Nanotechnology, Risk and Sustainability:
Moving Public Engagement Upstream

Bio – to – Nano?

Learning the Lessons, Interrogating the Comparison

(Amended Version)

A Working Paper by the Institute for Environment, Philosophy and Public Policy, Lancaster University and Demos.

Robin Grove-White, Matthew Kearnes, Paul Miller,
Phil Macnaghten, James Wilsdon, and Brian Wynne.

June 2004

Executive Summary

Background

- *Nanotechnology* promises to be one of the defining technologies of the 21st century. Based on the ability to measure, manipulate and organise material on the nanoscale – 1 to 100 billionths of a metre – it is expected by many to have dramatic and potentially disruptive impacts across the fields of physics, chemistry, biology, materials science and engineering as well as society more generally.

- Yet such aspirations beg a host of questions. At what stages in R&D processes is it realistic to raise issues of sustainability and the public interest, given the generally private and under-determined, nature of such processes at this stage? How and on whose terms should such issues be debated? And how adequate are dominant institutional discourses of risk and ethics in addressing such issues?

- The project asks how, in the light of recent experiences with biotechnology, socially and environmentally-sensitive governance processes might be developed, which can improve the contribution of nanotechnology to sustainable development, by moving the site of public involvement further 'upstream' within R&D processes.

- Reflection on the GM experience highlights the deficiencies in contemporary procedures for the regulation, assessment and public debate around emerging technologies.

- Whilst reporting on the first stages on the two year, ESRC funded project *Nanotechnology, Risk and Sustainability: Moving Public Engagement* Upstream, this paper asks what can be learnt from this experience, in both the regulation and regimes of public engagement, for ensuing debates around technology at the nanoscale. This paper also seeks to interrogate the limits of the bio-to-nano comparison suggesting that new forms of interaction and reflection between scientists and others are necessary in the 'nano-era'.

Findings

- Faced with new situations, legislators and their advisers generally turn first to the tools close to hand. When EU regulation of GM releases first came under consideration in the 1980s regulators drew upon existing resources, appropriate to other technologies. The deficiencies of this approach suggest a need for searching, socially-realistic analysis of the distinctive character and properties of new technologies before regulatory commitments begin to be made. This need for prior review applies as much to reflection on recently developed 'public deliberation' approaches, as to that about more conventional risk assessment methods. It cannot be assumed that the conceptualisations and analytical categories currently available will be able to capture what may prove most distinctive about nanotechnology.

- Risk assessment of the kind implemented in the UK for GM releases, despite its EU 'precautionary' structure, can no longer be seen as an expert scientific' tool' or 'method' entitled to automatic political deference. Before embarking on new frameworks aiming at assessment of potential impacts of nanotechnology, a more sophisticated appreciation needs to be internalised within government and industry of:

  A: Inherent limitations of risk assessment applied to new technologies, even in its new 'precautionary' guises; and

  B: Developments within the social sciences, and in a growing body of recent international practice, of the understanding of risk assessment as properly a social and cultural process, involving public discussion of the values to be protected, the analytical methods to be relied upon, and the parameters of the scientific issues to be addressed.

- The GM experience demonstrates the degree to which contemporary scientific research is informed by tacit visions and imaginaries of the social role of technology. Often explicitly utopic these visions form the basis upon which research priorities are negotiated and planned. In the GM experience such tacit visions were never openly acknowledged or subject to public discussion and debate. Such hybrid techno-social visions or imaginaries need to be more expressly articulated by their scientific authors and subjected to wider social deliberation, review and negotiation.

- In approaching possible concerns about nanotechnology, it is important to be more realistic about the diverse roles and nature of NGOs .The breadth and unfamiliarity of issues now being thrown up by new technologies mean that the sphere is in continuing flux, to which their responses will vary. The ways in which NGOs 'represent' opinion in wider society needs richer understanding, if misleading assumptions are not to be incorporated into discussions about new social or political processes for nanotechnology.

- The GM experience suggests that the deficit model of public scepticism or mistrust of science and technology is a fundamental cultural handicap for institutions charged with the regulation and assessment of new technologies. For nanotechnology there is a need to develop patient and bold attempts to build in more rich, more complex and nuanced, and more mature models of publics into 'upstream' modes of practice. This

can only lead to more sensitive, intelligent, robust and legitimate forms of science, whatever substantive forms they take.

- The GM experience demonstrates the ways in which new technologies often operate as nodal points around which wider public concerns condense. Such processes of 'condensation' are inherently unpredictable. However, a richer understanding of the underlying dynamics of such processes – informed by recent thinking in the social sciences – could begin to provide some clues. In considering approaches to the social handling of nanotechnology and its potential manifestations in applied forms, care will need to be taken to 'design in' resilience against the strains likely to emerge in the event of such patterns of exceptional controversy. This looks set to be a major challenge for political-democratic institutions in the decades ahead.

INTRODUCTION

1. The issue

How likely is it that the emergence of nanotechnology could precipitate socially divisive rows over the coming decade? Are there steps that can be taken now to ensure that this developing field of scientific innovation evolves in ways which come to be seen as constructive and consonant with real human needs and social values? Is it possible to learn from recent previous upsets around new technologies – most prominently, those surrounding GM crops and plants – to move proactively towards widely shared conditions for nanotechnology's development? And if so, what specific forms of political and institutional innovation could help arrive at sensible decisions?

These are the sorts of questions with which the present Lancaster-Demos research project, towards which this working paper is an early contribution, is concerned.

The particular focus of the research – a two-year sociological study based on a partnership between a university research institute and a leading London policy think tank – is on nanotechnology. But the exercise also has a more generic aim – to contribute to fresh thinking about the future assessment and integration of socially powerful technological developments in the novel circumstances of today's increasingly globalised political economy.

This aim assumes particular significance in the light of recent government announcements concerning new funding programmes for 'Science and Innovation' (DTI 2004) – an initiative which aims to give an added boost to the commercial exploitation of leading edge science, to assist national wealth creation in the period ahead.

2. The researchers

Members of the research team have been working on issues of this kind for at least two decades, both as academic social scientists (Wynne & Grove-White 1995, 1998; Wynne 2002; GW et al 1997, 2000; Wilsdon & Willis 2003) and as more engaged advisers and participants for such bodies as the Royal Society, the House of Lords Science & Technology Committee; the Agriculture and Environment Biotechnology Commission (AEBC), the Royal Commission on Environmental Pollution, Greenpeace, Forum for the Future, and Demos.

3. Nanotechnology

Nanotechnology promises to be one of the defining technologies of the 21st century. Based on the ability to measure, manipulate and organise material on the nanoscale – 1 to 100 billionths of a metre – it is set to have dramatic and potentially disruptive impacts across the fields of physics, chemistry, biology, materials science and engineering (Wood, Jones & Geldart, 2003). Yet such aspirations beg a host of questions. At what stages in R&D processes is it realistic to raise issues of sustainability and the public interest, given the generally private and as yet under-determined nature of such processes? How and on whose terms should such issues be debated? And how adequate are dominant institutional discourses of risk and ethics for addressing such issues?

THE PAPER

The present working paper offers reflections arising from the first six-month stage of the ESRC research study.

This stage has involved interviews with a number of individuals active in the pre-1999 development of the regulatory and public involvement phases for GM plants and crops. (These individuals are listed in Annex A).

Given the brouhahas which overtook GM plants and crops in the UK in the 1990s, it is not surprising there is speculation in many quarters as to whether nanotechnology could experience a similarly rough time, in the failures and successes of developing the basic science into commercial applications over the period ahead. Here, it is argued, is a further potentially transformative technology, at roughly the stage of development of biotechnology in the late 1970s or early 1980s. Some NGOs are already suggesting that the issues and problems nanotechnology raises are of such far-reaching political and social importance that there should be a pause, or even a moratorium, till the terms and conditions of its acceptability have been sorted out in advance (ETC 2002).

The basic science is developing rapidly, with encouragement from governments on both sides of the Atlantic. And associated environmental and social issues are already attracting official scrutiny in the UK; not only is a working group of the Royal Society-Royal Academy of Engineering (RS-RAE 2003) expected to report soon, but the ESRC has published an illuminating summary of some of the research issues the new technology can be expected to throw up for social scientists (Wood et al, 2003). All of these initiatives – and other besides – have had an eye to the biotechnology (GM crops and plants) experience.

The reflections that follow seek to draw lessons from this latter history – but lessons of a particular kind. Drawing on the interviews, we comment from our particular research perspective on what might be called the 'GM experience' of the past decade or so, to assist development of the next stages of the ESRC nanotechnology project – stages which will be ethnographic and institutionally experimental in character. The paper is written for discussion purposes, to gain the benefit of others' experience at an appropriately early stage.

A preliminary comment should be made on the period discussed in the paper. The principal focus of the analysis is on the 1980s and 1990s, up to the moment when the controversies over the first period of GM development reached their peak, in February 1999. Clearly, since that time, there have been a number of further developments, including the creation of the AEBC, the Government's GM Dialogue, completion of the Farm Scale Trials, and, not least, the ongoing hearings at the WTO into the formal US complaint on 'Biotech Products' against the EU. But we have drawn the line at February 1999. This is because, for the purposes of this stage of the research, our concern has been to reflect on the underlying processes which shaped the controversies, rather than the unfolding of the post-1998 events themselves.

DISCUSSION

The commentary below is in six sections, each of which discusses a key 'finding' from reflection on the interviews – leading, at the end of each, to a suggested implication for the development of future institutional handling of nanotechnology, within and beyond the present study.

1. 'The GM experience points to the danger of policy community tendencies to "fight the last war"'

Early EU decisions on the social handling of biotechnology in the late 1970s and 1980s took place against a background of growing world-wide experience of environmental and social controversies surrounding civil nuclear power and the diffusion of agrochemicals. The perceived power and potential of biotechnology meant that sensitive handling of its real world possibilities would be imperative, if social 'acceptability' was to be achieved.

Public acceptance problems with civil nuclear power in the 1970s had led UK bodies like the National Radiological Protection Board and Health and Safety Executive to develop increasingly elaborate formalised procedures for 'risk assessment', building on earlier experience within the chemical industry (Royal Society 1982). Such processes offered procedural templates for the advance 'expert' identification of specific potential mishaps ('risks'), leading to assessment of probabilities of adverse outcomes in relation both to particular pathways and to the overall 'system' in question.

Tait & Levidow (1992) have described such systems of risk assessment as constituting a 'reactive/preventive system of risk regulation', including three characteristic features:

- the assessment process reflected only 'scientifically proven adverse impacts that (had) arisen in previous generations of products or processes';
- new products or processes were screened to make sure they did not give rise to similar hazards;
- build-up of the system arose as new generations of product or process exhibited different hazards'.

Thus significantly, this risk assessment template built on past knowledge, rather than taking account also of new types of hazard as yet unproven (the field of concern to which the so-called precautionary principle became directed).

In the mid 1980s, EU governments began negotiations about a system of risk assessment for possible *releases* into the environment of GM artefacts for either research or commercial purposes. Consistent with advice of the Royal Commission on Environmental Pollution (1989), they adopted the established broad template of product-by-product risk assessment, but required that the industry concerned should also look beyond past knowledge to possible future hazards *in advance of empirical evidence for their existence.* Because this system was itself set in place before any products (or their possible hazards) were yet in existence, it was seen as a '*precautionary*' system.

This new GM risk assessment framework (specified in EU Directive 1990/20 and enacted in Britain through the Environmental Protection Act 1990) came quickly to provide more than simply a statutory basis for prior evaluation of specific GM artefacts. We suggest it acted also to set in advance within the policy community a distinctive *normative* understanding of the *nature* of GM artefacts and of how their possible impacts ('to human health or the environment') might legitimately be conceptualised and analysed in wider society.

In the UK, building on the template developed from nuclear power and agrochemicals, the focus of risk assessment was to be only on potential '*direct*' risks arising from the products or processes in question – an emphasis consistent with established British empiricist scientific culture.

The body made statutorily responsible for the assessment of individual GM constructs, the Advisory Committee for Releases to the Environment' (ACRE), thus became the de facto *political* authority on GM releases, backed by the Government's commitment to 'sound science'. The scientists appointed to the committee were overwhelmingly molecular biologists, with an expertise in the 'direct' behaviours of GM plants.

A pattern was set. For most of the 1990s, public debate on the matter was obliged politically to proceed in terms of the categories (particular potential direct 'risks') of individual GM artefacts, considered 'case by case'.

Whatever the merits of this approach, it embodied an unacknowledged limitation carried over from the treatment of nuclear power and agrochemicals. Methodologically consistent, though the case-by-case analytical processes may have been, they had never generated public confidence. For example, much of the controversy surrounding civil nuclear power in the 1970s and 1980s focused on parameters of 'risk' concern inaccessible to such an approach. Matters such as cumulative safety implications of nuclear waste generation and management flowing from reliance on the technology, concerns about plutonium separation and dependency, and contention about the significance of possible 'low probability-high impact' accidents (confirmed as central by Chernobyl in 1986, with its subsequent corrosive consequences for the industry's further development) lay unambiguously outside the method's scope. Indeed, the normative authority of the reductionist risk assessment template can be seen in retrospect to have favoured a misleadingly optimistic official picture of the economic and social robustness of nuclear power.

Nevertheless, we suggest that the 'precautionary' risk assessment approach for GM under Directive 1990/20 embodied a similar fallacy. This led, as the decade advanced, to mounting problems for regulatory authorities like ACRE in the UK, and for governments more generally. As our interviews confirm, from the start advisory scientists in such committees were caught in (but resisted) pressures to extend their remits:

> A lot of the critics have been people who have an innate sense that if a God or related being had deigned that something should be so then we have no right to change it. I just don't believe that … Because he made tomatoes we have no right to put a gene from another species into that tomato, because there is an inviolate right. And because it's an inviolate right, by so doing we're going to perturb something mystical. I'm afraid I don't have any time for that. *But* that's a serious flaw in a regulatory system. The moral, the ethical are other issues. They sometimes are very important. You need to have a way of looking at those. But I have no way of beginning to answer that. But if enough people believe it then it needs to be answered but not by a scientific assessment group. And so the fact that most of these questions were never answered we appeared to be disdainful in not even addressing them I think upset a lot of people. (Interview with Professor John Berringer)

We pursue this matter further in Section 2.

More immediately significant in the present context was the restriction of risk assessment to 'direct' effects, following the nuclear and agro-chemicals template. Whilst at earlier stages superficially plausible (if contested) in relation to processes which were *physical* (in the case of nuclear power), or *chemical* (agro-chemicals) – such a restriction came rapidly to be experienced as deeply misleading in relation to the *biological* nature of GM artefacts, given the situated ecological relationships such living entities inevitably entail, if and when released into wider environments.

Indeed, in retrospect, much of the intensity of the UK's GM controversies in the 1990s can now be understood as having flowed from successive corrective processes to the forms of risk

assessment adopted EU-wide in 1990. Not only did it prove necessary to spend four years painfully revising the scope and terms of the Directive, in order to encompass ecological and other wider effects (achieved finally in Directive 2001/18) – but the ways in which Ministers' and officials' defended the manifest inadequacies of the system operated by ACRE over the period – including sweeping Prime Ministerial criticisms of 'anti-scientific' 'emotionalism' by ACRE's critics – were central to the government's escalating loss of public credibility on the matter.

Possible implications for nanotechnology

Faced with new situations, legislators and their advisers generally turn first to the tools close to hand. The sequence above suggests that this happened with approaches to risk assessment developed for different situations, when EU regulation of GM releases first came under consideration in the 1980s. Even new 'precautionary' adjustments left intact a still-problematic procedural template in the UK.

As regards approaches to nanotechnology, this history suggests an early need for searching, socially-realistic analysis of the distinctive character and properties of the technological form (including its 'social constitution – see Conclusion below), before regulatory commitments begin to be made. This need for prior review applies as much to reflection on recently developed 'public deliberation' approaches, as to that about more conventional risk assessment methods. It cannot be assumed that the conceptualisations and analytical categories currently available will be able to capture what may prove most distinctive about nanotechnology.

In other words, be very careful to ensure we don't set ourselves up 'to fight the last war'.

2. 'The GM experience suggests risk assessment as conventionally understood is unhelpful for anticipating future fault-lines of controversy'

The previous section has noted the tacit *normative* power of the particular reductionist 'risk' discourse embodied in UK (and wider EU) GM regulation from 1990 onwards. By early 1996, ESRC-funded research had investigated and revealed widely shared concern at the consequences:

> Because the regulatory system which addresses the risks of release of GMOs is the only focus for public involvement in the debate, much attention is directed at ACRE. However, both non-governmental organisations' concerns about wider issues and industry's concerns about the [understating of] the potential benefits of GMOs were seen to lie outside ACRE's remit. ACRE and other regulators thus find that neither public interest groups nor industry are entirely happy with their role. There is immense pressure on regulatory mechanisms which are presently legally defined in narrow technical terms, to take responsibility also for wider issues. The mechanisms in question are not appropriate for addressing such issues adequately and there are no other for a for addressing these dimensions. (Mayer et al 1996)

Our interviews confirm that these patterns of discontent caused impotent dismay within ACRE at the time.

> The big issue in terms of commercialising is what happens if you then approve another variety with another gene and then another variety with another gene. You'd need to know something about the inter-relationship of those genes if they come together. And I finished chairing the committee before it was properly decided… First person's dead easy, second person has to take into consideration the first gene, the third has to take into consideration the first two, the fourth has then got three prior genes plus their own in number of different. So there were lots of arguments. I think it's still not remotely solved as to what happens when you've got lots of different genes out there, what are the possible combinations of activity. Again I would go back to saying yes, but if you've got four different varieties of a crop each having been crossed with different related species and such like you've got four lots of unknown assortments of genes reassorting, so we know that when genes reassort you don't end up with disaster. But that's never an acceptable answer for somebody who's got a worry because they'll say well one risk is not the same as another and we're only interested in this one. We don't want to know about that one. That in practice appears to be all right. But had plant breeding come the other way round with GM first and then wide crosses to related species second, there is no way that the related species crosses could be tolerated. So I have a problem how to communicate that quite honestly. (Interview with Professor John Berringer)

Whilst other European governments (including Denmark, the Netherlands, Germany and Norway) responded to such challenges with institutionalised forms of wider social debate about GMO releases and the issues they raised, the only wider UK initiatives were a single 1992 consensus conference, initiated and organised in isolation from government by the Science Museum and AFRC, and with no reporting line into either Parliament or the executive (Joss ref) – and a restricted government-organised 'National Biotechnology Conference' held in early 1997, in belated response to concerns expressed by its own Government Panel on Sustainable Development (1996). Neither of these initiatives was framed to allow examination of concerns of the kind identified in Mayer et al (above).

> I think in the early '90s there was a huge sort of public shift in the understanding and perception of science and science policy makers. I think that was hugely influenced by BSE. And that again I was very much involved in because I had to brief ministers, a lot of the BSE research I was responsible for. The problem is whenever we got on a platform in the early '90s they [government ministers] would always try to explain government policy as being based in good science policy. And I tried to explain to them that, you know, science came in different shapes and sizes and a lot of it was uncertain and that academics carefully chose their projects. There was a degree of certainty but if you were in policy, then

> you had to take things which you needed to know about and not all the data was in and so there was uncertainty through having insufficient knowledge. There was uncertainty because some things are just statistically random. And there's uncertainty because, you know, it's almost impossible to understand the complex mechanisms. And certainly in BSE we saw all of those. I had ministers saying that everything was based on sound science whereas I was still in the laboratory debating whether the prion was associated with DNA, I mean, let alone all of the other steps in transfer of disease, strain dependents. There's a huge complexity. (Interview with Professor Thomas Blundell)

As the 1990s advanced, university social researchers became increasingly active observers of the labile state of public opinion in relation to GM plants and foods. Much of this work – like that of MORI – focused on shifting public 'attitudes', conceived individualistically largely in psychologistic terms, rather than focusing on underlying sources of social tension reflecting limitations in the risk-regulatory framework itself (a matter we consider further in section 5 below). Indeed, most built on the assumption that the normative discourse of atomised science-defined 'risks' offered an analytically sound basis for commentary on the state of public opinion. Our own 1997 study (Grove-White et al, 1997) built on Mayer et al, to point to burgeoning new political dynamics with potentially major implications for both government's authority vis a vis GM releases, and the GM industry's future prospects.

So powerfully entrenched was the established reductionist GM risk assessment discourse, however, and so unrecognised within government the idea that its own 'sound science-based' approach might be contributing to the tensions, that such warnings went unprocessed within Whitehall. Nevertheless, by mid-1998, Monsanto's public relations adviser was reporting a dramatic 'collapse of confidence' in GM plants and foods in the UK - leading to the first high point of GM-related media controversy which engulfed the Government in February 1999.

Possible implications for nanotechnology

Risk assessment of the kind implemented in the UK for GM releases, despite its EU 'precautionary' structure, can no longer be seen as an 'expert scientific' tool' or 'method' entitled to automatic political deference.

Before embarking on new frameworks aiming at assessment of potential impacts of nanotechnology, a more sophisticated appreciation needs to be internalised within government and industry of: (a) inherent limitations of risk assessment applied to new technologies, even in its new 'precautionary' guises; and (b) developments within the social sciences, and in a growing body of recent international practice, of the understanding of risk assessment as properly a social and cultural process, involving public discussion of the values to be protected, the analytical methods to be relied upon, and the parameters of the scientific issues to be addressed. One set of pointers as to how this might be approached has recently been proposed to the World Trade Organisation in relation to the current US-EU 'Biotech Products' dispute (Busch et al 2004).

3. 'The GM experience reveals the formative political and social role of scientific and technological 'imaginaries'.

In the 1970s, many leading genetic scientists expressed effusive visions (in social science terms, 'imaginaries') of the transformative societal futures that would result from advances in genetics and biology. One such figure, C.H. Waddington, described the arrival of genetics as presaging a 'second industrial revolution', surmounting the destructive effects of the earlier revolution based (in his view) on physics and chemistry. This preceded more recent and now often lamented intensifications of commercial pressures within science. Visions such as Waddington's were not simply *scientific* imaginaries. They were *social* too. One of our GM interviewees recalled it thus:

> I remember so clearly getting a very passionate talk, a lecture, evangelical almost about the future of biotech. This must have been in the very early 1970s. And I was totally convinced – that in biotech we would start to see the end of the chemical industry or massive change in the chemical industry. And I think they even said that by the turn of the millennium the chemical industry would have been gone. To me biotech is using water [where] the chemical industry tends to use organic solvent, biotech is using ambient temperatures where perhaps the chemicals industry uses incredibly expensive and high temperatures. Biotechnology allows you to produce some very exciting molecules which you can't envisage producing chemically, proteins being the classic example. I don't really think then we were thinking about DNA, you know gene therapy and that stuff - that was a bit too early. But those were the dreams and that's still my belief. It's a belief that goes right back to 1972. (Interview with Professor Nigel Poole)

Societal and scientific imaginaries of this kind – projections of future imagined worlds embedded within the present – frequently inform and shape new scientific fields. In the STS literature, this is often referred to as a sociology of promises, or expectations (eg Brown and Michael 2003; van Lente, 1997; Hedgecoe and Martin 2003).

Similarly, in the commercial sphere, Monsanto's initial strategic R&D commitment to GM crops and foods systems was justified in terms of equally positive projected visions for future global agriculture and society, beyond 'terminator technology' or proprietary brand herbicide-resistance as purely technical matters. Although now often disparaged as having been focussed exclusively on private corporate profit and control (a plant scientist interviewee spontaneously described GM plant science to us as 'having been hijacked by the big corporations, and not only in their own funding but their influence on public funding too') Monsanto's imaginaries in the 1980s and 90s nevertheless reflected a particular social vision for a more environmentally-benign global agriculture – justified indeed as a major contribution to future sustainable development. Equally striking however was the degree of naiveté within this vision about other social actors' possible responses and expectations.

In the human genomics domain too, comparably questionable visions can be identified. One example is the widespread taken-for-granted assumption within much genomic scientific research, that the postponement of ageing is a natural social good to which science is and should be devoted. The imaginary is clearly benignly intended – but it implies enormous human/social questions, which ought properly to be examined and deliberated, perhaps to be revised, by society at large, in whose name it is being done.

This points to an important learning opportunity. We have found that such human visions and imaginaries are an embedded constituent element of scientific research in the biosciences and genetics. The same appears now to be happening in the nanosciences too.

How does this come about, and in what way is problematic?

The conventional understanding of the relationship between scientific research and the public domain remains an essentially linear model, despite extensive critical discussion. Such models maintain that science produces new knowledge under conditions of insulation from all social influences or values, determined only by natural scientific factors, and ethically neutral. Only once scientific knowledge is thought to have potential 'applications' do such social and ethical dimensions enter in, according to this model. This means that ethical and social issues are acknowledged to arise only in connection with possible impacts, not with the aims and purposes underlying scientific knowledge-production.

In the last decade or so, this model has come under increasingly intense pressure, particularly as competition for research funds has intensified in tandem with the changing political economy of research, under which commercial exploitation and property rights have become centrally significant. Under these conditions the need for even 'basic' scientists to project images of how their research might benefit society in future, has intensified. As basic or pure research comes to be called 'pre-market' research, an unavoidable implication is that the 'basic' research practices are *imagining* possible market outcomes, in ways which may subtly but significantly shape those research agendas and cultures themselves, upstream from eventual outcomes.

A further influence on the knowledge-culture, with similar implications, may be that as commercial-competitive pressures come increasingly to be routine elements of practical scientific research cultures, the imagination of a conceivable pay-off period for a 'do-able' research question may be attenuated, so that only those even 'basic' questions which have an expected scientific pay-off over a shorter timescale, come to be imaginable as 'worthwhile' scientific problems.

Recent experience points to the fact that, despite their scientific significance and, arguably, persuasive power for governments and investors, all of these imaginaries and their social dimensions are insulated from wider recognition and debate, accountability, and negotiation, because they are shielded by myths about scientific 'purity' with respect to normative influences. The GM experience suggests that these tendencies have been reinforced by their repetition in conditions of relative insulation from society within research-policy culture 'silos', or in corporate environments protected by commercial secrecy and/or assumptions about wide societal incapacity for such deliberation. Such tendencies are reinforced by the absence of any political impetus aimed at encouraging the elicitation, explication or wider critical public discussion of what therefore remain informal, unaccountable but undoubtedly influential human visions.

Possible Implications for Nanotechnology

Nanotechnology is now at a much earlier phase of development than biotechnology (in this case, GM crops) public controversies of the late 1990s. Thus particular technological applications and possible impacts are difficult to establish as foci for public deliberation, as they have not yet come to have material forms.

Nevertheless the kinds of projected scientific vision or imaginary, including both informal implicit social dimensions and assumed future benefits, are already in play. There could be benefits for the more legitimate and acceptable social shaping of these technologies if encouragement could be given to the articulation of these hybrid techno-social imaginaries by their scientific authors, with a view to their wider social deliberation, review and negotiation. Consistent with our discussion in section 2 above, the issue of promised social benefits and social purposes (now systematically excluded from established regulatory processes) should become a more deliberate focal point of such public discourse and engagement.

4. 'The GM experience suggests continuing misunderstandings about NGOs and their relationships with civil society'

There is a continuing view – particularly amongst scientists in the biotechnology sphere – that NGOs, acting irresponsibly in association with a sensation-seeking media, *created* the controversies about GM crops. For example:

> '*The conclusive influences on the GM debate in the UK were those of the media and the NGOs*…In addition to the hostile attitude of many newspapers, the NGOs involved in the GM debate in the UK have proved themselves to be very skilled at presenting their position in the media. They are highly organised, have clear points of view and are well funded. They know how to "spin", or change the ways journalists approach a story. *Their mission is not to debate facts and findings but to influence public opinion*, and any debate with them is unlike a standard scientific debate. NGOs are not looking to find a mutually agree solution, but rather *to promote a single uncompromising message.* As one objection is dealt with, they move on to the next, never admitting they might be wrong. Scientists, in contrast, know that science at the cutting edge is not always able to provide clear conclusions. But that does not mean "we shall never know", or even "it is impossible to find out". In that sense, scientific findings are always provisional, but faced with the clear, crisp and often outrageous claims of NGOs, they are unimpressive in public debate' (Professor Derek Burke, former Chairman, Advisory Committee on Novel Foods and Processes, in *EMBO Reports*, 5, 5, 432-436 (2004) (emphases added).

Some of our interviews echoed such views:

> There was a clear view that there was an anti-science agenda that was coming through…The biggest frustration was the dishonesty and the distortion [on the part of NGOs and the media] which it's very difficult to handle. It's extraordinarily difficult to handle (Interview Professor Raymond Baker)

> Fear of the unknown…it's like MMR in many ways. You know, no real benefit – and fear of the consequences. And a confusion because they were being fed downright lies by people. There is no way of actually correcting the [NGO] lies (Interview with Nigel Poole)

Generalised charges of these kinds risk obscuring both important strengths and limitations of NGOs in relation to new-technology issues of the GM kind. Forceful allegations of deceit and misrepresentation carry the implication that NGOs have been purposeful institutionalised actors in society, of one mind and acting ruthlessly to manipulate policy in misguided directions.

But this underlines the importance of understanding more clearly both the limitations and cultural realities of NGOs.

In the first place, it is important to be clear about who and what were 'the NGOs' in the GM case. National bodies like Greenpeace, Friends of the Earth, the Soil Association and RSPB, each of which made a distinctly different contribution to the more visible stages of the controversies, are preoccupied with multiple issues reflecting their own histories and concerns. But from the mid-1990s, wider bodies of opinion, independent of such organisations, crystallised in a host of more ad hoc and *GM-specific* networks, at national, regional and local levels - including Genetix Snowball, the Genetics Network, the Genetics Alliance, Corporate Watch, Genewatch (formed in 1997 partly in reaction to perceptions of Greenpeace's slowness to take up the issue) and many others. This further range of frequently internet-focused associations embraced wide and diverse constituencies of concern, and can be read as 'organisational' crystallisations of the pervasive, but previously latent, public unease about GM-related issues noted in UK social research as early as 1996-97 (Grove-White et al 1997). Contributing to that unease, as such pre-controversy research noted, was burgeoning mistrust at official reassurances on 'risk' matters (including salmonella and BSE), and at over-confident official 'denial' of the validity of other perspectives – as already discussed in Section 1 above.

In reality, UK national NGOs (of the former kind) were relatively slow and uneven in developing coherent 'campaigns' on GM crops. Looking at their interventions over the period with which we are concerned, what is striking is less the clarity and unanimity of those bodies' challenges to GMOs than the difficulties each experienced before late 1998 in knowing how to respond to an issue with implications well beyond the 'environmental' concerns for which they were (and are) differentially organised. Greenpeace for example, following its initial (and resonant) direct action drawing attention to Monsanto's first ship import of GM soya in mid-1996, was uncertain what do next. Despite the existence of a long-established formal Greenpeace International stance of 'opposition' to GMOs, there was protracted internal discussion within the UK office about whether there was any appropriate basis for further initiatives, or on what grounds. Friends of the Earth took the issue up only in 1998, in parallel with the RSPB's shared concern, with the statutory agency, English Nature, in the specific issue of potential biodiversity impacts from commercial growing of GM crops – which led to the setting-up of the Government's Farm-Scale Trials at the end of that year.

To a considerable extent, the national NGOs, far from *leading* the mounting controversies about GM commercialisation up to this point, found themselves in the position of *responding* to the intensity of the wider public unease being expressed through the spontaneous emergence of new independent networks and initiatives. Greenpeace's 1996 soya ship action, and a sequence of subsequent supermarket-focused demonstrations, were essentially ad hoc initiatives, unrelated to any over-arching campaign strategy. Indeed the 1998 recognition of possible specific biodiversity impacts of GM crop commercialisation, with RSPB in the vanguard, reflected the first successful translation of public concern into terms familiar to established UK NGO praxis. Once that watershed had been crossed – and given firm official expression through the setting in motion of the Farm Scale Trials programme – GM crops became validated as an *environmental* issue, and associated NGO interventions then proliferated. But, as previous experience of new campaign issues suggests, little of this would have become meaningful unless reflecting deeper prior tensions in society at large.

This sequence reflects something important about the nature of environmental NGOs. In their present form and modus operandi, they became institutionalised in the 1970s and 1980s, at the interface between official bodies and wider public constituencies, with the common aim of influencing official priorities on a diverse range of environmental matters. Their expertise, and claims to public support, have come to rest on their ability to shape government (and latterly corporate) behaviour in this regard. This has meant translating frequently inchoate concerns into issues to which policy-community actors could respond, *as far as possible in terms consistent with the vocabularies and working practices of such bodies*. Much of the initial difficulty for Greenpeace, Friends of the Earth and others in campaigning coherently on GM-related issues arose from the fact that the dominant 'risk' discourse into which GMO had been channelled offered them minimal scope for interventions of this kind.

As the findings from the 2003 public debate, *GM Nation?*, subsequently confirmed, public concerns were wide and various, including perceptions about intensifying ownership of the food chain by multi-nationals, the latter's closeness to government, scepticism about past regulatory performance, and the potential for future unpredicted mishaps. Ironically by contrast, for their own internal reasons, Greenpeace's stated strategic approach to GM issues was articulated in the idioms of science alone:

> …the difficulty Greenpeace has, is that we are a global organisation and, if one is to take value-based stances on what is and is not natural and the value judgements and the sort of loadings that that comes with, how relevant is it to talk about it in those terms and try and explain one's concern in those terms in China, where the term for nature doesn't actually exist or certainly doesn't exist in any meaningful form that we would recognise in the west? And the same is true to a greater or lesser extent in other cultures,

> that the term nature is not always translatable in the same way or certainly with the same meanings. So whilst I think it's true to say that the motivations for the kind of values based campaigning or campaigns with a value base are, I'd be wrong to dismiss that from what we do. That is not our position. Our position is about scientific risks. Our kind of globally applicable standard is the science of environmental risk. You can say that's the basis of our campaign policy and that's where we're coming from. (Interview with Doug Parr)

Collectively, these various pointers suggest that, whatever the beliefs or personal inclinations of individual NGO supporters or even campaign staff members, national NGOs face unacknowledged constraints in their ability to transmit *the full texture* of concerns of the wider population to new technologies. The drive for legitimacy in relation to arms of government with whom they must interact continuously enforces its own disciplines and habits – even as such bodies seek to channel and give expression to wider concerns and preoccupations.

Their relationships with the national media - environment correspondents in particular - make it relatively easy for them to become seen as embodying wider opinion in circumstances of controversy. But in the GM case, this may have acted to foster a simplistic impression of calculated campaign leadership from top-down – translating in some quarters into 'blame' for the pattern of events which ensued.

Such exaggerated ascriptions of agency to NGOs in relation to recent GM events need to be understood alongside the equally questionable 'deficit model' of the public, considered in section 5 below. Both notions are equally misleading as guides to what really went on.

Possible implications for nanotechnology

In approaching possible concerns about nanotechnology, it is important to be more realistic about the diverse roles and nature of NGOs .The breadth and unfamiliarity of issues now being thrown up by new technologies mean that the sphere is in continuing flux ,to which their responses will vary. Even new global NGOs like ETC, whose radical critique of nanotechnology has already been influential, have their own histories and priorities.

The ways in which NGOs 'represent' opinion in wider society needs richer understanding, if misleading assumptions are not to be incorporated into discussions about new social or political processes for nanotechnology.

5. 'The GM Experience Highlights the Misleading *Construction* of 'the Public"

Like earlier nuclear controversies, the recent GM events stimulated a proliferating body of social research seeking to understand public attitudes, understandings and responses. Yet despite such work, including a succession of official EU-wide Eurobarometer quantitative surveys of attitudes and understandings, it remains disappointing how relatively primitive the understanding of publics in this regard remains.

Paradoxically, much of the self-conscious attempt to 'listen to and understand' people's responses in the GM context, has appeared to impose representations of 'publics' which embody presumptions on the part of the 'listener/observer', rather than attempts genuinely to *hear* what public respondents may be trying to express in all its challenging complexity, obliqueness and subtlety. Social scientists must assume some responsibility for this state of affairs, as much as the policy actors to whom they have sought to communicate findings and interpretations.

The philosopher John Dewey expressed the basic problem colourfully, in 1927:

> Is the public much more than what a cynical diplomat once called Italy: a geographical expression? Just as philosophers once imputed a substance to qualities and traits in order that the latter might have something in which to inhere and thereby gain a conceptual solidity which they lacked on their face, so perhaps our political 'common-sense' philosophy imputes a public only to support and substantiate the behaviour of officials. How can the latter be public officers, we despairingly ask, unless there is a public?

Dewey recognised however, like sociology of science constructivists later, that 'construction' does not mean 'unreal' – quite the opposite. But this underlines how easy it is for selectively simple accounts of the complexity and depth (and perhaps contradictions) of public attitudes, meanings, and responses to institutional behaviours, to be reproduced as if 'real'.

The 1970s and 80s arguments around civil nuclear power saw the systematic 'expert' characterisation of public attitudes as subjective, emotional and false *risk perceptions.* In the late 80s and early 90s, equivalent advisers in the biotechnology field, with few exceptions, fell into a similar trap, assuming that public concerns about GM crops could only be founded on a public deficit of understanding. Anyone with a correct view of reality could not conceivably question these technologies, such scientific participants suggested. To public scientific advocates in bodies such as COPUS (the Royal Society committee), Health and Safety Executive, and DTI – who all presumed that issue was properly about risks as defined by risk-assessment science –any disinclination to accept must therefore be based on a (false) belief that the risks were too high. This was assumed to be the meaning of the issue to the public – an imputation which involved both a construction *of* 'the public', and a projection *onto* them, of the unquestioned conviction that the meaning to the public must be the same as its meaning to scientists.

Thus the deficit model came to confuse public debate about the science and related issues (eg Royal Society 1985). But it was not the identification of deficits of understanding which was the problem, so much as the presumptive belief that this must be the cause of opposition or scepticism.

Even following the official discrediting of the 'deficit model' (eg in the House of Lords March 2000, *Science and Society* report), this misconception came to be resurrected, albeit in a succession of new versions. Such persistence reflected an institutional science and policy culture – of regulation, policy advice, industrial lobbying, risk assessment, research funding and science communication – which continued to project problems of conflict, mistrust and

scepticism about prevailing science and what was done and said in its name, onto other supposedly blameworthy agents - elements of the public themselves, sensationalist media, or mischievous NGOs. In other words, responsibility for such problems was continually externalised away from official institutions and their embedded cultural reflexes, such that government and scientists' own roles were never put in question.

A further element of this insistent but misleading construction of the public throughout the 1990s GM events was the conviction that public opposition was founded in *fear*, as distinct from mistrust or even outrage at being misrepresented by those scientific and policy institutions. Thus on this view the public was concerned only instrumentally about risk, and risk discourses were the only appropriate resources for forms of (attempted, but failed) reassurance. This aspect has already been discussed in section 2 above.

There were further dimensions to these projective constructions of the public, experienced institutionally not just as hypothetical and revisable representations but as embedded convictions, including:

- individualism as a supposed citizen-attribute
- zero-risk and certainty-craving (thus acknowledgement of scientific lack of knowledge was assumed to be dangerous and destabilising)
- incapacity to cultivate autonomous meanings through relational interactions and experiences
- framings of issue-meanings as reflecting discrete scientific boundaries (eg risks from specific technology or practice or site), rather than truly experienced social boundaries (eg trajectories of past claims and promises, and future possible developments).

The emergence of the newly-created and more inclusive AEBC after 2001, led to the 2003 GM Nation debate and to some effective challenge to these deficit model, risk-ridden institutional constructions of the public. But to the extent this has occurred, it has tended still to be within the embedded assumption that risk assessment is the fundamental mode of authority.

Thus the dominant discourse continues to neglect acknowledgement of unpredictable effects (beyond risk assessment which by definition is only about known effects), which could in turn lead to debate of upstream purposes and ends of scientific research knowledge. This reconnects us with the discussion of section 3, on scientific imaginaries and their accountability.

Possible Implications for nanotechnology

The biotechnology experience suggests that the deficit model of public scepticism or mistrust of science and technology is a fundamental cultural handicap of the UK's institutions dealing with such issues. It is as if they are unable to take the risk of trusting their publics a little bit more. It is a syndrome which is not only a function of scientific institutional cultures, but one reinforced by a wider policy and political culture.

Wherever these problems (and potential solutions) may be seen to originate, they are surely key problems, and can only be remedied for nanotechnology by patient and bold attempts to build in richer, more complex and nuanced, and more mature models of publics into new institutional experiments. This could point the way towards more sensitive and socially intelligent outputs of scientific research, whatever the substantive forms they might take.

6. 'The GM experience suggests that controversies about particular new technologies may serve as condensation points for new forms of political argument, in the circumstances of late-industrial society'

GM crops had become something of an *iconic* environmental and social issue in many countries by the end of the 1990s. Precisely how and why is much discussed.

At the immediate level, concern crystallised around the potential for unforeseen ecological consequences and the relevance or otherwise of GM to the needs of agriculture and food production. But discussion of the technology also reflected a broader set of tensions. These condensed onto GM crops because of a particular range of institutional and cultural contingencies shaping the technology and its development (Wynne 2002; Jasanoff forthcoming).

Global drives towards new forms of proprietory knowledge; shifting patterns of ownership and control in the food chain; issues of corporate responsibility and corporate closeness to governments; intensifying relationships of science and scientists to the worlds of power and commerce; unease about hubristic approaches to *limits* in human understanding; conflicting interpretations of what might be meant by sustainable development – these and numerous other 'non-scientific' issues were part and parcel of what many people have seen as being involved. Whilst scientists and governments urged restriction of discussion to issues falling within the 'rational' frame of scientific risk assessment, for others it was equally reasonable to call a far wider range of meanings into play.

In reflecting this broader array of tensions, the GM crop controversies became, for many, a medium for arguments reflecting underlying patterns of political economy in the post-GATT world – a world of intensifying global trade, generating extensive social and economic change and upheaval, creating new haves and have-nots, and further eroding historically-given patterns of political accountability.

This was hardly without precedent. In the very different circumstances of the 1970s, world-wide disputes about civil nuclear power had played something of an analogous role. Here too was an apparently unstoppable technology, which became a vector for both issue-specific concerns and more general social and political anxieties. Thus beyond detailed challenges about nuclear safety, open-ended problems of nuclear wastes and the like; bigger issues presented themselves in intense forms. Just as the recent generic concerns about GM have been reflections of tensions within the particular contemporary political economy of the millennium, so with nuclear power in the 1970s and early 80s, a range of then-current wider preoccupations were integral to the disputes. Amongst these were concerns about centralisation of the state, the power and carelessness of technical bureaucracies, creeping encroachment on civil liberties, partisan official use of economic and scientific knowledge, and so forth. The nuclear power controversies gained much of their dynamism from that technology's appropriateness as an expression of such tendencies, inherent in its very nature or 'social constitution' (Grove-White et al, 2000).

For both GM and nuclear power, the social intensity of the arguments reflected not simply 'technical' issues held to be legitimate by governments and scientists, but also wider social relations in which the respective technologies were embedded (indeed, of which they were judged to be reflections) at their particular historical moments. Thus it is not too much to suggest that in the GM case, what has been at issue is an implicit debate about different visions of society through the medium of particular manifestations of the technology itself. In the

absence of other meaningful fora in which such debates can take place, GM became the occasion and the opportunity.

There are sharply different views about the propriety of this. As we have argued in sections 1 and 2 above, politicians, industrialists and many scientists have sought to give *normative* social force to their favoured 'risk-assessment' framing of GM issues, and to marginalise the wider concerns as illegitimate and irrelevant to the specific decisions society must take. Others take a different view – technologies are not simply 'tools' but embody political and social values, which are legitimate and indeed necessary foci of discussion.

The key point is, whatever the merits, these things will happen. One possible form of response is to deplore the incursion of 'non-scientific' issues into such matters and to seek to expel them – reasserting 'science' as the sole arbiter, from its late-modern position of cultural supremacy. But this would seem to fly in the face of both political realism, and growing understanding in the social sciences of the contingent, value-judgement-laden nature of science itself, when harnessed in risk assessment contexts.

An alternative is to accept that values and social contingencies are inherent in the development of all technologies, and to explore creative institutional approaches for generating greater mutual understanding.

To persist in denial of the political meanings of technological controversies appears a recipe for continuing corrosion of respect in political and scientific expertise. In ever more technology-implicated societies, such processes of condensation onto particular manifestations of technology seem bound to occur. The events around GM have been simply the latest graphic instance.

Possible Implications for nanotechnology

Of their nature, the processes of 'condensation' discussed above are inherently unpredictable. This is true both of the possible focal technologies in question, and of the social and cultural dimensions likely to emerge as significant in particular future contexts. However, a richer understanding of the underlying dynamics of such processes – informed by recent thinking in the social sciences – could begin to provide some clues.

In considering approaches to the social handling of nanotechnology and its potential manifestations in applied forms, care will need to be taken to 'design in' resilience against the strains likely to emerge in the event of such patterns of exceptional controversy. This looks set to be a major challenge for political-democratic institutions in the decades ahead.

Conclusion

The goal here, in thinking through the GM experience, has been to conceptualise the implications of this experience for approaches to the future development and assessment of nanotechnology. Our basic contention is that there is significant insight to be gained from reflecting on the GM experience.

Throughout, we have sought to suggest some of the possible implications of this experience, that need to be incorporated into future negotiations around nanotechnology, and science and technology more generally. For example, the GM experience evidenced a tendency that when faced with new situations and technologies, regulators turn to assessment frameworks developed for previous technologies and tied into existing debates. We suggest that, in the context of this understandable tendency to 'fight the last war', there is now a need for searching, socially –realistic analysis of the distinctive character and properties of particular technologies. Similarly we suggest that the fact that the still inherently narrow Risk Assessment paradigm adopted in the evaluation of GM implies the need for a more sophisticated understanding of the limitations of Risk Assessment and the understanding of risk assessment as a cultural and scientific process. For each of the six key reflections on experience of GM we suggest that there are important implications that need to be addressed in the assessment, evaluation and public policy around nanotechnology. However, beyond these implications lies a more fundamental question—what might it mean to 'learn from experience'? If, as suggested by Lowenthal (1985), the 'past is a foreign country', in what ways is it possible to 'learn' from such experience?

For Lowenthal, history is not an objective record of facts and past events. Rather it is constructed in its telling and retelling as history. History is, in this sense, stories that make sense of the past rather than a simple record of it. Our sense of the recent GM history is composed through a combination of our own direct involvement and recollections and the history-telling of those we have interviewed. That is to say that—the history of the GM experience, from which we aim to glean insights for further investigation of nanotechnology's possible future, is based in memory (or memories) rather than strictly in fact[1]. It is a kind of distributed history, pieced together in fragments through a combination of direct encounter and stories and narratives of qualitative interviews.

This fact is, undoubtedly, a challenge that confronts any historian or sociologist. However, aside from the question of accuracy, the deeper challenge is; how is it possible to learn from such history? Levitt and March (1988) term this kind of intentional, deliberative learning 'organisational learning'[2]. They suggest that such learning is collective and distributed, based in 'inferences from history' rather than in facts about the past. In seeking to learn from the GM experience it is necessary to specify exactly how we expect this learning to take place. Whilst we have suggested that there are instrumental implications of the GM experience for the regulation of nanotechnology (and science and technology broadly) we distinguish between 'reflective' (or even 'moral') and 'instrumental' forms of learning. What we are interested in pursuing is a deliberative or reflective mode of learning rather than simply the compilation of insights, from the GM experience.

Instrumental learning might be summarised as that which occurs as an accumulation of insight, but insight within more or less assumed and fixed (explicit or implicit) ends. As we have explored, there is a tendency in the initial stages of the evaluation and regulation of novel

[1] See also Hacking (1999)
[2] See also Huber (1991), Easterby-Smith (1997), and Popper & Lipshitz (1998).

technologies for assessment protocols and discourses to be built on the existing range of resources. For GM, regulatory procedures more suited to the assessment of the physically enclosed processes of physics were problematically applied to the assessment of the biological and ecological technologies. Similarly debates that played out in the GM experience were informed by awareness of previous antagonisms around the controversial development and construction of nuclear power stations. This discursive and policy setting, in which GM was placed, evidenced an instrumental sense of learning. Though debate around nuclear power had tested the limitations to the regulation of science and technology, any lessons taken from this experience were of an instrumental character, affecting the underlying discursive foundation of Risk Assessment itself to only a limited extent.

This same sense of instrumental learning is evidenced in current EU-level discussions about the future regulation of nanotechnology. Despite gathering discussion about inadequacies in current Risk Assessment paradigms, current regulatory frameworks continue to rely upon a model of the public based on the deficit model of the public understanding of science. Despite the fact that social, ethical and moral implications of nanotechnology should form an essential element of the upstream development and assessment of nanotechnology, an assumption that Risk Assessment should be both neutral and 'expert-led' persists.

For example, whilst the recent European Commission communication on nanotechnology: *Towards a European Strategy for Nanotechnology* (2004) outlines the importance of the co-constitution of nanotechnology with broader societal questions. It also perpetuates a model of the public inherent to the regulation and assessment of GM:

> It is in the common interest to adopt a proactive stance and fully integrate societal considerations into the R&D process, exploring its benefits, risks and deeper implications for society. … this needs to be carried out as early as possible and not simply expecting acceptance post-facto. In this respect, the complex and invisible nature of nanotechnology presents a challenge for science and risk communicators. (p. 19)

Whilst the communication signals the importance of the upstream inclusion of consideration of the societal implications of nanotechnology, it goes on to to suggest that these implications represent a challenge to the communication of 'science and risk' rather than to the constitution of the technology itself. The deficit model persists in this suggestion that, despite forms of upstream public engagement, public concern may be simply handled by 'a serious communication effort' (p. 20). Such persistence with the deficit model despite recent recognition of its inadequacy, when seen in the context of recognition of the need for more up-stream engagement practices in the development of nanotechnology, risks representing a form of instrumental appropriation of the GM experience. In this mode, the challenges posed to existing regulatory frameworks by GM imply a need for experiment in new forms of public engagement. Without challenging the adequacy of expert-led Risk Assessment, techniques of up-stream public engagement risk being simply added to the existing set of regulatory methodologies. Indeed Dr Ian Gibson (MP) spoke of this currency of newly proposed methodologies for public engagement:

> Everybody's doing public understanding of science now. I must have been at thirty-five dinners this year on public understanding of science and you just shut your eyes and it could be anywhere. They're all the same, they're all saying the same thing. But not one of them really, *really* has got the mechanism to get into the public. They don't know where the publics at. You know. They're called public meetings, you know, I've been, the public meetings I've been at I know everybody there, you know, and I know where they're coming from, the different groups, sub-groups or whatever, you know. Breakaway groups. And I just think that's a real problem how we get into the public on these issues. (Interview with Dr Ian Gibson MP)

Gibson signals the widely held belief that, due to the level of controversy and public disquiet in the official regulatory and assessment mechanisms for GM, there is a need for a different approach to the future assessment of science technology, including nanotechnology. However, for Gibson, this is purely a matter of fashion—that 'everybody's doing public understanding of science now'. That new techniques for assessing the public understanding of science are 'in vogue' demonstrates a kind of instrumental learning. In this mode the suggestion is that the lesson to be learned from the GM controversy is that science needs to be more effectively communicated, and that new methods need to be engaged in conceptualising public understandings of science. This mode of 'learning' is simply that of adding fresh techniques of public engagement to the existing range of technical assessment methodologies. This is not the kind of deliberative learning that might challenge assumptions of expert-led Risk Assessment in the way that now seems appropriate.

Such 'instrumental learning' may be distinguished from 'moral' or 'reflective' learning, which rather than being the accumulation of historical insights is a form of reflection upon the past and one's own position in it. Rather than the use of the past to bolster one's own position for future action, such learning is self-reflective. It includes both:

a. A learning about other legitimate actors that one has not previously noticed or respected, but whom one learns are worth taking account of respectfully in the relevant arena; and

b. A learning about how the ends of the processes in which one is involved might be worth revising, or making open to review. This would 'naturally' involve reflection about one's own institutional outfit or culture and its assumed commitments and identity.

It is this sense of reflective learning that seems appropriate to engage in relation to nanotechnology. Rather than simply compile a series of insights about the GM experience, or simply add another form of 'upstream public engagement' to the existing set of evaluative techniques, we wish to critically reflect on the GM experience. This necessitates a kind of learning that reflects on and questions the very pillars around which the GM experience was formed: science, technology and the public.

Building on insights summarised in this first stage of the project the aim in subsequent stages will be to explore and then to experiment practically with the implications of relevant forms of reflective learning. This will aim to be an experiential process, interacting with scientists in nanotechnology laboratories and a range of wider groups, both 'expert' and 'lay'.

This will build, inter alia, on ideas ex0plored in an earlier Lancaster study – *Wising Up: The Public and New Technologies* (Grove-White et al, 2000) – concerning modes of 'upstream' social scientific interaction within the R & D for new technologies ('interactive understanding') and the distinctive social 'properties' of individual technologies (their 'social constitution' – see Annex B).

Hence, the researchers themselves will be participating, in an exploratory fashion, in the very learning processes it is hoped will consolidated from the study, upon its completion.

Annex A – Inventory of Interviewees

Professor Raymond Baker, former CEO, BBSRC, 24 February 2004.

Professor John Berringer, former Chairman ACRE, 23 March 2004.

Sir Thomas Blundell, former CEO BBSRC, 30 April 2004.

Dr Ian Gibson MP, Chairman, House of Commons Science and Technology Select Committee, 15 March 2004.

Julie Hill, Former ACRE member and Former Director Green Alliance, 30 March 2004.

Professor Sir Martin Holdgate, former Chief Scientist Department of the Environment, 19 March 2004.

Interview with Sue Mayer, Director Genewatch, 1 April 2004.

Interview with Doug Parr, Chief Scientist Greenpeace, 4 March 2004.

Interview with Professor Nigel Poole, Chief Bio-Scientist Zeneca, 16 March 2004.

Annex B: The 'social constitutions' of information technology (IT) and genetic modification (GM); some perceived comparative features.

Comparative dimensions	Information technology	Genetic modification
Consumer benefits	Visible, authentic, personal empowering.	Invisible, indirect/questionable, artificial.
Intrinsic hazard potential	External to body.	Internal to body.
Manufacturer-consumer	Flexible. Responsive via interactions.	Inflexible, unresponsive markets.
'Consumer' sense of agency/discrimination	Distributed knowledge/expertise. Wider.	Minimal distributed expertise. Personally remote.
Knowledge sources	Competitive markets. Informed social networks.	Restricted, 'Partisan', closed networks.
Industry structure	Plural, highly competitive. Multiple entrants.	Oligopolistic, faceless.
Political-regulatory frameworks	Visible. 'Familiar' patterns of liability/accountability. (Though problems coming?)	Invisible. Regulators (government) seen as compromised. Patterns of liability/accountability obscure/absent. Official 'denial'?
Nature of uncertainties/ ignorance	'Familiar' forms. Distributed professional expertises (law, engineering, finance, etc.). But 'globalising' unknowns.	Largely undefined, under acknowledged, long-term.
Public idioms	Dynamic, evolving, increasingly vernacular/shared.	'Expert', alien, opaque.
'Retrievability' in crisis	Shared social implication in retrievability, despite involuntary dependency.	Potentially unretrievable, imposed, pervasive. Public as 'bystanders'.

Table A illustrates a range of differences in the 'social constitutions' of current IT and GM – differences which, we suggest, cast useful light on the reasons for the widely varying public receptions of the two technologies in Britain. These distinctions are consistent with the contrasting responses encountered in the discussion groups.

References

Brown, N. & Mike, M., 2003: A sociology of expectations: retrospecting prospects and prospecting retrospects. *Technology Analysis & Strategic Management* 15(1): 4-18.

Burke, D., 2004: GM food and crops: what went wrong in the UK? *EMBO Reports,* 5(5), 432-436.

Commission of the European Communities, 2004: *Towards a European Strategy for Nanotechnology*. Communication of the European Commission

Department of Trade and Industry., 2002: *New Dimensions for Manufacturing: A UK Strategy for Nanotechnology*. Office of Science and Technology, Department of Trade and Industry

Doubleday, R., 2004: *Political Innovation: Corporate Engagements in Controversy Over Genetically Modified Foods.* Unpublished Ph. D. thesis, Unversity College London.

Easterby-Smith, M., 1997: Disciplines of organizational learning: crontributions and critiques. *Human Relations,* 50, 1085-1113.

ETC Group 2003: *The Big Down: From Genomes to atoms'*, ETC Group.

Greenpeace UK., 2002: *Transforming Sciences: A Matter of Public Involvement*. Briefing note, Greenpeace UK.

Grove-White, R. & Wynne, B., 1995: *Science, Culture and the Environment I (Research Report)*, Lancaster: IEPPP, Lancaster University.

Grove-White, R. & Wynne, B., 1998: *Science, Culture and the Environment II (Research Report)*, Lancaster: IEPPP, Lancaster University.

Grove-White, R., Macnaghten, P., Mayer., S. & Wynne, B., 1997: *Uncertain World: Genetically Modified Organisms, Food and Public Attitudes in Britain (in association with Unilever)*, Lancaster: IEPPP, Lancaster University.

Grove-White, Robin, Phil Macnaghten and Brian Wynne (2000), *Wising Up: The public and new technologies*, Lancaster: IEPPP, Lancaster University.

Hacking, I., 1999: *The social construction of what?* Harvard University Press.

Hedgecoe, A. & Martin, P., 2003: The drugs don't work: expectations and the shaping of pharmacogenetics. *Social Studies of Science*, 33(2).

Huber, G., 1991: Organizational learning: the contributing processes and the literatures. *Organization Science*, 2, 88-115.

Jasanoff, S., forthcoming. *Designs on Nature*

Joss, S., & Durrant, J., 1995: *Public Participation in Science: The Role of Consensus Conferences in Europe*. Science Museum.

Levitt, B., & March, J., 1988: Organizational learning. *Annual Review of Sociology,* 14, 319-340.

Lowenthal, D., 1985: *The Past is a Foreign Country*. Cambridge University Press, Cambridge.

Marris, C., Wynne, B., Simmons, P. & Weldon, S., 2001 *Public Perceptions of Agricultural Biotechnologies in Europe*. Final Report of the PABE research project funded by the Commission of European Communities Contract number: FAIR CT98-3844 (DG12 - SSMI).

Mayer, S., Hill, J., Grove-White, R. & Wynne, B., 1996: *Uncertainty, Precaution and Decision Making: The Release of Genetically Modified Organisms into the Environment*. ESRC Global Environmental Change Programme Briefing, number 8.

Popper, M. & Lipshitz, R. 1998: Organizational learning mechanisms: a structural and cultural approach to organizational learning. *Journal of Behaviorial Science,* 34, 161-179.

Stirling, A. and Mayer, S. (1999) *Rethinking Risk: A pilot multi-criteria mapping of a genetically modified crop in agricultural systems in the UK.* University of Sussex: SPRU

Tait, J. & Levidow, L., 1992: Proactive and reactive approaches to regulation: the case of biotechnology, *Futures* 24 (3): 219-31.

Van Lente, H. 1993: *Promising technology: The dynamics of expectations in technological development*, PhD thesis, Twente University, Delft: Eburon.

Wilsdon, J., & Willis, R., 2003: *From Bio to Nano and Beyond: A Progressive Agenda for Technology, Risk and the Environment,* Demos.

Wilsdon, J., Forthcoming: The politics of small things: nanoscience, risk and democracy. *Renewal,* forthcoming.

Wood, S., Jones, R. and Geldart, A., 2003: *The Social and Economic Challenges of Nanotechnology*. Economic and Social Research Council.

Wynne, B., 1991: Knowledges in Context. *Science, Technology & Human Values*, 16(1), 111-121.

Wynne, B., 1995: Public Understanding of Science. In S. Jasanoff & G. E. Markle & J. C. Petersen & T. Pinch (Eds.), *Handbook of Science and Technology Studies*, Thousand Oaks, Ca.: Sage, pp. 361-388.

Wynne, B., 2001: Creating public alienation: expert cultures of risk and ethics on GMOs. *Science as Culture*, 10(4), 445-481.