*Workshop on*
***Societal Aspects of Nanotechnology***
***9 November 2005, Barcelona***

Workshop Report No. 8

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**ECETOC WORKSHOP REPORT No. 8**



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## FOREWORD

In publishing this Workshop Report it is recognised that ECETOC is making a bold move outside of the domain in which it has earned a respected reputation, namely for publishing peer-reviewed science in the fields of toxicology and ecotoxicology. It was a difficult decision to enter the domain of the Social Scientist on such a complex topic. We concluded that in this pilot venture we should act as a bridge between the social scientists and the natural scientists. This approach had the support of the ECETOC Board of Administration and the ECETOC Scientific Committee. They recognised that societal aspects are playing an increasing role in the regulatory environment. It was decided to action this pilot in an ECETOC organised workshop co-sponsored by the Cefic LRI programme and assisted by their External Science Advisory Panel (ESAP).

It has been an enormous challenge to those who have been responsible for progressing this workshop report to publication. There has been extensive consultation to ensure a result which meets the ECETOC quality standards. However, it is fully recognised that the criteria against which such a report will be judged should be different and need to be related to the content addressed. It is sincerely hoped that this excursion by ECETOC into the subject of societal aspects impacting scientific issues is viewed positively and provides a unique contribution. This approach will be explored in future ECETOC activities since it is well understood that such perspectives and challenges will be an increasing part of our consideration.

Prof. G. Randall
Chairman Scientific Committee

Dr. M. Gribble
Secretary General

*Workshop on Societal Aspects of Nanotechnology*

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## 1. EXECUTIVE SUMMARY

Increasingly, public perception and acceptance are key factors in the introduction and development of new technologies. The question of acceptance is no longer simply a matter for potential users; the acceptance of technologies by society at large has become increasingly important. In general, the social, ethical-legal, economic, and political issues surrounding the introduction and development of new technologies are much more critical to successful innovation than they were 50 years ago (or even 25 years ago). It is an apparent paradox that the advent of a ‘knowledge economy’ has coincided in Europe with a crisis of public trust in science and technology. There are increasing demands for more accountability and regulation of the outcomes and impacts from such a science-based development. Part of this is explainable by the ongoing shift in power toward the citizen and consumer and increasingly toward non-governmental organisations and other ‘organisational citizens’ in what can be referred to as the ‘new politics’. The implications of these developments are apparent today. The successful and cost-optimising introduction and development of new technologies require informed consent from major stakeholders and the public.

Social sciences and humanities provide a number of concepts, models and empirical results which shed light on public acceptance, the ultimate success or failure and the cost profiles of the introduction of new technologies. As we have learned from the genetically modified foods issue, the choice for some stakeholders is not between different modes of deliberation and negotiation, but between these and antagonistic forms of social action. This should be of great concern to all those involved in the introduction and development of nanomaterials (e.g. business and banking interests, scientists and government policymakers).

This workshop followed a two-day workshop on ‘Testing Strategies to Establish the Safety of Nanomaterials’ (published as ECETOC Workshop Report No. 7). Participants at both events included 70 scientific and clinical experts from industry, academia, government agencies and one non-governmental organisation. The workshop was a mixture of lectures and plenary discussions, aimed at providing some overview of European social science capabilities in relation to research and to give advice on the societal context of technical innovation and development. A further aim was to identify and focus on several key societal factors that are likely to affect the future acceptance and commercialisation of nanomaterials.

A key challenge facing society in the broadest sense, and interestingly also the natural scientists themselves, is the definition of nanomaterials; just what are they and how do we imagine them if we cannot touch, feel or see them? There is a natural fear of the unknown or distrust and negative concern about likely impacts on health and environment. Under these circumstances commercial introduction of nano-technology and -materials is viewed as a large scale experiment in the public domain with a perceived high uncertainty regarding safety aspects. Among natural

scientists, the view prevails that current risk assessment methods, in principle, can also be applied to assess the risk arising from the use of nanotechnology, although they may have to be adapted to suit the specific characteristics of nanomaterials. But there is also a perception in parts of the public, that this may be inadequate. As a result the public, often through non-governmental organisations, are demanding to be informed and involved. Several of the known key social, including political, conditions of opposition to or rejection of prior technological innovations were compared with conditions of possible acceptance, or rejection, and legitimisation of nanotechnologies.

## 2. INTRODUCTORY REMARKS

**Professor Tom R. Burns**

We have listened for two days to toxicology and ecotoxicology experts and realise that much is unknown, in purely natural science and medical terms, about nanomaterials. Certainly, we will come to know more over the coming years. However, even with substantial testing, there will be unexpected and unintended consequences, some of them negative. That is, we will discover some of the problems of nano-development by ‘experimenting’ in a certain sense on ourselves. In this early state, many risks are unknown or incalculable. Hence, we speak of uncertainty more than risk. This relates to people’s perceptions and discourses about risk, which are substantial subjects of the social sciences.[1]

Many comments of the last two days have stressed the need to understand the public and the societal aspects of new technologies and technological development. These are matters which social scientists and scholars in the humanities address in their research. When new technologies and technology systems are created, new worlds are opened up but also new problems and many uncertainties. There are more questions raised than simply technical and economic ones, as we will hear from the presenters.

This part of the workshop is predicated on the idea that the social sciences and humanities have a useful role to play in providing insights and models of the public and their reactions; specifically of the reactions and movements that slow down or prevent certain technological developments. This is why you will find some of us stressing the importance of engaging the public, future ‘stakeholders’ who may not know now that they are, or will be, stakeholders. Increasingly, third parties are important, e.g. non-governmental organisations. Public perceptions depend on the position of the perceiver, as do scientific framings of ‘risk’. What is a risk for one may not be considered a risk by another. There is hardly absolute risk – unless there are absolute value judgements defining what hazards are; and there are intrinsic social dimensions to risks, as in the definition of what is at stake, in the constitution of technologies which embody hazards and in the conditions under which hazards and risks are controlled – or not. The public react to many new technological developments and to how they are promoted and handled as well as to some of their consequences. Nanotechnologies will be no exception.

Contemporary politics is changing, creating new conditions and challenges for technological innovation and developments. Non-governmental organisations have become ‘organisational citizens’ and are increasingly prominent and accepted as ‘stakeholders’. They are prepared to make use of the mass media and non-parliamentary pressure techniques, often with considerable

[1] In Appendix 2, Professor Wynne explains why this often unrecognised distinction between ‘risk’ and ‘uncertainties’ bears directly, and logically, on the issues of trust.

success. Scientists who find themselves questioned or attacked in such ‘new politics’ may not understand why this is happening to them. “Aren’t we doing what we are supposed to do? Aren’t we doing a good job?” There are multitudes of people who refuse to accept the authority of science and engineering, who are sceptical about scientific enterprises, their motives, their forms of institutional control and direction, and their impacts. In a democracy, these may question, vote and oppose; they may support organisations which resist or try to redirect many technological initiatives and developments. We have to recognise this fact as a legitimate social reality and deal with it as best we can.

Public trust is critical and ways to maintain and develop it must be centre stage. Social sciences have a key role to play through their understanding of the basis of trust and trust mechanisms. There is also extensive social science research on, and experience with, the barriers, directional factors and facilitators to innovation and development. Among key factors are risk perception, risk communication and risk management.

The lectures by leading scholars in the social sciences and humanities will shed light on these and related matters (see Appendix 2).

## 3. PLENARY DISCUSSION: FACING THE OPPORTUNITIES OF NANOTECHNOLOGIES

The discussion of social and ethical aspects of nanotechnology revolved around a number of key themes that emerged from the various talks and were elaborated through subsequent questions and plenary debate. These key themes are outlined below.

**Avoidance of major mistakes of the past**

One concern that underpinned the day's workshop was the need to avoid the difficulties associated with previous technological innovations, in particular, the recent controversy surrounding genetically modified organisms (GMOs). These controversies have demonstrated the power of the public to influence innovation research and resulting applications, and indicated the existence of a 'new kind of politics' and a decline in the 'authority of science' (according to one speaker). New research arenas such as nanotechnology are typified by all kinds of scientific uncertainty, with the prospect of unknowable outcomes and unintended consequences. This raises questions of risk acceptability, assessment and management, and in particular, about who is to be involved in carrying out these activities and to what extent the public should have a role. 'Society as laboratory', was the phrase that some speakers used to capture this idea. Such questions have even become important with regards to the funding of nanotechnology research, as evidenced by, for example, the importance placed on social considerations by the US National Science Foundation (NSF).

**Science and technology should not only be technically robust but socially robust**

Various speakers spoke of the need for science to be 'socially robust', i.e. essentially to speak to societal concerns. This sparked some debate about what this meant for science *per se* and how we should judge it. An alternative perspective from the audience was the view that science can be either 'good' or 'bad'. From this view, the main role of science should be to strive to be good. It should also be transparent. This is essential today. However, this black-and-white view of science was contested. It is true that science does not advance through democratic decisions, such as a vote on whether the Earth is round or flat (though one participant wryly noted that he had seen scientists 'vote' on issues such as which of several methodologies might be the best or most appropriate one). Still, the scientific ideal is regarded by many social scientists as something of a myth, with science pervaded by dogma and untested/unrecognised assumptions. Clearly, scientists themselves do not always agree on what the 'facts' are. One of the speakers noted that science is not just about facts. There are distortions and disagreements and uncertainties everywhere.

**Improving definitions and communication with the public**

One member from the floor argued that the idea of transparency requires better definitions. Others concurred that there is a need for good definitions of what is meant by 'nanotechnology' so that scientists and the public are clear on what this discipline entails. This will allow people to understand better and be better able to engage in informed debate. Without a common language there is the risk of an accumulation of errors as information moves through various media from the scientists to the public. There was recognition that even scientists do not have a common language in this domain. One of the results of loose definitions might be public fears arising from media-highlighted perspectives. These are generally concerned with more exotic potential applications of nanotechnology, as typified by 'assemblers' and the issue of 'grey goo'. However, it was also noted that one benefit might be that such interpretations excite children into getting interested in science. But will they retain their interest on finding that the topic is less exotic than they might have initially thought? The issue of definitions was not fully resolved. One participant argued that 'nano' should stop being seen as something that is 'special'. It is, after all, just a subset of science. The difficulties of providing common definitions were seen as one theme throughout the entire three days of the workshop. The problem of definitions also proved to have consequences for institutional strategies to deal with risks and benefits: should we think of 'nano-risks' as an analogue of chemistry, or pharmaceuticals, or food and products safety, or environmental protection?

**Informed and mis-informed public and policymakers**

There was considerable debate about the issue of informed policy making, following from the debate on the need for common definitions and understandings. That is, should the public and their views be involved in the managing of nanotechnology (as one speaker put it, 'an expanded model of risk assessment')? On the one hand, there is a fear of giving influence to an uninformed or misinformed public; on the other hand it is clear that systematic errors have also arisen in the past in alternative models of policy making (in which decisions are left to specialist committees). It is also clear that the public do and will have influence anyway (e.g. their perceptions may influence how they vote and spend money). Public engagement may help scientists consider their own assumptions. Similarly, it was argued that we should not fear heated discussions and controversy, for these are processes associated with the functions of democratic government (democracy being the 'least worst' form of government). The theme of how to involve the public came up several times. Although it was generally conceded that the public ought to be involved somehow, the method of doing so was not resolved. As one speaker noted, there is probably no 'magic bullet mechanism'. The nanotechnology community, it was argued, needs to be proactive, to accept the emergence of new forms of government, regulation and (risk) assessment, and importantly, to ensure that scientists are part of these activities.

**Proactive orientation and strategies**

The idea of proactivity was mirrored in several discussions, such as in the need for 'real time technology assessment', or 'constructive technology assessment', and the need for an ongoing reflective view of nanotechnology. In essence, we should not draw conclusions about the technologies too early, or too late, but constantly review and reassess what we know. There certainly was a view that, in a democracy, there is a responsibility for those involved in an ongoing reflective process to keep the public informed of all the different viewpoints and perspectives allowing them to come to their own informed judgments. It was also emphasised that simply providing more information is not going to resolve the problem of the 'uninformed' public in the sense of getting the public to agree with the scientific view of things. People may increase their understanding but still disagree (for example, that certain research should be conducted or certain applications allowed). Some speakers stressed that even the best risk assessment methods cannot be perfect and, therefore, hesitation about new technologies is not merely emotional, but also has a rational basis. In addition, it is clearly important to understand the public and the reasons for their concerns. As several speakers noted, the public do not perceive risks wholly in terms of potential human harm (the criterion for scientific risk assessment), but also consider issues such as uncertainty and environmental harm. One example emerged of attempts by members of the public to prevent the construction of a nanotechnology plant. This was not because of concern with the technology *per se*, but because of a history of environmental pollution in their state and a fear that the plant might lead to similar problems of pollution.

**Professor Burns' summary of the discussions:**

Among the critical questions addressed by several of the speakers, we heard:

- What kind of world do people want or believe they should have?
- What world would they be likely to oppose or resist?
- To what degree and how should they be involved in research and development planning and decisions about nanotechnology?

Moreover, what kinds of knowledge will the public need for making judgments and deciding future developments? This is not simply a question of technical or economic assessments. There are substantial societal and ethical aspects. The responses of the public are likely to affect the future of a technology or technological development. People ask questions such as who is behind a new development, what are their interests or motives. What impact will this development have on me or those close to me? We are living in a democracy, and people, whatever their beliefs, however wrong-headed and counter-productive these are, can oppose and vote against, or support organisations which are in opposition to a technological development.

How will these matters be decided, who will participate, how will they be organised? Clearly, there is a basic social science research side to this and there is also a design and experimental side.

A major theme in our deliberations, not only today but the previous two days, is the need to avoid non-trivial mistakes of the past. There is a need for:

- new concepts;
- new strategies.

On a related theme, there is a need to be more proactive in communicating and discussing the development of nanotechnologies. Several times it was emphasised that a repetition of the GMO experience must be avoided and that there is a need to start early to engage the public. If such public discussions are to be open and transparent, then we must be prepared to address the uncertainties and the unknown effects of nanotechnologies, in particular nanomaterials. This suggests new forms or models of research and development, much more upstream thinking and not impact assessment after the fact.

This has been an extraordinary meeting. Of course, we discovered what is generally known. Natural and social scientists do not have much of a common language. However, we have been learning some of one another's concepts and methods. We must go on with these mutual learning processes, of which this conference is an excellent example. This integrative activity is a desirable, even necessary endeavour in the 21$^{st}$ century.

The workshop has been a success in another sense. We have had an opportunity to examine the various roles of the social sciences and humanities in research on technological innovation and development. This concerned not only societal aspects of innovation and change, the reactions of the public, the perceptions, communication, and management of risk. But it also concerned new forms of governance, problems of assessment and judgment, and regulatory challenges.

In the face of revolutionising technologies, we need to mobilise our diverse competences. Teams of natural scientists as well as social scientists and scholars in the humanities should be mobilised to participate in, among other things, joint projects and programmes. We have heard that these are taking place in the United States on a substantial scale. We would hope to see similar initiatives in the EU, perhaps through the mechanism of the 'technology platforms'.

**Professor Randall’s closing remarks:**

In closing, it is worthwhile stressing the increased recognition by scientists of the uncertainties surrounding nanotechnology, on the technical-scientific side as well as, apparently, the societal and policymaking side. We have coined a new phrase, ‘a transparency about uncertainty’.

It should also be stressed that it is not enough to conduct research diligently but that scientists need to engage with the public. However, barriers must be overcome, and this would lead to changes in power structures. This may be accomplished, in part, through common efforts with social scientists. Without engagement, we risk seeing innovations in nanotechnology blocked by public responses. So let us not forget the importance of building trust.

In concluding, we would like to thank the organising committee and sponsors for helping make this workshop happen.

# 4. CONCLUSIONS AND RECOMMENDATIONS

The main take-home message of the workshop was that ongoing dialogue with the public on the nanotechnology issue is vital. Interaction with the public is key to understanding and addressing public perspectives. We should be informed by these and inform the public in turn about the main scientific issues (avoiding or countering the media hype of the past). Underlying the discussion was the issue of power, and it was recognised that there is a need to understand power relationships in society. These will ultimately influence the direction of research into nanotechnology and its applications.

*Key points and conclusions*

- It is important to understand and avoid major mistakes of the past such as in the case of genetically modified organisms. More is required than conventional risk assessment. It is important to recognise uncertainties beyond the known possible consequences with which risk assessment deals. It is essential to acknowledge the possibility of unknowable outcomes and unintended consequences.

- There are major problems facing industry, researchers, policymakers and the public as a result of the lack of definitions, contradictory definitions and, in general, confusion about nanotechnology and its possible or likely impacts on health and the environment.

- The problem of properly understanding and responding to informed and misinformed public and policymakers is a major challenge. Engagement of scientists with the public is important, as is a proper definition of the terms and expectations of this engagement.

- There is a good chance that society will serve as the laboratory in which nanotechnologies are tried out. This highlights the need to focus on the benefits that would justify such experimentation. After all, what would informed consent mean in such a case? Under what conditions would the public accept ‘residual’ risk? For example, if there are public concerns about neglected questions beyond known risks, how can a policy framing ‘risk’ alone be adequate? What further initiatives are needed?

- There is an obvious need to be proactive in engaging the public, policymakers and key stakeholders.

- The diversity, scope and inevitable lack of definition of nanomaterial development present significant challenges to greater understanding and to effective regulation.

- Different institutional models of regulation were discussed, e.g. pharmaceutical, chemical, environmental, food. The pros and cons of such models should be investigated.

- Public trust is critical; ways to maintain and develop it must be centre stage. However, the issue of trust must not become an instrument or object of policies. Anybody can only control their own trustworthiness, not that of others. Social sciences have a key role to play in this issue. Their models and understanding of the basis of trust and trust mechanisms are very important. There is also accumulated research knowledge and experience relating to risk perceptions, risk communication and risk management, and the tacit roles of other factors besides risk.

- The social sciences also have a history of research on barriers to and conditions for innovation and development. Much of this is applicable to the problems and challenges of nanotechnology development.

Social sciences and humanities are substantially involved with nanotechnologies in the USA. In a number of cases, programmes are integrated combining natural, medical, and technical sciences with the social sciences and humanities. To date, similar integrated programmes do not appear to have been developed on any significant scale for Europe. It would be worth considering such possibilities.

## ABBREVIATIONS

| | |
|---|---|
| AG | Anticipatory governance |
| BST | Bovine somatotropin |
| CFC | Chlorofluorocarbon |
| CNS | Center for Nanotechnology in Society |
| DNA | Deoxyribonucleic acid |
| EC | European Commission |
| ELSI | Ethical, legal and social issues |
| GM | Genetically modified |
| GMO | Genetically modified organism |
| IP | Intellectual property |
| IT | Information technology |
| NAS | National Academy of Sciences (USA) |
| NIRT | Nanotechnology Interdisciplinary Research Teams |
| NNI | National Nanotechnology Initiative (USA) |
| NNIN | National Nanotechnology Infrastructure Network (USA) |
| NRC | National Research Council (USA) |
| NSE | Nanoscale Science and Engineering |
| NSEC | Nanoscale Science and Engineering Center (USA) |
| NSET | Nanoscale Science, Engineering and Technology (USA) |
| NSF | National Science Foundation (USA) |
| TZ | Trading zone |
| UCLA | University of California, Los Angeles (USA) |

# APPENDIX 1: WORKSHOP PROGRAMME

## *Societal Aspects of Nanotechnology*

## *Wednesday 9 November 2005*

| | | |
|---|---|---|
| 09.00-09.15 | **Welcome** | Dr. Monique Marrec-Fairley<br>Cefic |
| | **Introduction** | Prof. Tom Burns<br>Uppsala University |
| | **Lectures (each followed by a plenary discussion):** | Moderator: Prof. Geoff Randall<br>ECETOC |
| 09.15-09.45 | **Societal Aspects of Nanotechnology:<br>NSF Initiatives and Developments** | Dr. Rachelle Hollander<br>US National Science Foundation |
| 09.45-10.15 | **Nanotechnology in Society: a New Model of Anticipatory Governance** | Prof. Clark Miller<br>University of Wisconsin-Madison |
| 10.15-10.30 | Coffee Break | |
| 10.30-11.00 | **Uncertainties as Opportunities: Broad Promises, Public Fears,<br>and Becoming Vested in Nanotechnologies** | Prof. Alfred Nordmann<br>Darmstadt Technical University |
| 11.00-11.30 | **Risk, Trust and Regulatory Aspects of New Technology Development** | Prof. Brian Wynne<br>Centre for Economic and Social Aspects of Genomics, Lancaster |
| 11.30-12.00 | **Societal Aspects of Nanotechnology Beyond Precaution:<br>Some Early US-EU Comparisons and Contrasts** | Prof. Hans Glimell<br>Göteborg University |
| 12.00-13.30 | Lunch | |
| 13.30-14.00 | **Ethical Issues Associated With Nanotechnology** | Prof. Michael Mehta<br>University of Saskatchewan |
| 14.00-15.00 | **Plenary Discussion:<br>Facing the Opportunities and Liabilities of Nanotechnologies** | Chair: Prof. Geoff Randall |
| | Panel: Tom Burns, Rachelle Hollander, Michael Mehta, Clark Miller, Raymond Oliver, Brian Wynne | |

**Refreshments and informal discussions**

# APPENDIX 2: PRESENTATION ABSTRACTS AND TRANSCRIPTIONS[2]

## *Social Aspects of Nanotechnology: National Science Foundation Initiatives and Developments[3]*

**Rachelle Hollander**
**US National Science Foundation**
**Arlington, VA, USA**

### Abstract

In the first five years of the new millennium, the National Science Foundation (NSF) has become increasingly supportive of research and educational activities that examine the relationships between social and ethical change and new developments in nanoscale science, engineering and technology. This presentation will review some of the history of these efforts and identify and describe some of the projects that are underway. The history demonstrates the recognition that public action and reaction are influential. The past five years have allowed NSF to develop a set of projects that can contribute to understanding that influence as well as that of organisations and institutions committed to innovation. These projects will, hopefully, provide a resource to develop useful knowledge products as well as useful forms of public engagement about these new developments and their potentials.

### Transcription

*Social Context*

The interconnections among social groups and institutions are becoming more and more apparent and more and more intricate. The tight couplings between science, engineering and technology and society or socio-technical systems are more than ever evident. The public and private and quasi-public and quasi-private money being invested in these efforts grow substantially, as do demands for accountability. Promotional language used by groups who want to justify their demands, both for money and for accountability, grows too. The promotional language of scientists and engineers and their organisations also creates expectations, either good or bad. Rob Kling coined the term ‘social informatics’ to cover the research field of informatics in society; we can also speak of ‘social genomics’ to cover the field of genomics in society. Perhaps we should also speak of ‘social nanotechnics’ to cover the new arena of nanotechnology in society. These fields are as complex and worthy of scientific study as their technical focuses; perhaps more so.

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[2] The transcriptions have been shortened, summarised and edited by the editors. Mistakes and misinterpretations in the texts are the responsibility of the editors.
[3] The viewpoints expressed in this presentation are Rachelle Hollander’s and should not be attributed to NSF.

It is imperative to highlight the genetically modified organisms (GMO) debacle in the history of the current focus in science and society on nanotechnology. The GMO controversy helped lead to legislative and political (as well as private for-profit sector) recognition of need for attentiveness. It led to the invigoration of social groups attentive to questions of down-sides of innovation. It led to attention from private sector groups and scientists and engineers themselves. Had these controversies not led to trade difficulties, we might not see the kind of political attention there is now.

In the US, PL108-153, the 21$^{st}$ Century Nanotechnology Research and Development Act[4] indicates that programme activities should ensure "*that ethical, legal, environmental, and other appropriate societal concerns…are considered….*" The Act notes a number of ways in which this can and should be done. It indicates that an Advisory Panel should assess whether these areas are adequately addressed in the National Nanotechnology Initiative (NNI) and it requires the National Academy of Sciences (NAS) to conduct a triennial evaluation that also includes these concerns. It requests a one-time study on the responsible development of nanotechnology to be undertaken by the National Research Council (NRC).

The Act also indicates that the programme should establish, on a competitive basis, an American Nanotechnology Preparedness Center. That call was certainly influential in the NSF decision to hold a competition in 2005, which has resulted in the funding of two centres and two large projects. Dr. Miller is affiliated with one of those two new centre awards, and he is also a member of a Nanoscale Science and Engineering (NSE) Center on Templated Synthesis and Assembly at the University of Wisconsin which has a strong social and ethical issues component.

### *National Science Foundation's Role*

The National Nanotechnology Initiative (NNI) began in 2001. A leader in NNI, NSF's role emphasises long-term, fundamental research, aimed at discovering novel phenomena, processes and tools, and the development of NSE educational capacity. NSF works with other Federal agencies to identify and address NNI 'Grand Challenges'. It supports new interdisciplinary centres and networks of excellence, research infrastructure (including shared user facilities), and research and education on the relationships between nanoscience, nanoengineering, nanotechnology and social change.

NSF's activity in this last area began in a small fashion during the first two years of NNI. It picked up strongly by 2003. Currently NSF has three major Nanotechnology Interdisciplinary Research Teams (NIRT) awards on social and ethical issues, and of course there are the four large

[4] 21$^{st}$ Century Nanotechnology R&D Act. S. 189, P.L. 108-153, 3 December 2003.

awards made in September 2005. Two of the previous NIRT awardees are among or involved with these four new awards:

Lynne Zucker at UCLA is directing a NIRT project to establish a 'Science and Commercialization NanoBank.' The project is building an integrated database, which will be made available as a public, web-deployed digital library called NanoBank.org. The database will be useful to researchers pursuing social science analyses, as well as investors and firms seeking to allocate investment to promising new technologies, policymakers attempting to assess the effects of alternative policy proposals, as well as nanoscientists and engineers, who will be able to trace relevant research.

This effort has now been expanded with an award to Richard Freeman at Harvard University. The new project, called 'NanoConnection to Society', involves Dr. Zucker and other researchers with ethics and environmental sciences expertise. It will add a NanoEthicsBank and a NanoEnvironBank to NanoBank; integrate these and other databases into an overall NanoIndicator series; and study the flow and distribution of patents in nanotechnology ($1.725M/5 years).

Davis Baird at the University of South Carolina is directing another NIRT award. Entitled 'From Laboratory to Society: Developing an Informed Approach to Nanoscale Science and Technology', the project focuses on outreach and research activities to examine concepts of understanding and control for purposes of achieving effective democratic deliberation about nanoscale research and technology. The expanded project will examine the role of images in communicating about nanotechnology, and how research in this field is changing the scientific and engineering practices of the researchers themselves ($1.375M/5 years).

The third NIRT award was made in 2004 to a research team led by Paul Thompson at Michigan State University. Called 'Building Capacity for Social and Ethical Research and Education in Agrifood Nanotechnology', this project investigates the potential social and ethical issues in research in nanotechnology for agrifood production and consumption. A goal of the project is to draw insights from social conflict surrounding agrifood biotechnology. It will develop a proactive strategy for understanding and addressing social and ethical issues associated with agrifood nanotechnology ($1.720M/5 years).

The centres' awards have gone to the University of California at Santa Barbara and Arizona State University in Tempe. These centres will support research and education on nanotechnology and social change, as well as international collaborations and public outreach activities. They both draw upon researchers at other institutions, as well as a diverse group of advisors, in undertaking their activities. Dr. Hollander hopes that some of the people in this audience are already involved with these efforts, or will become involved.

The Santa Barbara Center ($5.035M/5 years) will focus on the historical context of nanotechnology; on the innovation process and global diffusion of ideas in the field; and on risk perception and social response to nanotechnology, with a special focus on collective action and the action of global networks in response to nanotechnology. The centre will also explore methods for public participation in setting the agenda for nanotechnology's future.

The Arizona State University Center ($6.220M/5 years) will develop a broad programme of 'real-time technology assessment' (RTTA). The centre will use real-time technology assessment to map the research dynamics of nanotechnology, to monitor the changing values of the public and of researchers, to engage both these groups in deliberative and participatory fora regarding nanotechnology and to assess the influence of these activities on the researchers. The centre will organise its efforts around two broad nanotechnology-in-society themes: freedom, privacy and security; and human identity, enhancement and biology.

From 2003 until now, NSF has also supported five Nanotechnology Undergraduate Education projects to develop undergraduate programmes incorporating courses on societal dimensions in NSE education. It has supported four Nanoscale Exploratory Research projects, as well as a number of Small Grants for Exploratory Research and workshops to set research agendas and encourage networking in the field.

Very importantly, the 2003 competition for the National Nanotechnology Infrastructure Network required that the network include administrative and managerial competence in the social sciences in its coordinating structure. Several nodes of the Network include research in the social and behavioural sciences and related fields. Funding for the Network began in 2004 and continues for four additional years. The total award is $70M over that time; of course, only a very small percentage of that goes to this component. The Cornell team that directs this award includes science and technology studies scholar Bruce Lewenstein as the social and ethical issues coordinator; the NNIN home page includes a good page on social and ethical issues that should strengthen in coming years. NNIN activities in that respect also include research, and there is an activity with small grants for student social and ethical issues research. An associated award to the science and technology studies department at Cornell is funding graduate student training associated with nanotechnology in society.

*Conclusion*

Dr. Hollander concluded by mentioning several areas where she believed research was moving forward rapidly, areas where it was developing, and new areas under formation. The first includes research on the history and evolution of NSET, research on public opinion, and research identifying ethical issues. This research can build very effectively on prior research about science and technology in society. In category two, some of the infrastructure which will allow for continuing analysis of NSET and social change is being developed. This is in the form of both databases and human resources. Also in this category falls research on NSET and social movements as well as research on public engagement with new developments in science, engineering and technology. In the third category, we see the invigoration or reinvigoration of research that can influence the shaping of science, engineering, and technology in society. This is part of the promise of the real-time technology assessment efforts at the Center for Nanotechnology in Society at Arizona State University. It is also part of the promise of 'real-time ethics' at the NNIN and at other NSECs that have ethicists of a variety of disciplinary backgrounds on, as it were, the shop floor.

## *Nanotechnology in Society: a New Model of Anticipatory Governance*

**Clark Miller**
**University of Wisconsin-Madison, USA**

### Abstract

While the historical antecedents of the nascent field of nanotechnology in society can be found in the ethical, legal, and social implications project of the Human Genome Initiative, this new initiative departs from its predecessor in some notable ways. In the decade and a half since James Watson first persuaded his colleagues in the biological sciences and the U.S. Congress to fund ELSI research, the challenges facing democratic governance of scientific and technological innovation have become increasingly clear. Yet, at the same time, it has become equally clear that possibilities exist for transforming the relationship among scientists, citizens, and policymakers to create new ways of moving forward. Nanotechnology offers us the opportunity to take the next step toward what I will define as anticipatory governance - the notion that democratic societies might acquire the capacity to be more reflexive about the decisions they make regarding the scientific and technological worlds they are constructing for the future. Accepting this challenge will require new ways of imagining and organising the research enterprise that bring together the social and natural sciences, democratic publics, and the state in new configurations. We may not get it all right with nanotechnology, but just as nanotechnology in society has learned its lessons from ELSI, so too the next generation will learn from our experiments. Let us give them some interesting data to work with.

### Transcription

Professor Miller talked about the Center for Nanotechnology in Society which is involved in an experiment in anticipatory governance (AG) of a new and emerging technology at the University of Wisconsin-Madison (and other universities). Nanotechnology follows a tradition that reaches back to nuclear technology, chemicals and stem cells.

#### *Anticipatory Governance*

Professor Miller introduced what can be a useful concept in addressing some of the issues relating to nanotechnologies (and other high tech developments), namely anticipatory governance (AG).

He explained that we will construct new social worlds using nanotechnologies, but asked what kinds of worlds will we choose to build? what kind of knowledge will we need? how will we decide? Via anticipatory governance.

Governance is not government. Regulation is one alternative. Consider the US Federal Drug Administration or the Environmental Protection Agency; another one is the Office of Technology Assessment (prior to its dismantlement). Both reflect models of anticipatory governance. Other models also exist:

- legal system (defining rights, responsibilities, tort law, etc.);
- self-regulation;
- corporate governance;
- social movements;
- market choices;
- public deliberation and dialogue.

*Needs for Anticipatory Governance*

Thus far, this workshop has offered a clear illustration of the need for, as well as the benefits of, anticipatory governance:

- potential health and environmental risks are not trivial;
- desire to avoid mistakes made in the past;
- recognition of the need for novel approaches: proactive strategy, practical methods, attention to full life-cycle of technologies.

Thus, AG is not simply about health and environmental risks. It is also about 'anticipating unanticipated consequences' and ensuring that innovation addresses societal needs (in dealing with hunger in the world or disease, etc.). In addition, we must try to avoid societal dislocations that go beyond risk. Democratising innovation, which is one of the few legitimate *loci* of radical social change, is an important element of AG.

Nanotechnology is already moving in the direction of multiple types of governance. In the US, there is the adoption of the ELSI model (stressing consideration of ethical, legal, and societal aspects of nanotechnology developments). In the UK, there is public consultation and government review. Scientific policymakers and corporate leaders in the field of nanotechnology appear to recognise the importance of securing public trust. Discussions about environmental and health risk are already underway. Non-governmental organisations and social mobilisation have begun. "Nano deserves credit and respect for doing this".

So, now there are emerging networked centres for nanotechnology in society and NNIN social and ethical issues networks (e.g. Cornell University with other major universities):

- To build capacity for transparency and reflexivity (capacity to investigate, analyse, understand, evaluate and deliberate new technologies and work 'upstream' in the innovation process).
- To nurture human capital (also training people to participate in anticipatory governance).
- To strengthen partnerships. (Scientists, engineers, social scientists, industry and policymakers as well as the general public will all be essential.)

*Intellectual approaches of Anticipatory Governance*

1) Politics of risk

- Risk characterisation (environment/ecology, health, safety).
- Risk perception and tolerance (uncertainty, control, visibility, cost/benefit, framing). Think about death rates, e.g. traffic 41,000/year in the USA.
- But attention and funds are the reverses.
- Epistemological and regulatory cultures (standards of evidence, expertise, policymaking, participation/consultation, precaution).
- Social, cultural and economic risks (identify order, meaning, livelihood, lifestyle).

2) Co-production of technologies of society

- What is technological society? For example, think about the automobile: suburbs, filling stations.
- Society shapes technologies (markets, regulators, protests, engineering values, e.g. multiple styles of autos, seat belts, hybrid engines).
- Society reconsiders moral, ethical, legal and political values (e.g. bioethics, social security).
- Individuals and communities reorder social relationships, behaviours and institutions (e.g. *in vitro* fertilisation, 'anonymous sperm donation').

3) Motivation

Example: nanotechnology-enabled sensors.

- Virus detectors for avian influenza or West Nile fever. Think about personal relationships, monitoring your environment (is personal health status private information?), business liability (protecting worker's health), school liability and privacy (protecting children's health).
- Personal pollution monitors; air and water quality; core conceptual foundation of environmental regulation is the 'average risk to aggregate populations'. Do individuals have the right to a safe environment?

- Ubiquitous sensing. The surveillance society (I-pass: toll registration recently used in court).

4) Foundations

Example: Center for Nanotechnology in Society (CNS) at the University of Wisconsin: NSF funding of $2.25 million:

- It is a major partner in the Center for Nanotechnology in Society at Arizona State University (real-time technology assessment).
- Also, the University of Wisconsin has a Nanoscale Science and Engineering Centre (which is supporting foundational social science research, education, and public engagement).
- In addition, the University has a Nanoscale Undergraduate Education project (teaching teachers to integrate social and technical aspects of nanotechnologies; freshman seminars in nanotechnology in society; modules for nanotechnology courses; on-line course in integrated social and technical discussions).
- Engagement with local, state and federal policymakers. Nationwide effort to engage citizens with nanotechnology; for instance, in 2008 a National Citizen's Technology Forum, nationwide, and consensus conferences in at least 6 cities.

Research portfolio:

- Laboratory cultures and the commercialisation of the university.
- Nano economies.
- Knowledge systems for AG.
- Privacy, freedom, surveillance and security.
- Nanotechnology and the military.
- Policy and ethics for convergent technologies.

*Questions and answers following the presentation*

One participant remarked that 'anticipating unanticipated consequences' is a contradiction and that risk assessment is a very limited approach to these unanticipated consequences. Professor Miller's response was that it is possible to articulate new methods and approaches to address this question. New institutional arrangements would be needed to establish a dialogue between developers and society.

## *Uncertainties as Opportunities: Broad Promises, Public Fears, and Becoming Vested in Nanotechnologies*

**Alfred Nordmann**
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**Institute of Philosophy**
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### Abstract

Since World War II the relation of science and society has undergone a profound transformation. The strict boundary between specialised laboratory research and society has given way to interactions at many levels. New conceptions of expertise have emerged along with a 'new social contract' and a scientific community that uses powerful language and imagery routinely to communicate with the public at large. Particularly relevant for the discussions at this workshop is the notion that society at large has become the laboratory in which large-scale technological innovations are tested not only for their social but also for their health and environmental effects. Proposed methodologies for the characterisation, toxicological analysis, and risk-assessment of nanoparticles will be considered in this context. Such an assessment may ultimately have to rely (as with asbestos, fine and ultra-fine particles) on cumulative data from long-term exposure of large populations to sufficient concentrations. If society thus needs to serve as a laboratory, this affords also the opportunity to explicitly link questions of risks with expected benefits. A society willing to take a risk with nanotechnology is a society that is also vested in its success.

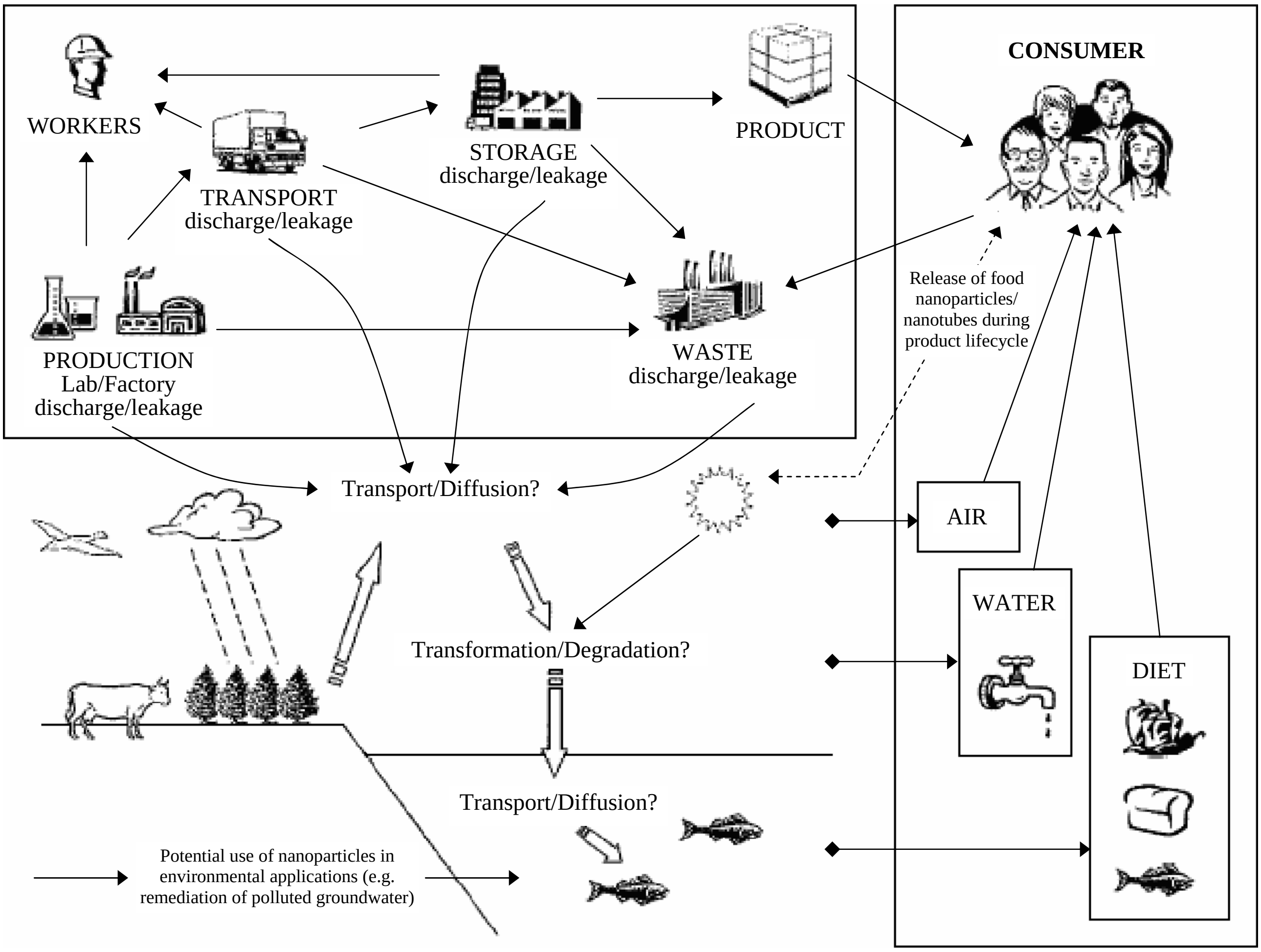
### Transcription

Professor Nordmann started off with a question on how novel are the challenges faced by nanotoxicology. He suggested that there are different responses to this question (see 'thought starters' in ECETOC Workshop Report No. 7). At this meeting, this question was raised implicitly and answered implicitly.

The scientific research process is necessarily based on an incremental approach: even where there is doubt that current methods are sufficient, we take these to their limits and beyond. The following question was raised: If nanotoxicology cannot proceed in isolation without other natural sciences, can investigations of nanoparticle hazards and risks proceed without social science, humanities, public engagement and science studies (history, philosophy, sociology of science)? The answer is no; it is already in the midst of it all.

This presentation investigated some aspects of this: nanotoxicology does not simply confront a complex social world but is an actor in that world. Its research process is simultaneously a search for scientific answers and possibilities for social intervention. To illustrate his arguments he presented the following diagram.

***Figure 1: Possible exposure routes for nanoparticles and nanotubes based on current and potential future applications.***[5] *(Adapted from: National Institute for Resources and Environment, Japan, www.nire.go.jp/eco_tec_e/hyouka_e.htm).*




This apt diagram cited in the UK's nanotechnology report[6] pictures a complexity that needs to be reflected and understood by nanotoxicological work and that is compounded by

[5] Little is known about exposure routes for nanoparticles and nanotubes and this figure should be considered with this in mind.
[6] The Royal Society & The Royal Academy of Engineering. Nanoscience and Nanotechnologies. July 2004.

nanotoxicological findings and interventions. Professor Nordmann suggested that this is at the limit of current methods and considered the following qualitative changes:

1) Qualitative changes in the sense that previously unconsidered effects have been moved to the agenda with engineered nanoparticles.

These effects are diverse and include, for example: (a) nanoparticles crossing the blood-brain-barrier; (b) deposits in the central nervous system; (c) potential interaction with DNA, proteins; (d) quantum effects, optical and electrical properties; (e) functional features (e.g. sensors); (f) targeting organs and cells (e.g. polymerised liposomes).

Research to understand and quantify these effects is often at the limits of current science.

2) Qualitative changes in the sense of a new research culture. For example, what about the characterisation and standardisation of nanoparticles?

On the basis of the model of characterisation of bulk material (mostly chemical composition), one looks for criteria of standardisation that include relevant aspects of size, shape, surface structure, etc. So far, we have looked in vain for the '*Linnaeus* of nanoparticles'.

It is just possible that nanoparticles will become standardised only within pragmatic limits of tolerance for robustness in production and application. Toxicology will have to deal with manufactured, not 'naturally' defined particles. Thus, nanoparticles are socially characterised in terms of their uses.

A new research culture might emerge where, for instance, data sharing becomes more pro-active. Data sharing (internationally, between private and public sectors) is desirable in order to arrive at generalisable knowledge. This requires some standardisation for comparability. However, there is likely to be resistance to data sharing because of competition and intellectual property rights. This may be bolstered by the difficulty, if not impossibility, of generalisation and standardisation.

3) New research culture - extrapolation

Predictive laws about structure-property relations at the nanoscale would be necessary in order to avoid late-in-the-game case-by-case risk assessments (toxicology plus epidemiology). But nanotechnology is premised on there being no need for such laws; nanoscale research is interested in the discovery and control of surprising novel properties, not in predicted effects.

4) New research culture - uncertainty

We can consider the general formulation of a systemic issue regarding nanoparticle risks, namely different types of uncertainty:

- Epistemological uncertainty.  This is due to the present lack of knowledge.
- Objective uncertainty.  This is due to complexity, sensitivity, interactivity and unpredictability in principle with lack of general knowledge of structure-property relations at the nanoscale.

Uncertainty is characterised by:

- Nanoscale research being an attempt to establish technical control at in-principle limits of scientific understanding.
- The tension between toxicological 'need to know' and the 'realities of the nanocosm' (as demonstrated by this workshop.)
- Uncertainty within the science, for example:
  - What kinds of generalisations are to be sought?
  - What are the institutional models for nanotoxicology?

What kinds of generalisations should be aimed for?  Examples of variants are many:

- "If this kind of structure, then always these properties."
- "Functionalised less toxic than untreated surface."
- "Concentrations of nanoparticles (any kind, vaguely characterised by size-range) should not exceed so many parts per billion."
- "This nanoparticle is safe within this fault tolerance, size-range, and surface variations."
- "These materials are biocompatible, let us use them as nanotechnological building-blocks."
- "The substitution of this material by that nanoparticulate structure is toxicologically sound."

But is there agreement?

What is the appropriate institutional model for regulation of nanotechnologies and nano-development?  Among established models we find:

- Pharmacology: case-by-case for contexts of application.
- Chemistry: material in any quantity for any application.
- Environmental protection: emission-thresholds, regulating pollutants.
- Food and product safety: a mixture of methods.

More specific considerations on the first point are that the 'pharmaceutical model' does not apply very well here. It assumes, first, that there is research on effectiveness and safety, concluding with clinical trials; second, only then, introduction in the market-place as tested/safe. Instead, toxicological and epidemiological studies need to work together to move from hazard identification to risk assessment. Models of pathogenesis need to be matched with health effects observed in sufficiently large populations with sufficiently high exposure levels over time.

Another aspect of the 'pharmaceutical model' is that clinical trials are conducted on subjects who provide informed consent to participate in the experiment on effectiveness and safety. But if society at large becomes the laboratory to determine social, environmental, and health effects, what is the analogue to informed consent? Is it informed dissent? Is it an implicit or explicit 'societal decision' to incur an unknown risk for the sake of expected benefits?

1) Society becomes a laboratory.

This makes nanotoxicology only part of a larger transformation in the culture of science developments:

- Expertise and authority have become distributed (science is no longer a privileged space of knowledge production in a protected environment).
- 'New social contract of science and society'.
- 'Research in the design-mode'.

2) The risk society as laboratory.

A question worth investigating (possibly a joint research project of toxicology, epidemiology, risk communication): So, why should (does) this risk society accept unknown nanoparticle risks? (Is it only as long as it is ignorant of them?) The 'risk society' tends to be risk-averse, yet, it often incurs unspecified risks along with perceived benefits (Professor Nordmann's favourite example being the car – obviously 'unsafe' from the start).

3) Uncertainty as opportunity

It is a good thing to be open about the objective uncertainties associated with nanotechnology. Is there an opportunity to jettison 'nanotechnology' in the singular and shift debate to specific and multiple nanotechnologies?

Is there an opportunity to mobilise social imagination for nanotechnology applications such that the public can become vested in the development of this technology? If silver particles in the lining of washing machines do not constitute unknown risk, perhaps environmental sensing or targeted drug delivery do?

Nanotoxicology can thus be an agent of change; its interventions triggering the formation (and dissolution?) of coalitions between industry, research, policymakers and the public.

*Questions and answers following the presentation*

One participant voiced his disagreement about the apparent suggestion that there were no structural properties of nanomaterials. This was not discussed further. The same participant raised the question about the predictability of nanoscience. In Professor Nordmann's opinion there is still a lot of piecemeal engineering and no general laws on structure-property relations.

It was remarked that below 100 nm particle size there was a grey area between classical, quantum and 'meso physics'. New rules are being discovered. Professor Nordmann agreed and highlighted the difference between practical rules that emerge from experience with novel phenomena and physical laws and that provide predictive understanding.

Another participant mentioned that generalisation is indeed the challenge of these phenomena. For example, the pharmaceutical sociology should once more look into definitions of nanoparticles as one could not carry out serious research without good definitions. Professor Nordmann agreed that definitions are important. He thought that nanotechnologies should be considered as a pluralistic research area although there are vested interests in keeping one category of nanotechnology research. Further, building on the example of pharmacological research, it was said that waiting for evidence of harm is probably not good. But can toxicological evaluations be carried out in parallel with use of products? Would that be another approach? Professor Nordmann did not believe that one is now waiting for evidence of harm and agreed that parallel multi-disciplinary investigations are the way to go. He thought that the technology development is on the right track given what is already being done. This was much better than what had happened, for example, in the case of asbestos (where warnings were ignored and reactions came slowly).

Finally, Professor Nordmann said our societies need to learn to live with constant vigilance rather than demand freedom from risk. We have to realise however that we currently live in a 'risk society' where citizens look to government and science for protection from risk.

## *Risk, Trust and Regulatory Aspects of New Technology Development*

**Brian Wynne**
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### Abstract

Scientific research has been embedded within two different dimensions of new technologies and their social (re)formations. The public and policy aspects of these are also different, and deserve more discriminating attention than they have typically received. Science's 'protective' role is to perform and communicate risk assessments for innovation to be regulated. But before this, it has also played a 'productive' role in producing and shaping innovations in the first place. Of course these roles are more mixed in practice. But this distinction allows recognition of the point that all of the huge policy and scientific concerns about public reactions to innovation, about ensuring global commercial competitiveness for our science, under the Lisbon Agenda European knowledge-economy etc., has been focused only on the back-end, or downstream issues of impacts, consequences, and risks – that is only on protection. Thus the very meaning of such issues, as public issues, has been that of 'risk', and reactions have been presumed to be based on 'risk attitudes' or 'risk perceptions'. Fieldwork shows time and again that publics have further concerns beyond risk as defined by institutional science. These raise questions about the social and human meanings, purposes and visions shaping the innovation upstream from risk and impacts questions. The new fashion for upstream public engagement with science has largely remained locked into a downstream imagination that this is about earlier anticipation of consequences, when it should be more about integrating the serious limitations of prediction and risk assessment, and the social assumptions that have to be invested in these as scientific pursuits. Thus it should be more about eliciting, debating and negotiating more accountably, the human visions and assumptions (imaginations) built often quite informally even implicitly into scientific knowledge programmes oriented towards innovation, and not only the assumptions shaping risk assessment science for policy. This would also require private-sector investments in scientific R&D to be examined from this point of view, a shift which raises complex and difficult regulatory institutional questions.

### Transcription

Why is the issue of public trust endemic to new technology? It is a central structural and logical aspect, and not simply a secondary, emotional matter. It is rational, and thus, central. Here Professor Wynne explained why, before concluding with some observations about treating the (re?)gaining the trust of 'the public' as an instrumentalised objective of our activities.

*Trust, (Non-)Knowledge, and Dependency*

Even the best risk assessment of possible impacts of any technological innovation is always inadequate. Professor Wynne has made the analytical distinction between four different kinds of ‘knowledge’ or ‘uncertainty’ which pervade any attempt to predict consequences, for example with risk assessment.

- Known knowns - where we are confident from evidence that we know of a consequence and the conditions which affect its likelihood, magnitude and so on.
- Unknown knowns - where *someone* knows the defined possible consequences, but their knowledge has, deliberately or inadvertently, been excluded and ignored by decision-makers and scientific advisors.
- Known unknowns - where the institutional actors making policy may know of a possible consequence, but are aware that they do not know the precise conditions affecting its likelihood, scale, nature and distribution of damage, etc.
- Unknown unknowns - where some key potential consequences are simply unknown at the time of regulatory attention even as possibilities, so that risk assessment does not even know the full set of questions it should be asking. Key consequences may erupt later as traumatic surprises. Two major examples in modern times are CFCs and stratospheric ozone damage, and thalidomide. Significantly, both of these were spontaneously raised by typical public respondents in a European study of public attitudes to agricultural biotechnologies in Europe.

There are also always questions that are too expensive and difficult to study even if we know them to be potentially important, such as multiple chemicals’ (or other agents, e.g. stress, radioactivity) interactions. Our focus-group research in five EU member states (Germany, France, Italy, UK, Spain) concerning GM crops showed that public respondents associated CFCs with problems of GM crops. What could they mean? A typical institutional expert reaction would be to conclude that the public was even more ignorant of science than had been thought, and was equating CFCs with GMOs!

But this would be a stupid interpretation. Just as we know that experts often express themselves in metaphorical terms (does anyone really believe that an atomic structure is a planetary orbital system?), so too were these groups of the public. They were emphasising, using concrete examples like thalidomide, that unpredicted effects always happen, despite the best science’s being in play. Yet these unpredicted unknowns, and the lack of complete scientific control which they underline, are regularly denied, by repeated institutional reference to ‘risk assessment’ as the supposed means of addressing those public concerns.

The point of the above distinctions between different kinds of uncertainty is that risk assessment never completely controls consequences and the public typically know this. The public are aware that this creates an endemic situation of dependency on such regulatory institutions to respond to inevitable (but as explained above, denied) surprises in a trustworthy public interest manner. Thus, 'risk' issues, as we misleadingly call them, always rationally and inevitably raise questions of trust and trustworthiness.

This indicates a key problem of institutional self-misunderstanding embedded within our ways of framing such public issues. Expert institutions do not understand or respect the public, and relentlessly exacerbate their own public mistrust problems. They do this in two ways. Firstly, they deny the existence of scientific ignorance and thus, lack of control – unknown unknowns. Secondly, they doggedly reinforce the entrenched assumption that people must be anxious only about risk, as they define it.

With regard to the trust issue, we recognise that the central question is not about risks. It is about some combination of known knowns (probability × consequences) and known unknowns (known consequences, but unknown probabilities, conditions), and about unpredicted consequences coming from ignorance or unknown unknowns. We then immediately see also that the logical question for people to ask, after realising that surprises are going to occur, is "who will be in charge of public responses to these un-specifiable surprises? and will these responses be in the best public interest?" That is, the trust question. It is only recognised as central once we have managed to breach the entrenched expert institutional resistance to acknowledging that unpredicted consequences are normal routine – as most common-sense experience already tells. Scientists also know this of course; yet it is systematically excluded from regulatory public science discourses.

Thus to address the trust issue, we must first recognise it is essential, legitimate, and endemic. Moreover, it is a question which concerns our expert institutions, our ability to acknowledge as a public matter, our own limited knowledge and control.

Professor Wynne has elsewhere summarised the following distinctions:
Risk = probability × consequences.
Uncertainty = credible possibility with unknown probability (e.g. climate change).
Ignorance = unknown but real possible effect; we don't know the questions we should be asking.
Ambiguity = there is confusion as to what we are concerned about? (Human health? Environment? Institutional exaggeration? Irresponsibility? Private interests being presumptively confused with public interest?)

Technology is not just a piece of hardware, but is also intrinsically social, (skills, routines, disciplines, organisational arrangements). This is even more the case in complex, distributed systems as is true for modern technologies. But then, what are we assessing? Consider nuclear risk assessment with respect to power plants. The whole fuel cycle is outside of the scope of this assessment. The question must be asked, not only risk of what harm(s)? but also, from what activities? If we omit salient elements of this in our framing, or omit salient questions about what people may see as harmful that experts haven't recognised as such, we have ambiguity. This is because we have not properly addressed what the issues are for people. These may be legitimately different from those imposed by tacit expert presumptions. Risk assessment is intrinsically social. However reliable and precise it is, its very scientific units (of specified selective measures of harm, from selective units of activity) reflect implicit value-choices and social assumptions which may not be universally shared, so do its intellectual framing commitments (what is deemed salient, and what is implicitly deemed non-salient as a concern).

Structure – property relationships of this kind are discussed. Stability of cause-effect may be observed within ranges, but what ranges? Are laboratory observations valid for real conditions? We need to pose more complex and more self-reflective questions. Moreover, one form of public concern is that, beyond risk questions, there are implicit and thus unaccountable visions of human ends in innovation-oriented research. These are material issues for society, not just abstract analytical ones.

*Upstream Questions: From risk to scientific imaginations of human ends*

The current expert conviction is that people are only concerned about risk and safety. But they are not concerned about these questions alone. When people explain their concerns about GM for example, they express questions such as what assumptions and visions of social ends are driving this, what are the driving interests and purposes? And why are these unaccountable? Why are scientists even studying this (and, under the name of innocent 'study', also manipulating)? One wants to question the scientific players about their assumptions, and imaginations, of social outcomes and human ends. This goes far beyond risk assessment but is entangled in it in an unanswered and unaddressed manner. In a risk assessment context, questions are restricted. Some questions are excluded.

Consider the bovine somatotropin (BST) example (higher cow milk production): because of higher udder-infection rates with BST, many farmers administer antibiotics, as a preventive measure. This is not included in BST risk assessments, because it is an indirect causal pathway to harm (wider societal antibiotic resistance). Is it part of the risk of BST, or not? In this, as in more general cases like GM crops and foods risk assessment, the public experiences' denial on the part of officials, all in the name of 'sound science'. Is it surprising that science is discredited?

Risk assessment is, in general, very downstream, when possible impacts become visible on the radar. The public have more upstream concerns: why all of this in the first place, what is the motivation? There is an un-stated lack of predictive control – people have a sense of this. This is the basic reason for public mistrust of scientific claims over regulation and risk assessment. It is about an unrecognised dislocation of meanings, and an institutional-scientific misunderstanding of the public. Granted that plenty of – too much – public misunderstanding of science exists, this is *not* the cause of public resistance or mistrust. This is due to institutional misunderstanding and denial of its own lack of (predictive) control.

People with upstream questions, recognising that there are always unpredicted effects, do not normally expect or demand that things be shut down. They just want to hear good reasons, and to experience honesty and modesty, as well as debate of those reasons. They wish to experience respect! Regulations have been institutionalised in such a way that they address only risk questions. The benefits and alternatives questions have already been presumptively and privately answered, because if any product is advanced for regulatory decision it is deemed by definition to be of social benefit, and alternatives are simply excluded. This needs to be reconsidered. Risk assessment is thus crippled, since benefits questions are excluded. What human visions and considerations of social gain, need and priorities are driving scientific research and technological development? Ultimately, scientists and the public have the same fears: who is in control of these things, for what assumed ends? There is a yawning democratic deficit here; and it is one whose remedy does require us not to pretend that the typical public are able to know science or tell it what to do.

*Public trust: or trustworthiness?*

Finally, on the 'restoring trust' issue, Professor Wynne underlines that most public involvement activities are motivated by the expectation and aim of regenerating public trust. He has two critical observations on this. One is that the founding premise, that previously there was positive public trust in science, is most likely a historical fallacy. Lack of mobilised public concern, in the form of overt opposition, does not mean lack of public concern. Most previous so-called golden ages of public acceptance, such as the 1950s-60s, and nuclear power were more of actively cultivated public quiescence. This was despite copious public concern, scepticism and opposition at a less mobilised, more diffuse and distributed local level. This context of multivalency, scepticism and questioning – from within independent collective public frames of meaning – is a more generally typical state of affairs. Concerns are rightly often about social dependency on institutions operating in the supposedly neutral name of 'science'. Their real aims, expectations and assumptions, however, may be obscure and unaccountable. Furthermore, their track-record may not have been open and accountable. For these reasons, these institutions are unlikely to engender trust.

A second remark is that to make 'the public trust in us' into an objective or expectation of public engagement is self-defeating from the start. This instrumentalises the relationship involved into one where (for however benign or otherwise the intent) we are manipulating the other in the relationship – here ‘the public’. It is a contradiction in terms to expect such manipulation to generate trust. It may engender public quiescence, but that is different and much more unstable. Whatever else we do, we should not engage in false pretences. The only thing which we can or should manipulate here, and exercise control over, is our own trustworthiness.

*Questions and answers following the presentation*

One participant remarked that he agreed on the need of interaction between natural sciences, social sciences and the public. But the problem is the lack of a common language. Professor Wynne’s response was that this is indeed hard work and takes time; however, “a little can go a long way”. A common language means mutual understanding, and in early 21st century society we have historically developed, almost celebrated, a science and technology which deliberately cultivated public alienation from science (“go away and leave us to do our own thing and you can trust us. You don’t need to know what we do”). Thus the lack of a common language or common basis for mutual understanding will not be overcome instantly.

## *Societal Aspects of Nanotechnology beyond Precaution: Some Early US-EU Comparisons and Contrasts*

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### Abstract

Under the influence of the much-debated losses of public trust linked to bioscience, and before that to nuclear energy, the makers of the current boom of public nanotechnology investments in 2000 assured that “this time we’ll make everything right from the start”. Fair enough, we all want to make everything right, and even better if it is from the very start. But who then can help us with this? Where should we look? Could we start with what we have on our shelves and just add the tiny ‘nano’, swiftly creating the helpful nano sociologist, the nano psychologist/therapist, the nano philosopher, the nano media expert, and so forth? Or do we instead have to re-educate and re-style the nanoscientists and nanotechnologists, breeding, as it were, the ultimate, universal, impeccable ‘make-nano-right-from-the-start specialist’, in order to pursue that zero-mistake/zero-trouble vision?

Starting with some observations about who has and who has not been enrolled in the nano endeavour since that promise was made, this presentation will proceed by raising a few more fundamental issues concerning our relations to and constructions of expertise. Also, the cultural comparative dimension will briefly be touched upon, by way of suggesting some national/regional differences influencing this; with reference, in the concluding part, to current research on the importance of recognising the role of public or civic epistemologies.

### Transcription

We all want to make everything right from the very start. This was the official policy declared when the American National Nanotechnology Initiative was launched in 2000. From day one, this initiative included funding which was particularly oriented towards the societal, legal and ethical implications of the emerging technology. But where could we look to get going? Could we start with what we have on our shelves and just add the tiny ‘nano’, swiftly creating the helpful nano sociologist, the nano psychologist, the nano philosopher, the nano media expert, and so forth? Or do we instead have to re-educate the nanoscientist? Do we need to breed the ultimate, universal, impeccable ‘make-nano-right-from-the-start specialist’, in order to pursue that zero-mistake vision?

Professor Glimell's talk started with some observations about who has and who has not been enrolled in the nano endeavour since that vision was announced. He proceeded by raising a few more fundamental issues concerning our constructions of expertise, and how a communication between natural and social scientists can be enabled. In the concluding part, some current research was introduced on the importance of recognising the role of what has been labelled civic epistemologies (see below).

*A new social contract between science and society*

There are new expectations: (1) Science is increasingly expected to re-enter society to engage also in joint production of 'contextualised' or 'socially robust' knowledge, beyond scientific truth; (2) Policy is expected to move away from élitist and authoritarian forms of government towards more open and inclusive patterns of governance; (3) In the knowledge society, citizens are expected to shift from being ignorant or perhaps distant critics of science to becoming true participants and active consumers of the novelties of science-based innovation (the breeding of 'the scientific citizen').[7]

Professor Glimell stressed the necessary linkages between hard and soft sciences. He considered a number of conceptual tools:

Conceptual Tool (I) for dealing with interdisciplinarity – boundary object:

- Boundary objects are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain common identity across sites.
- ...plasticity is the ability to adapt to different circumstances to meet the heterogeneity of the local requirements represented among involved actors.
- ...coherence is the capacity of the theory to incorporate many local circumstances and still retain a recognisable identity.
- Boundary objects serve as repositories of multiple meanings.

Conceptual Tool (II) for the exchange of knowledge – 'trading zone' (TZ)[8]

- An unequal TZ: a network where experts use their specialised knowledge to dictate how a system will function. The expertise is 'black-boxed' for others, as when social scientists identify needs and tell them to the nanotechnology researchers.

[7] Elam M, Bertilsson M. 2003. Consuming, Engaging and Confronting Science; The Emerging Dimensions of Scientific Citizenship. *European Journal of Social Theory*, 6(2):233-251.
[8] Gorman ME, Groves JF, Shrager J. 2004. Societal Dimensions of Nanotechnology as a Trading Zone: Results from a Pilot Project. In Baird D, Nordmann A, Schummer J, eds, *Discovering the Nanoscale,* IOS Press, Amsterdam, The Netherlands, pp 63-76.

- TZ as a Creole: experts from different fields interact in the development of a technology or object. They see the objects in ways dictated by their own expertise, however interacting in making decisions about societal impacts, sharing terminology and developing new concepts.
- A shared representation trading zone: creole re-placed by genuinely new languages as experts work collaboratively. Boundaries are blurred, boundary objects temporary. This puts the social sciences alongside sciences where nanotechnology breakthroughs occur.

*Four roles for the nano social scientist [9]:*

- Observation: carefully track the emerging field and catalogue its practice, without necessarily intervening to divert its course.
- Communication: allow nanoscience researchers to explain technical capabilities and limitations to the general public while allowing the general public to explain social needs and concerns to the research community.
- Remediation: build on both these, assisting in helping to control and repair undesirable side-effects before they become too severe.
- Restructuring: take advantage of the sweeping novelty of nanotechnology in order to envision new social institutions (laboratories, disciplines, markets, professions) more flexible, open and egalitarian than those they would replace.

*Civic epistemology*

Sheila Jasanoff has published quite relevant work[10] here**.** In a society there exist (just like folkways) culturally specific tacit knowledge-ways through which the rationality and robustness of scientific claims are assessed. Civic epistemology denotes these and the institutionalised practices by which members of a given society test and deploy knowledge claims for making collective choices. Research has demonstrated how these are historically and politically grounded, i.e. culturally specific. For a current example, see the following table summarising a comparative study of biotechnology/bioethics (in particular GMO and stem cells) in the United States, Great Britain, and Germany**.**

[9] Suchman M. 2002. Social Science and Nanotechnologies. In Roco M, Tomellini R, eds, *Nanotechnology: Revolutionary Opportunities and Societal Implications,* Proceedings from the 3rd Joint EC/NSF Workshop on Nanotechnology, Lecce, Italy, 2002, pp 95-99.

[10] Jasanoff S. 2005. *Designs on Nature: Science and Democracy in Europe and the United States.* Princeton University Press, Princeton, NJ, USA.

***Table 1: Civic epistemologies – a comparative view***

| | **United States**<br>**Contentious** | **Great Britain**<br>**Communitarian** | **Germany**<br>**Consensus-seeking** |
|---|---|---|---|
| Styles of public knowledge-making | Pluralist<br>Interest-based | Embodied<br>Service-based | Corporatist<br>Institution-based |
| Public accountability (basis for trust) | Assumptions of distrust<br>Legal | Assumptions of trust<br>Relational | Assumptions of trust<br>Role-based |
| Demonstration (practices) | Sociotechnical experiments | Empirical science | Expert rationality |
| Objectivity (registers) | Formal<br>Numerical<br>Reasoned | Consultative<br>Negotiated | Negotiated<br>Reasoned |
| Expertise (foundations) | Professional skills | Experience | Training<br>Skills<br>Experience |
| Visibility of expert bodies | Transparent | Variable | Non transparent |

*Delimiting novel issues of responsibility from familiar ones*

Again, according to Suchman (see footnote on previous page) nanomaterials arise from the manipulation of the nano-scale structure of macro-scale substances (wear-resistant tyres, super-hard ceramics, ultra-fine membranes, etc.). Nanotechnology is here primarily linked to chemical engineering and material science.

- Nanomaterials are not a new phenomenon (transformative compounds).
- Nanomaterials may become revolutionary, but ‘revolutionary in relatively familiar ways’.
- Policy issues are linked to particular products, not to inherent traits of the technology *per se*; case-by-case planning an adequate and sufficient response.

Nano-machines concern technologies constructing nano-scale devices for use in macro-scale environments; e.g. ultra-small *in vivo* medical devices, miniaturised surveillance systems, or Lilliputian mining and manufacturing equipment. This links nanotechnology to mechanical engineering and robotics. Nano-machines**:**

- entail distinctive properties: invisibility (dramatically increasing the potential for orchestrated covert activities); micro-locomotion (the ability to move through and within macroscopically solid matter); self-replication;
- pose unprecedented policy issues, ‘open up a genuinely new frontier’.

Consensus is only one option here. As science helps expand the scale and scope of innovation processes in society (e.g. by opening up innovation to broader participation), so it helps expand the scale and the scope for potential disagreement in society (i.e. controversy is just as likely as consensus to characterise innovation processes). As Latour[11] puts it: "…by adding new ingredients to collective experiments, science does not promise to put an end to politics, it only serves to enlarge politics further".

Finally, one quote about being sensitive to the demands of public arenas: "The viability of the regulatory process may therefore actually depend upon the very opposite of intensification of science; it may require that some imprecision and ambiguity of formal regulatory standards and definitions be maintained, as an adaptive arena in which contending parties can interact, negotiate, and settle and renegotiate the practical meanings as they go along"[12].

[11] Latour (1998), cited in Elam M, Bertilsson M. 2003. Consuming, Engaging and Confronting Science; The Emerging Dimensions of Scientific Citizenship. *European Journal of Social Theory,* 6(2):233-251.
[12] Wynne B. 1999. Knowledges in Context', in Scanlon E, Whitelegg E, Yates S, eds, *Communicating Science: Contexts and Channels, Reader 2*. The Open University, London, UK, pp 4-13.

## *Ethical Issues Associated with Nanotechnology*

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### Abstract

Social scientists, ethicists, and others have been slow to appreciate the impacts of nanotechnology on society. Those who have examined this topic have focused on questions dealing with social justice, equity, technology transfer, benefit sharing, nano-divides, and privacy issues. Much of this analysis is predicated on an assumption that nanotechnology is a suite of enabling approaches and technologies that will incrementally improve manufacturing techniques, product design, and product performance. Consequently, the social and ethical 'risks' that are hypothesised to flow from these advances deal with issues of allocation and potential misuses of the technology. Simultaneously, risk assessments on the products of nanotechnology tend to focus on the toxicity of nano-particles. In a sense, these approaches fail to appreciate that many of the risks to society, human health, and environment are likely to result from the convergence of nanotechnology with biotechnology, robotics/cybernetics, and information/communication technologies. This presentation will examine how converging technologies pose unique ethical dilemmas.

### Transcription

There are few direct ethical issues associated with nanoparticles. These include the nature of the research enterprise. A key development concerning the ethics of nanotechnology is its convergence with other technological revolutions[13]. Convergence is the norm. Most products are the result of it, and it appears to be accelerating. What are the characteristics of convergence? It is a process, iterative (incremental) or stochastic (random), leading to novel products resulting from the coalescence of ideas/insights and the pooling of intellectual property. It varies in pace, complexity and degree of co-ordination. It requires response by several kinds of actors (e.g. competitors, regulators, non-governmental organisations) to address shifts and realignments.

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[13] There are several notable reports on the topic of convergence and nanotechnology.
(1) Roco MC, Bainbridge WS (eds). 2003. *Converging technologies for improving human performance: Nanotechnology, biotechnology, information technology and cognitive science.* Kluwer Academic Publishers, Norwell, MA, USA.
This book is focused on motivations and outlook, expanding human cognition and communication, improving human health and enhancing physical capabilities, enhancing group and societal outcomes, and national security.
(2) Nordmann A. 2004. Converging technologies: Shaping the future of European societies. Report. European Commission Research, Brussels, Belgium.
The report includes definitions of convergence, limits, implications to European research and society, benefits and risks, mobilising knowledge to support convergence, research governance, ethics and social empowerment.

*What drives convergence?*

- Globalisation: driven by IT; enhanced mobility of capital; trade agreements.
- Corporate concentration: IP; strategic alliances and reconfigurations.
- New research dynamic between triple helix actors.
- Expansion of the marketplace: driven by changes in the developing world.
- National innovation agendas and strategic research programmes: nano-based national strategy on comparative advantage.
- National security concerns in a world facing increased terrorist threats.

***Table 2: Convergence***

| **Convergence areas** | **Examples** | **Social/ethical issues** |
|---|---|---|
| Biotechnology and Information-communication | - Bioinformatics (computational molecular biology, comparative genomics, medical informatics) | These issues concern data mining and risks to vulnerable populations, biopiracy, pathogen sequencing and national security risks. |
| Information-communication and Cognitive science | - Expert systems (artificial intelligence)<br>- Implantable devices (spinal cord stimulation to control pain; seizure control) | These issues include effects on labour, whose knowledge is encoded, problems of monitoring/surveillance and social control. |
| Biotechnology and Cognitive science | - Searching for a genetic basis for criminality or homosexuality<br>- Use of DNA databanks for criminal investigations | These issues relate to debates on embryo selection, designer babies, genetically-based justice system. |
| Biotechnology, Information-communication and Cognitive science | - The 'ultimate soldier' | These issues concern matters such as human agency and self-determination, dampening of conscience, risks to society. |
| Nanotechnology, Biotechnology, Information-communication and Cognitive science | | - Regulatory and legal capacity: novelty, pace of change, liability<br>- Privacy: enhanced reach, power effects<br>- Military uses<br>- Nanomedicine: mDNA, genetic testing<br>- Transhumanism: blurring boundaries, performance enhancement, life-extension<br>- Intellectual property, competitiveness, nano divides<br>- Smart materials, assembler-era concerns |

How does convergence create ethical/social concerns? Table 2 above summarises Professor Mehta's presentation of different areas of convergence, the issues involved, and examples. The last row identifies the potentialities and issues when nanotechnology is added to other technological revolutions.

In conclusion, convergence is the norm. However, as suites of transformative technologies come together more complex social/ethical issues emerge (cumulative effects). We need to learn iteratively how convergence operates to generate these issues. Public consultation on topics like nanotechnology will remain inadequate if questions arising from convergence are not addressed fully. National and international policy needs to be developed to address these issues earlier rather than later.

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