From Bio to Nano:

Learning the Lessons, Interrogating the Comparison

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In this paper we consider the political, institutional and regulatory contexts in which contemporary considerations of, and debates about, nanotechnology are currently situated. We draw upon an analysis of the public and political controversy which overtook GM plants and crops in the UK in the 1990s. Given the starkness of the 'GM Controversy', it is not surprising there is now speculation in many quarters as to whether nanotechnologies might not be expected to experience a similarly rough passage. Here, it is suggested, is a further potentially transformative technology, now arguably at roughly the stage of development as was biotechnology in the late 1970s or early 1980s, and subject to similar levels of utopian promise, expectation and dystopian fear (Nordmann, 2004b). Some NGOs are already suggesting that the issues and problems nanotechnology raises are of such far-reaching political and social importance that 'governments [should] declare an immediate moratorium on commercial production of new nanomaterials and launch a transparent global process for evaluating the socioeconomic, health and environmental implications of the technology.' (ETC 2003, 72)

Crudely put, the GM experience represents a warning, a cautionary tale of how not to assess an emerging technology and allay public concern. For many, addressing the question 'Is nanotechnology the next GM?' is critical to the commercial success and public acceptability of emerging applications in the field. As such the 'GM experience' has been portrayed as a model 'to be avoided' in the future development and governance of nanotechnology. The comparison between GM and nanotechnology – and the lessons that may be drawn from the regulation of biotechnology – has been made in a number of different contexts (see for example, Einsiedel & Goldenberg, 1997; Mayer, 2002; Brumfiel, 2003; Wolfson, 2003; Mehta, 2004. As discussed below our analysis here is limited to the UK. However, as we have emphasised elsewhere (see Wilsdon & Willis, 2004; & Macnaghten et al, 2005) our analysis is also focused on how the governance of biotechnology illuminates the paucity in regulatory responses to new and potentially

radical technologies. In this sense the goal of this paper is not a direct comparison between GM and nanotechnology. Rather the comparison sheds light on the failures of governance and regulation implicit to the handling of a technology in the early stage of its development.

As with all such stories, however, the comparison between GM and nanotechnology is more complex than may first appear. They are both very different technical endeavours, emanating from different disciplines, with vastly different scope. Therefore a direct comparison between GM and nanotechnology is probably of limited value. Rather we ask in what ways the GM experience can inform and shape contemporary political and regulatory debates in which the development of nanotechnologies will be negotiated. We ask whether there are any instructive lessons to be learned from this experience, particularly in relation to the governance and regulatory responses to new and emerging nanotechnologies.

This paper aims to address the above set of questions, albeit in a modest way, through critical reflection on a set of interviews with key individuals active in the pre-1999 development of the regulatory and public involvement phases for GMO plants and crops in the UK and Europe.[ii] The reflections that follow seek to draw lessons from this latter experience – 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.[iii]

Elsewhere we have argued that nanotechnology represents an extraordinary opportunity for social science insights to be reflexively incorporated into its regulation and development (Macnaghten et al. 2005). By taking the reflexive governance of nanotechnologies as a central concern, we set out a prospective agenda for the social sciences as a progressive actor in these changes, providing insights that are simultaneous with scientific, technological and social changes. In this paper we complement such a prospective agenda by taking a backward look at a previous technology – biotechnology – by reflecting on the ways in which the public and the science was framed in the

formation of regulatory and governance regimes developed during its formative stages. We argue that we can learn from two sets of competing understandings in the exegesis of the biotechnological controversy: *competing understandings of 'the science'*, and *competing understandings of* '*the public*'.

1. Competing Understandings of 'the science'

The formative role of the socio-technical imaginary

In the 1970s many leading genetic scientists expressed effusive visions 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 (see Waddington 1978). 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.

Marcus (1995) describes these kinds of visions as *technoscientific imaginaries* which are defined as:

> A socially and culturally embedded sense of the imaginary that indeed looks to the future and the future possibility through technoscientific innovation but is equally constrained by the very present conditions of scientific work. (p. 4)

Such technoscientific imaginaries represent sets of future oriented 'structures of contingency' that provide a sociocultural context for technological change. Such imaginaries are technical, *and* social and cultural. Though they are 'constrained by the present conditions of scientific work' they articulate the future social worlds in which it is imagined that technological innovation will be situated. This imaginary context for technological innovation defines what might be termed the social constitution of technology. Marcus' notion of *technoscientific imaginaries* expresses this social constitution by describing both the technical and deeply cultural discourses that imbue contemporary science and technology. A resonant feature of technological innovation is,

therefore, a set of future-oriented socio-cultural imaginaries (van Lente, 1993). One of our GM interviewees spoke with singular passion about the potential for genetic and plant science to transform social relations and agriculture:

> 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 …. the chemicals industry uses … 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, Former Chief Bio-Scientist Zeneca)

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 the more narrow and arguably more technical visions of 'terminator technology' or proprietary brand herbicide-resistance (Doubleday 2004). 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. The move to GM was justified as a major contribution to future sustainable development through its supposed reduction of reliance on *chemical inputs*, thus feeding into a wider-ranging debate over the future of agriculture both in the US and Europe. Equally striking however was the degree of naiveté within this vision about other social actors' possible responses and expectations.

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 (see Brown and Michael 2003; van Lente, 1993; Hedgecoe and Martin 2003).[iv] The GM experience points to the fact that, despite their scientific significance and, arguably, persuasive power for governments and investors, such imaginaries tend to be insulated from wider recognition and debate, accountability, and negotiation. They are shielded not least by myths about scientific 'purity' with respect to normative influences. Conventional understandings of the relationship between scientific research and the public domain have assumed that this relationship is essentially linear (Wynne 1991, 1995). Such models maintain that science produces new knowledge under conditions of insulation from social influence or public values, is ethically neutral, and determined by natural scientific factors alone. 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.

However, in the last decade or more this model has come under increasingly intense pressure, partly due to the changing political economy of research where commercial exploitation and property rights have become central, and partly due to emerging policy significance of 'public engagement' discourses notably in the UK and EU. Under these conditions the need for even 'basic' scientists to project images of how their research might benefit society in the future, has intensified. As basic or pure research comes to be called 'pre-market' research, an unavoidable implication is that '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.

Limitations of risk assessment to anticipate fault-lines of controversy

The regulatory context for genetically modified foods was framed within a predominately reductionist conception of 'risk' and 'risk assessment'; one which was methodologically quantitative and almost exclusively concerned with possible 'direct' effects of individual GM crops. The overwhelming regulatory response in the UK and Europe to GM crops

concerned the potential risk and safety impacts of particular GM constructs. Whilst important in itself, this approach had the effect of marginalising social, ecological, medical and political implications of GMO technology from serious official consideration. The primary framing of key issues as exclusively 'risk'-related coupled to official assurances of safety, had the effect of turning risk assessment into a *de facto* locus of political contestation towards GM releases (Ravetz, 2005). It also, we argue, handicapped the UK government in developing appropriate responses in the face of public concern, thus playing a shaping role in the development of public controversy in the late 1990s.

The emergence of the emphasis on determinate 'risks' as the criterion for evaluation, and the associated neglect of wider societal concerns had evolved in the circumstances of world-wide experience of environmental and social controversies in the 1970s and 1980s surrounding civil nuclear power and the diffusion of agrochemicals. Public acceptance problems with civil nuclear power in the 1970s had led UK bodies like the National Radiological Protection Board to develop increasingly elaborate formalised procedures for quantitative risk assessment, building on earlier experience within the chemical industry (Royal Society 1983). 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. It was against this background that EU governments began negotiations, in the 1980s, 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 they also required that the industries concerned 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. Though EU Directive 1990/20 incorporated methodological innovations in risk assessment – creating the conditions for expanded recognition of the presence of scientific uncertainty (see Levidow, 2001) – nevertheless its 'risk' framing acted to constitute a *normative* framing that structured how the *nature* of GM artefacts was understood by the policy community *and* the way that possible impacts ('to human health or the environment') were conceptualised and analysed in wider media and NGO discussion. (Grove-White 1996; Wynne 2001).

In the UK, the Environmental Protection Act 1990 established the Advisory Committee for Releases to the Environment (ACRE) as the formal body responsible for assessing the risks to human health and the environment from the release and marketing of genetically modified organisms (GMOs). ACRE's position and framing was awkward from the outset. As the only established mechanism for the regulatory assessment of GM releases this *advisory* body became the de facto *political* authority on GM releases, backed by the Government's commitment to 'sound science' (Mayer, 2002; Mayer & Stirling, 2002). However, as we have noted, ACRE was concerned solely with the risks of individual GM crops, on a case-by-case basis. Tait & Levidow (1992) describe the way in which such assessment processes became a 'reactive/preventive system of risk regulation', in which the assessment process reflected only scientifically proven adverse impacts that had arisen in previous generations of products or processes. In seeking to address specific risks on a case-by-case basis, its assessment template came to rest on past knowledge rather than taking into account the potential for new eventualities that could arise in as yet unknown forms.

The ex-Chair of ACRE confirmed in our interviews the way that this created difficulties in considering the wider cumulative implications of multiple GM crops:

> The other big related difficulty [was] in terms of [the way] government departments respond. We recognised quite quickly in the advisory committee for

> releases to the environment that it was really very easy to give approval, say, for GM maize as is being done at the moment. You could not see any human risks, you couldn't really see any serious environmental ones, and as was proven in the farm trials, it's actually slightly better than traditional herbicide treatment in terms of wildlife. But we asked the question, sure, we can do this for one crop, one manipulation. But when all crops are being manipulated, every effect becomes additive. So if you approve an insect resistant oilseed rape, you can do analysis and we'll say well, that particular variety is only likely to occupy such a percentage of the area of the UK. The impact on insect production is small, the impact on birds is therefore likely to be small, probably quite acceptable, not major difference from use of pesticides. However, if every farmer grew those crops at every farm suddenly the impact is enormous. Where is the mechanism to put it all together? (Interview with Professor John Berringer)

He expanded this concern later in the interview:

> 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. (Interview with Professor John Berringer; See also ACRE, 1998; Levidow & Carr, 2000)

Coupled with its case-by-case focus on single GM constructs other attributes of ACRE's framing and self-constitution – such as its 'bounded' character, its emphasis on quantification, its aggregation of alternative outcomes, presumptions of compliance, and neglect of 'Type II' errors – produced what Stirling (2003) describes as a 'reductive aggregative' in its approach to the assessment of GM crops. Similarly Levidow et al (1999) point to the way in which the risk debates concerning GM crops became 'scientised' as some scientific uncertainties were addressed and others downplayed. Though initially imagined in precautionary terms, ACRE's limited remit and reductionist framing nullified the extent in which ongoing and cumulative uncertainties could be thoroughly considered, as explained by former ACRE committee member Julie Hill:

> I suppose the main sort of insight I have on that is what happened in ACRE with suddenly everybody, it dawning on everyone that huge conditions had been

> attached to trials but they were conditions that didn't allow you to gain any level of knowledge about what happened at commercial scale and therefore they'd actually made an almost impossible leap from trial stage to commercial stage. … So in effect what ACRE was being was incredibly precautionary. But precautionary to the extent you can make no logical leap from trial to commercialisation so it's not being that precautionary. (Interview with Julie Hill)

Such limitations, embodied in the 'precautionary' approach developed for GM under Directive 1990/20, contributed to mounting problems for government as wider political controversies around GM food emerged (Jasanoff, 2000). Such concerns – including the perception that government and corporate decisions had already been taken, that GM foods would lead to an inevitable diminution in consumer choice, of GM as 'unnatural', and concerns about corporate control of food systems (see Grove-White, et al, 1997; 2000) – were simply not captured by the language of risk and safety. One effect of this deletion was to make debates about the risk and safety of GM crops stand-in for a host of other unacknowledged concerns (Gaskell, et al, 2004). Yet the intensity of these wider social concerns was reinforced by the lack of any official recognition and official assurances of the adequacy of assessment mechanisms.

Our interviews confirmed the dilemmas faced by ACRE advisory scientists: constrained on the one hand by a 'sound science' remit, yet also subjected by both internal and external pressures to extend their remits beyond their science-based domains of competence. For example, the ex-Chair of ACRE expressed his chagrin at the way that ACRE had become the default locus for the political contestation of GM crops:

> We [ACRE] were there such that when something has to be done that could be contentious we can be blamed. … I believe that what we've set up was the best mechanism we had to do something safely, and that was my primary concern. … And I knew damn well that what they [the government] wanted was a system that relieved them of having to make decisions. And so we were constantly having turned on to us 'We don't really want to do something? Is it safe?' That was constantly being articulated in the press and such like wasn't it? And of course we would do our analysis and we'd have to come back and say well, there are always risks and the risks seem to be sufficiently low that we can't say it's not. (Professor John Berringer)

The approach in question embodied a limitation carried over from the treatment of nuclear power and agrochemicals in regarding as valid only those the parameters of concern specifiable through (selective) 'risk'-based framings.. Significantly, such processes failed to generate public confidence or to allay public concern. For example, much of the controversy surrounding civil nuclear power in the 1970s and 1980s revolved around concerns inaccessible to such an approach, such as the cumulative safety implications of nuclear waste generation, social and political concerns about plutonium separation and dependency, and disquiet about the significance of possible 'low probability-high impact' accidents (confirmed as central by the Chernobyl events of 1986). All of such concerns lay unambiguously outside the methodological scope of case-by-case risk assessment.

There was a degree of precedent for widening the ways in which GM releases were considered across certain countries in Northern Europe. Other European governments, including Denmark, the Netherlands, Germany and Norway, responded to the concerns raised about GM artefacts with innovative institutionalised forms of social debate and dialogue (Levidov 1998). In modest echoes of such European precedents two such initiatives were undertaken in the UK – a consensus conference, organised in 1995 by the Science Museum and AFRC (UK Government 1994; Joss & Durant 1995), and a government-organised 'National Biotechnology Conference' held in early 1997 (Macrory 1997). Unfortunately, both of these initiatives were limited in their scope, public visibility and ability to shape the trajectory of GM regulation and development. Similarly neither was framed to allow examination of the wider societal and ethical concerns. And neither fed into any visible policy process.

Indeed, in retrospect, much of the intensity of the UK's GM controversies in the 1990s can now be understood as constituting successive corrective processes to the forms of risk assessment framing 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 were central to the UK Government's escalating loss of public credibility on the matter. Indeed, sweeping Prime Ministerial portrayals of critiques of biotechnology as mere 'anti-scientific emotionalism' further exacerbated such a dynamic (Jasanoff 2005b)

2. Competing understandings of 'the public'

The Misleading Construction of 'the Public''

During the 1970s and 80s public attitudes to civil nuclear power were systematically characterised as subjective, emotional and false *risk perceptions* (Wynne 1982; Irwin and Wynne 1996). In the late 80s and early 90s, an equivalent dynamic emerged in the biotechnology field. With few exceptions, it was assumed that public concerns about GM crops could only be founded on a public deficit of understanding. The overriding discourse was that public concern about these technologies stemmed from either an incorrect understanding of the technology or a complete lack of knowledge altogether.

As the 1990s advanced, social-science researchers became increasingly active observers of the state of public opinion in relation to GM plants and foods (Durant et al. 1998; INRA 1993, 2000; Martin and Tait 1992; MORI 1999). Much of this work focused on shifting public 'attitudes' rather than wider examinations of underlying sources of social tension, and how these reflected limitations in the risk-regulatory framework itself (Irwin 2001). 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. As such, even though survey data began to point to steady decline of public confidence towards biotechnology throughout the 1990s (Gaskell *et al.* 2003), most were unable to conceptualise the underlying tensions inherent to GM releases and the increasing political fragility of official reassurances. They therefore offered little explanation or warning for why GM became a site through which concerns over a whole raft of 'risk controversies' were articulated (for an exception, see Grove-White et al. 1997. Also see Levidow 1998).

Such assumptions tended to be shared by public and expert bodies such as COPUS (the Royal Society Committee on the Public Understanding of Science), the Health and Safety Executive, and the DTI. All such bodies presumed that the key issue of public concern were the risks as defined by the risk-assessment discourse, and that any disinclination by the public to accept such risks was based on a (false) belief that the risks were too high. In other words, this presumed that the meaning of the issue to the public must be the same as its meaning to scientists.

Even following the official discrediting of this 'deficit model' (symbolically put to bed in the House of Lords *Science and Society* report in March 2000), this misconception has come to be resurrected, albeit in a succession of new versions. Such persistence reflects an institutional science and policy culture which continues to project problems of public conflict, mistrust and scepticism about prevailing science onto other supposedly blameworthy agents – commonly a sensationalist media, or mischievous NGOs. In other words, responsibility for such problems has been continually externalised away from official institutions and their embedded cultural reflexes, such that government and scientists' own roles are rarely if ever put in question.[v]

Inherent to this externalisation is the conviction that public opposition is 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 is concerned only instrumentally about risk, rather than with the aims, purposes and political economy underlying scientific knowledge-production, and that risk discourses are the only appropriate resources for forms of communication to reassure a misinformed public (Wynne, 2005).

Continuing misunderstandings about NGOs and their relationships with civil society

In this view it is assumed that public concern is actually something that has been created by NGOs, acting irresponsibly in association with a sensation-seeking media. 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 with Professor Raymond Baker, former CEO, BBSRC)

> 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 Professor Nigel Poole, Former Chief Bio-Scientist Zeneca)

Forceful allegations of deceit and misrepresentation carry the implication that NGOs have been purposeful institutionalised actors in society, of one mind, and of acting ruthlessly to manipulate policy in misguided directions. Generalised charges of this kind rely on assumptions about the capacities of NGOs to *create* controversy in the absence of pre-exisent public unease. Interviews with NGO actors involved with GM campaigns throughout the 1980s and 1990s, supplemented by personal experience of the authors themselves, suggest however that such charges may exaggerate the capacities of NGOs.

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 late 90s' GM controversies, tend routinely to be preoccupied with multiple issues, each of which have their own particular histories and concerns. Such UK national NGOs were relatively slow and uneven in developing coherent 'campaigns' on GM crops. Indeed the overall response by these groups to GMOs lacked clarity and unanimity. 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, over the specific issue of potential biodiversity impacts from commercial growing of GM crops. This 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 a wider public unease being expressed through the spontaneous emergence of new independent networks and initiatives[vi]. Greenpeace's 1996 Soya ship action, followed by 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.

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. For example 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 Dr Doug Parr, Chief Scientist, Greenpeace)

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[vii].

New technologies may serve as condensation points for new forms of political argument

GM crops had become something of an *iconic* environmental and social issue in many countries by the end of the 1990s. 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: global drives towards new forms of proprietary 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 condensed onto GM crops because of a particular range of institutional and cultural contingencies shaping the technology and its development (Wynne 2001; Jasanoff 2005a).

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 and open-ended problems of nuclear wastes wider issues presented themselves in intense forms. Just as the recent generic concerns about GM have been reflections of tensions within the particular '*multi-national*'-dominated political economy of the millennium, so with nuclear power in the 1970s and

early 80s, a range of then-current preoccupations about then *state-dominated* political economy were integral to the disputes. The nuclear power controversies gained much of their dynamism from that technology's appropriateness as an expression of such tendencies of its time, 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 stake 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 spaces in which such debates could take place, GM became the occasion and the opportunity.

Conclusion

In re-examining the GM experience we have sought to highlight the way in which this experience demonstrates the generic challenges and failures governance and regulation of new and emerging technologies. Rather than a directly compare biotechnology and nanotechnology we have sought to outline the implications of this experience for future approaches to nanotechnology. 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 new technologies. Similarly we suggest that the deficiencies of case-by-case risk assessment process calls for a more sophisticated understanding of the limitations of the methodology and of its use as a cultural and scientific practice.

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 tacit, technoscientific imaginaries form the basis upon which research priorities are negotiated and planned. Importantly, however, in the GM experience such tacit visions were never openly acknowledged or subject to public discussion and debate. As such forms of official regulation and risk assessment – which were largely confined to discussion of the potential human and environmental risks of GM crops – effectively denied any broader discussion of the public value of biotechnology. In this context Jasanoff (2005b) suggests that:

> The problem for governance, then, is not the spread of techno-scientific cultures in and of themselves, but rather their increasing isolation from other institutions and modalities of deliberation … [which is characterised by a] loss of reflexivity within the scientific enterprise itself, a phenomenon that disables modern science from recognising, and admitting, how profoundly normative are its visions of progress. (p. 196)

As such Jasanoff suggests that we have entered a 'new politics of knowledge' in which tacit sociocultural visions of progress will become the subject of increased public concern and scrutiny. The implication of Jasanoff's thesis is that the regulatory and governmental responses to new and emerging technologies – such as nanotechnologies – constitute a genuine opportunity for open-ended public debate and discussion of the social and political purposes of science and technology. She suggests that the most appropriate response to this politics of knowledge is to 'by open up science's hidden normative presumtions to authentic and inclusive public debate' (p. 197).

Elsewhere we have outlined the ways in which the development of nanotechnologies is fuelled by a diverse set of tacit technoscientific imaginaries (Macnaghten et al 2005, Kearnes 2006 forthcoming). Nanotechnology is variously imagined in a number of ways. Some of the most significant technoscientific imaginaries of nanotechnology include: the notion that nanotechnology will lead to the 'next industrial revolution'; as facilitating complete control over the very structure of matter; as enabling a technological convergence between biotechnology, information technology and cognitive science at the nanoscale; as leading to radical advances in information storage, drug delivery and material science; and as a lucrative route for national and corporate wealth creation.[viii] In

this sense nanotechnology is characterised by forms of social and cultural innovation that parallel the technological possibilities of the field. Following Jasanoff's notion of the new politics of knowledge we contend that these tacit normative visions of societal progress implicit in the current research and development of nanotechnology need to be opened to forms of public scrutiny and debate (Wilsdon et al 2004; 2005).

Similarly, 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.

Whilst risk assessment will be crucial to the regulation of nanotechnology it is important to recognise the lesson of the GM experience that such necessarily scientistic forms of appraisal must be couched within a broader discussion of public value of nanotechnology and its inherent normative aims. The recent report *Nanoscience and Nanotechnologies: Opportunities and Uncertainties* jointly published by the Royal Society and Royal Academy of Engineering (2004) raised concerns about the possible toxic risk of nanoparticles and recommended tight regulation and the instigation of stringent risk assessments on such particles. Whilst such considerations are strategically important they need now to be situated within a broader upstream dialogue regarding the complex normative dimensions of nanotechnology and how its future development might be shaped if wider society is to benefit.

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.

Annex A – Inventory of Interviewees

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

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

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

Mark Cantley, Adviser, Directorate for Life Sciences (Biotechnology, Agriculture and Food), Research Directorate-General, European Commission, 6 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, Former Chief Bio-Scientist Zeneca, 16 March 2004.

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[i] This paper forms part of the output of the ESRC funded project entitled: *Nanotechnology, Risk and Sustainability: Moving Public Engagement Upstream.* An earlier version was published under the same title as a working paper on the project.

[ii] These individuals are listed in Annex A. Whilst we quote directly from only a small number of these interviews the analysis presented here draws implicitly on all the interviews, and our own experiences of the events of the 1990s (see, for example, Grove-White, 1996; 1997 2000; Mayer, et al, 1996; Grove-White, et al, 1997; 2000; Wynne, 200; Macnaghten, 2004).

[iii] 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 genetic modification (GM) development reached their peak in the United Kingdom, in February 1999. Clearly, since that time, there have been a number of further developments, including the creation of the AEBC, the UK 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 (Busch et al. 2004). This is because for the purpose of this paper is to reflect on the underlying processes which shaped the controversies, rather than the unfolding of the post-1998 events themselves.

[iv] See also papers by Selin and Rip (this volume) for an emerging analysis of the socio-technical imagination of nanotechnology.

[v] 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.

[vi] Indeed, as a response to the perception that such groups were not campaigning actively on GMOs from the mid-1990s, wider bodies of opinion, independent of such organisations, crystallised in a host of more ad hoc and GM-specific networks – including Genetix Snowball, the Genetics Network, the Genetics Alliance, Corporate Watch, Genewatch 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).

[vii] Of course, within such constraints, the tactics of environmental NGOs and notably Greenpeace were clearly potent, both in their ability to document biophysical risks and especially uncertainties, and in the metaphoric framing of GM material as contaminants (Levidow 2000).

[viii] See: Drexler 1986; National Science and Technology Council 2000; Roco and Bainbridge 2001; 2003; Department of Trade and Industry 2004; European Commission 2004; House of Commons Science and Technology Committee 2004; Lux Research 2004; Nordmann 2004a.