and concerns. If one begins to take these issues and concerns seriously, the stakes will suddenly appear high and a genuinely deliberative process needs to begin, one that seeks a negotiated closure of debates on contested questions. With its *Lessons for Public Policy* the DEEPEN project underscores the need to answer the demands that have been created by promises of inclusivity and transparency with regard to nanotechnology in society. For example, it calls for a move from conversational to more deliberative modes of engagement, and calls for new, more explicit and reflective ways of organizing responsibilities.

Signs of this impatience with ethics in a merely conversational mode have begun appearing in various places, particularly within the European Union:

- The European Commission proposed a contested *Code of Conduct for Responsible Nanoscience and Nanotechnologies Research* which questions the accepted division of moral labour and suggests a renegotiation of the contract between science and society in particular as it concerns assignments of responsibility.
- There has been profound unrest within the regulatory arena. The difficulties of fitting nanotechnologies in general, and nanoparticles in particular into classical risk assessment schemes have forced stakeholders to develop a new regime of vigilance that includes observatories, codes of conduct, stakeholder platforms, ELSA research and thus a host of alternative institutions and forms of governance.
- In response to such moves towards soft law and voluntary measures, the European Parliament is attempting to reassert regulatory authority with rather restrictive legislation on NanoFood.

3

New perspectives for nanoethics

What insights can ethical inquiry produce in order to make decisive questions of value visible and negotiable? And in order to go beyond the conversational mode, why engage in ethical inquiry at all? As opposed to the open-ended collection of ethical concerns, the proposed perspectives for research provide a foundation in knowledge for foresight, public debate, and anticipatory governance – they provoke deliberative processes. Here, we indicate six perspectives for research that go beyond the familiar repertoire of storylines and themes identified above. In all these cases we find that behind the re-enactment of classic themes and concerns, contemporary problems await analysis so that informed decisions about nanotechnology can be made.

1. The ancient ambivalence of desire is expressed by the theme ‘be careful what you wish for’ – in face of the seductive promise of nanotechnologies, it expresses the moral concern that getting exactly what we want may not be good for us in the end.

Nanotechnology is said to become one of the defining technologies of the 21st century. Despite the fact that there are few applications of nanotechnology that have actually made it to the market place as yet, there are great expectations of revolutionary changes in the entire mode of production. Were it not for these expectations, no one would warn that we should be careful what we wish for – as if wishful thinking might produce desirable and undesirable realities. In other words, the very concern that we should be careful what we wish for, is based on an implicit faith in the boundless possibilities of nanotechnological wish-fulfilment.

This implicit faith takes various forms. It appears in the assumption that there are so many potential benefits of nanotechnology that everyone can be a beneficiary – and if everyone benefits, no one needs to lose. Thus, the agenda of ‘responsible development’ is motivated by a quest for win-win situations – not a bad thing, surely, unless one starts believing that these are literally possible and therefore that one need not identify the losers and those that carry a disproportionate burden of risk. This implicit faith also takes the form of believing that every societal or environmental or medical problem can be recast as a technical problem with a nanotechnological solution.

The idea of boundless technical possibility is not without precedent, of course. Previous generations learned to disbelieve it in regard to electrification, behavioural engineering, and nuclear power. It is all the more striking, therefore, that with nanotechnology it reappears so forcefully. As a corrective to such

hubris, what is required is sustained reflection on limits of technical control, be it control of molecular structures at the nanoscale or the control of societal responses to nanotechnology. Such a reflection would mitigate an exaggerated faith in our ability to shape the world atom by atom, or in our ability to shape the development of nanotechnology and make it safe by design.

This research agenda on *boundless desire and the limits of control* would include a historical component to allow for a comparison of our current faith in what technology can do to earlier phases of techno-optimism. The reflections on the limits of control enables a critical evaluation of the implicit desire to 'live long enough to live forever', that is, to use technology primarily as a way to prop up with the hope to extend indefinitely current patterns of production and consumption. More importantly and immediately, perhaps, reflections on the limits of nanotechnology may have a sobering effect on a discourse characterized by hype and the unrealistic expectations it generates. By holding promoters of nanotechnology accountable for their claims, it makes a contribution to the *ethics of promising* and institutes 'responsible representation' of nanotechnologies as a prerequisite for responsible development. Finally, it has been said that the difference between technology and magic is that technology struggles constantly against material constraints, complexities, and the resistance of nature to fit our technical ideas, whereas magicians use their tools to conjure a world that conforms to our wishes. A focus on limits of control will reassert the difference between technology and magic and will do so by letting us appreciate the difficulties of the task.

2. The fear of evil is conjured by the theme 'Pandora's Box' – in face of the temptation to imagine perfect technical control of molecules and societal problems alike, people warn of unsettling uncertainties, dangers, and even catastrophe.

As Jean-Pierre Dupuy points out, the story of Pandora pertains to the flipside of boundless desire. It is intertwined with the question of hope. By saying 'yes' to hope, by saying 'yes' to technological innovation and its promise to solve global problems, by opening Pandora's box one might be joining rather thoughtlessly a march forward that continues dangerous trends where perhaps one should stop, reflect, prioritize.

Only on the face of it, then, the story of Pandora's Box is one of fear of the physical or social dangers that are inside the box. Instead, one needs to fear primarily that the box will be opened because it contains hope, especially the hope that technology will solve the most pressing problems of contemporary societies. But given that hope is included in the box along with countless dangers, there is cause to wonder and worry when governments and societies are mostly hoping for better technologies in the face of global warming, resource depletion, economic crises, problems of an ageing society here, problems of starvation and genocide there.

In the case of nanotechnology, one of its most striking features is that hardly anyone says 'no' to it. Famously, Pandora is a figure of seduction and her 'lure of the yes' draws promoters and sceptics alike to accept the invitation that they should join a broadly defined, unobjectionable process that goes by the name 'responsible development of nanotechnology'. It gives expression to the hope that all will be

well, if everyone joins in with the belief that nanotechnologies can and will be developed responsibly. In this respect, nanotechnology mirrors a more general trend. The environmental movement, for example, began by reminding us that we need to accommodate ourselves to limits of growth within a finite world and scarce resources. Now, many environmentalists argue that they will only be heard if they say 'yes' to technological innovation and green technologies. The verdict is out on which kind of environmentalist will prove to be right.

In addition to an economic, scientific, or technological benefit/risk analysis, what is needed is therefore a ***philosophical hope/risk analysis***. To the stories about public worries and concerns about nanotechnology one might now go beyond the DEEPEN-project to add the stories of hope and of the ambivalence, even dangers of hope. By analyzing these stories, an expanded notion of 'risk' will come to the fore – a risk to self and community as hopes are disappointed or basic tenets betrayed.

3. The notion of the sacred is invoked by the theme 'messing with nature' – in face of the possibility of re-designing nature according to our needs, it expresses the moral concern that one should not frivolously disrupt an established order of the world with its sacred divisions.

For decades, perhaps centuries philosophers, scientists, and enthusiasts of all kinds have taken a perverse pleasure in contemplating the transgressive power of science and technology to undermine the sacred order of the world. This mixture of self-flattery and self-reproach persists today and many nanoethical discussions tend towards attempts to fuse living and non-living matter, to blur the distinction between mind and machine, artefact and organism, between that which is constructed and that which grows. But here, in particular, one might be asking whether lay publics and academic philosophers alike are barking up the wrong tree.

As Martin Heidegger, Hannah Arendt, and Jean-Pierre Dupuy have pointed out, the order of nature ceased being a sacred order a very long time ago. Indeed, we become blind to a striking, rather novel aspect of nanotechnology if we see it merely as a next step in a long history of scientists challenging fundamental categories, creating monstrous hybrids, or 'playing God'. What is that novelty?

In general, nanotechnologists do not claim a mastery of nature, do not play God, destroy one and create another world. Instead, they assimilate nature to a very mundane human order by looking at nature as if it were just another engineer who has designed a system with certain properties and traits. And in the eyes of nano-engineers, nature is not necessarily a very good engineer – it had to rely on evolution and could not benefit from design. So, yes there are a few technical tricks that we can learn from nature, but in terms of efficiency nature leaves much to be desired.

Nanotechnologies can therefore be seen as the triumph of the paradigm of design. It advances the project of designing material and human nature all the way up to societies – 'shaping the world atom by atom'. Where many ethicists worry primarily about the ambition to design human nature, it is first of all the notion of the infinite plasticity and potentiality of all things that calls for ethical inquiry – inquiry into ***the logic, hubris, and metaphysical program of design***.

4. The modern condition of alienation is given voice in the theme 'kept in the dark' – even in face of measures to assure inclusiveness and transparency, people still feel powerless.

When people worry that they are being kept in the dark, they raise the question of power. While expressing their own feeling of powerlessness they also believe that there is a power that more or less deliberately misleads them. But where might we locate this power in respect to the development of nanotechnologies, and where do the asymmetries of the powerless and the powerful appear? Here, the experience of European citizens with regard to nanotechnologies appears to be very different compared, for example, to the experience of South American farmers with regard to the agricultural technologies that are introduced by global corporations. This difference needs to be understood by way of a careful ***analysis of power*** in its various forms.

When European citizens feel that they are kept in the dark, one cannot straightforwardly trace this back to a sinister conspiracy of corporations or political interests. And if there are techniques of exclusion and inclusion at work, it is not apparent how these operate. After all, people express their powerlessness in an environment that appears to be all about inclusiveness in an effort to make their concerns heard. But perhaps one can trace this feeling to a general sense of unease that results from the very fact that power is nowhere visible. As in a hall of mirrors, power is everywhere and nowhere, and as in a hall of mirrors, it might work by drawing all of us into a dynamic of consumption and innovation as ends in themselves. This immersive or participatory conception of power might have to be distinguished from those that are based on violence or interest or discipline or control. What needs to be understood is that in our European societies, there is nearly unanimous support of nanotechnologies but that there is a lingering unease even among those who join in.

5. The critique of exploitation resonates in the theme 'the rich get richer' – in face of the pervasive notion that nanotechnology will open new worlds of consumption and even an age of global abundance, people are concerned about the realities of injustice and inequality.

On first sight, the notion that the rich always get richer expresses an elementary historical experience, namely that the benefits of even the most visionary new technologies are distributed unevenly. Some get rich and others remain totally deprived and between these extremes are ordinary citizens who get a share of the benefits if they are willing to pay the price. However, this commonplace takes on a special significance in light of promises that nanotechnologies will produce global abundance, that with their help the United Nations' millennium goals will be met, that it can be safe by design and therefore cause no harm, that it can draw everyone together so that everyone will be a beneficiary and no one a loser.

This lofty rhetoric is inspired by ideas of justice, if only in the sense that it envisions an equality of unparalleled wealth. But all the while, this rhetoric may harbour profound injustice, if only because it does not take the time and effort to identify the cost that is associated with an investment in the development of nanotechnologies. As Dupuy points out, it is a dream of reason that celebrates the power not only to control molecules but also to guarantee the splendid future of our societies, and this dream of reason has no patience with contingencies and externalities, with complexity and sheer bad

luck – it has no patience, in other words, with human suffering. And this blindness to suffering is even more pronounced when it comes to animal suffering: some argue that nanotechnologically enabled analytic techniques will put an end to animal testing, whilst at least in the short and medium term they appear to increase. Such asymmetries of rhetoric and perception run ahead of the material exploitation that may follow without careful attention to losers and potentials for harm, and without due consideration of *questions of justice*.

6. The uncertainties of agency and accountability emerge in the process of ‘responsible development’ – in face of an open invitation to all societal actors that that they can share in the responsibility for the development of nanotechnology, these actors begin to wonder what their scope of influence and agency really is.

The DEEPEN project considered the stories that are being told by European citizens, scientists, business representatives, and policy makers. But why does one tell stories at all, especially regarding issues in the policy arena? Stories are a way to represent how the world works, how things came to be the way they are, who is to be praised and who to be blamed. However, one of the striking features of the nanotechnology-stories is that they fail to perform this role. They are strangely in limbo, suspended in thin air, unable to link nanotechnology to specific interests, social or economic drivers, or worldviews. Instead, they refer vaguely to a world in which ‘innovation’ appears to be an end in itself. They do not assign praise and blame.

This feature of the stories is unsettling and draws attention to the reasons why they fail to gain traction: Not only is the definition of nanotechnology all-encompassing, elusive, and diffuse, but so is the idea of innovation and so is the notion of responsibility when it is used too broadly. In the current context of responsible development of nanotechnology, everyone is invited to assume responsibility for the development of nanotechnology. At the same time, however, people in ‘positions of responsibility and power’ are transformed into the paradoxical figures of stakeholders without acknowledged stakes. Cast in the role of a stakeholder at a public forum on nanotechnologies, scientists and business representatives are supposed to act as individuals with opinions and concerns and not as advocates for powerful interests. The stakeholders who join together as individuals speak only for themselves – they assume responsibility through mere participation but they cannot be held responsible for it. In the meantime, the responsibility of decision makers and even the fact that decisions are being made disappears behind the veil of ‘responsible development’.

It is high time, then, to revisit the notions of ***agency, responsibility, accountability***, and thereby to render them more definite and meaningful. This is a task not just for philosophy but for new ways of organizing responsibilities. We observe, for example, numerous strategies by policy makers, publics, and industry to meaningfully differentiate good and bad firms, where ‘good firms’ distinguish themselves by assuming responsibility in credible ways. Might such a conception of responsible innovation or might such new institutions of public vigilance serve to distinguish in a similar fashion good and bad governance, good and bad research in nanotechnology?

4

Final observation

What the DEEPEN project has achieved and the research that needs to be done became visible only through a deliberate combination of approaches. On the one hand, DEEPEN conducted a kind of opinion research with advanced methods of public engagement and discourse analysis – such as are suitable to the EC-funded ‘coordinating and support actions’ which are concerned with the quality of communication between research, policy, and European publics. On the other hand, for purposes of analysis and understanding, this research was related to theoretical traditions and perspectives from philosophy, social science, and political theory. The preceding analysis demonstrates that it is one thing to elicit the ethical intuitions or standard repertoires of stakeholders, publics, or policy makers and quite another to identify the challenges posed by emerging nanotechnologies. As it turns out, the intuitions that are brought to the table by most stakeholders and concerned publics reflect assumptions about emerging technologies that are being challenged by the nanotechnological programs and visions. Where our intuitions begin to fail us as a guide in ethical and political matters, what is required first of all is improved understanding. We would be heading down the wrong path, therefore, if DEEPEN were to have been the last EC-funded *research* project in this area.

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This report is based on several internal documents that were produced as part of the DEEPEN research process. These are available on request (contact the project coordinator, Phil Macnaghten, on p.m.macnaghten@durham.ac.uk).

- *Review Statement: Philosophical Analysis*, 2007, Arianna Ferrari. This provides an extensive survey of past and current contributions to ethical reflection about nanotechnologies.
- *Diagnosis Report: Ethics in the Real World*, 2008, Arie Rip and Clare Shelley-Egan. Identifies some of the central themes that concern scientific and industry stakeholders.
- *Working Paper: Comparative Analysis of Lay Ethics in Two European Nations*, 2008, Durham and Coimbra project teams. This provides an analysis of conversations with citizens in the UK and Portugal from which the public narratives described in this document are derived.
- *Working Paper: Governance and Regulation of Nanotechnologies in Europe*, 2008, Arie Rip and Matthew Kearnes. Gives an analytical overview of the 'new governance landscape' of nanotechnology.
- *Contributing Report: Governance and Regulation of Nanotechnologies in Europe*, 2009, Matthew Kearnes and Arie Rip. Develops the analysis of the governance landscape, characterising the ways in which 'nanotechnology' and 'Europe' are constituted by it.
- *Contributing Report: Deliberative Fora Across Two European Nations*, 2009, Coimbra and Durham teams. This discusses the experimental deliberative fora run by DEEPEN researchers.
- *Contributing Report: Enhancing Ethical Reflexivity in the Real World*, 2009, Arie Rip and Clare Shelley-Egan. Builds on Deliverable 7 in analysing the opportunities for enhanced ethical reflection within nanoscience and industry.
- *The Narratology of Lay Ethics* (2009) is a commissioned paper by Paris and Stanford philosopher Jean-Pierre Dupuy that provides a critical assessment of the five lay narratives DEEPEN research has identified. The paper shows their linkage to the classical and modern themes of desire, evil, hope, alienation, and exploitation and probes their adequacy for dealing with the peculiar ambitions of nanotechnologies.

In addition, a number of journal articles and book chapters have been developed by members of the DEEPEN team drawing on DEEPEN research. These include:

- A special issue of the journal *NanoEthics*, focussing on DEEPEN analysis of ethics and narrative, is planned for early 2010 and will include work by Clare Shelley-Egan, Jean-Pierre Dupuy, Alfred Nordmann, Sarah Davies and Phil Macnaghten.
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Note on DEEPEN project participants

DEEPEN is a three-year (2006-2009) research project funded by the European Commission's Framework Programme 6.

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. It brings together academics from across Europe and across a number of disciplines.

The project is coordinated by the Institute for 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).

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