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What Could the Foundations of *NanoBioInfoethics* Be? Some Lateral Thoughts

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SUMMARY: I do not believe in "nanoethics" as such. I passionately believe in ethics, as an endeavour disciplined (not determined) by reason; but not in an ethics of nano-scale objects and processes. The same could be said of bioethics and its supposed objects, like genes, proteins, etc. If, as I believe, the ethical here must be an ethics founded in questions about the human relations, imaginations, meanings, commitments and normative visions of valued ends and needs which human knowledge and technology-making should be devoted to, then to frame this ethics as "nano-" or "bio-" is likely to be misleading. It will omit some of its more important dimensions, which transcend such object-categories and are not reducible to them.

In this paper I discuss various features of the late-modern intensification of instrumental scientific framings of social needs and endeavours such as the deliberate and systematic harnessing of scientific research knowledge-investment – public R&D policies for example, as in the 2001 EU Lisbon Agenda – for economically competitive innovation. I highlight some of their ethical dimensions. This wider context is the source of the technologies whose "ethics" we are trying to address; and those technologies as human projects uphold those contextual realities. That context has an implicit 'ethics' which shapes those technologies and our human subjectivities as ethical practitioners. The ethics of any technology, especially of ones which claim synthetic status like 'nano' or 'bio', or NanoBioInfo convergence, NBIC, cannot be defined adequately without also addressing this context, as well as the ethics inscribed into the technologies' human relations and 'required' subjectivities. In this context I include three particular dimensions: the human imaginations which shape the material and intellectual commitments made in the name of science; the ways in which public reactions to these techno-sciences and their human dimensions are defined and 'managed'; and the ways in which institutionalised forms of regulation of the ever-more ambitious scientifically-intense technological programmes such as NBIC technologies, are developed, with so-called precautionary policies and 'public engagement' to address those reactions.

Virtually all of these 'ethical dimensions' which I identify in such proliferating issues in the life-sciences, nanosciences, neurosciences, and their convergences, and others, are: (a) institutional and collective; (b) dynamic, interactive-relational, and thus continually evolving; (c) reach way beyond discrete decision problems; (d) imbued with imaginative dimensions which deserve more deliberate interrogation; and (e), problematise the unacknowledged normative dimensions of *knowledge-production* processes, not only applications and impacts of knowledge-uses. Yet

conventional ethical frameworks as institutionalised have largely passed these by, something which may relate to the contradiction (in 'object'-ethics) I identified at the outset. They have instead been restricted – at least, explicitly – to issues of individual responsibilities, discrete decisions, abstract ethical problems, and notional applications and impacts of existing knowledge, whose origins (including founding human imaginations) are exempted from ethical scrutiny. This therefore opens up a deep gulf between legitimate and necessary aspirations to subject current processes of scientific research and innovation to ethical appraisal and control (including claims that this is already under way), and existing ethical frameworks for representing what is at stake.

"Bioethics are to ethics what whores are to sex"

(R.J.Neuhaus, 2001, quoted by Carl Elliot, *London Review of Books*, 28 Nov 2002: p.36)

INTRODUCTION

. It is an interesting feature of the familiar and increasingly powerful public terms, "bioethics" and now "nanoethics", that they start from an apparent contradiction: how can inanimate material things like carbon nanotubes, or even genomes, have ethics? But they leap this potential contradiction by framing the ensuing ethical issues as those only about the *human uses* of those supposedly inanimate worlds of 'bio', 'nano', or – as the US NSF has given it primacy[1] - convergent 'nanobioinfo' (NBI) innovations. A similar fundamental question about the social relations of technologies was answered in just the same basic way: how can such technologies be thought to have a social life, except in terms only of their *social impacts*?

[1] And the EU has followed up. See eg: Mihail C. Roco and William S. Bainbridge (eds.), Report *Converging Technologies for Human Performance*, US NSF, Washington DC, June 2002; European Commission, DG Research, Technology and Development, report of EC working group, "Foresighting the New Technology Wave", rapporteur Alfred Nordmann, *Converging Technologies*, EUR 21357, Brussels, 2004. The convergence envisaged here included: "Nano-Bio-Info-Cogno-Socio-Anthro-Philo-Geo-Ec0-Urbo-Orbo-macro-Micro-Nano" – quite a synthesis. The aspiration of artificially-creating 'synthetic life' from such convergence is of course one expressed ambition which would, literally, animate such objects.

Science and Technology Studies (STS), of sciences and technologies while in-the-making, have emphasised instead how there is an intense social world of complex and channelled relations, imaginations and interactions, operating through social delegations of human agency and intention to what are often extremely powerful and once established deterministic inanimate forms, natural or artefactual. This social (and ethical) world *already existing* in the material technologies and the scientific knowledges is typically rendered invisible through a combination of wider social beliefs about science and technology, and forms of representation of those contingently constructed worlds as if they were predetermined and their design-logic simply revealed, not created according to human purposes and ends interwoven with natural realities in techno-scientific knowledge-making. Although various fields have in practice reflected this social understanding of the makings of science and technology, dominant policy and techno-scientific discourse-practices still privilege a more deterministic account which continues to restrict the social, and by implication also the ethical, only to the domain of downstream impacts issues, and thus continues to conceal from attention the various upstream human processes, including imaginations and meanings, which shape knowledge and technology production, and in-so-doing also shape ourselves as ethical subjects.

Thus in addressing the question of what ethical questions are raised by the NBI convergence scenario, to the extent this concealment occurs, a further double-set of ethical as well as social issues needs to be defined and addressed, about:

1. the impacts of this institutionally-misrepresentation of technoscientific objects and knowledges, as if they themselves carry no social and ethical commitments, and about the human responsibilities for this profound state of institutional denial. This sits at the acknowledged core of our society, namely its relentlessly increasing dependency upon, and shaping by, science and technology; and
2. collective deliberation over the normative ethical and social questions, about not just the scale and speed of innovation, but about its directions, and conditions, its human imaginations and purposes; these normative questions having been historically obscured thus the necessary capacity undeveloped in existing institutional forms of public appraisal and regulation of technologies.

Whilst this agenda certainly includes important ethical issues, they are more profound even than 'ethics', at least as conventionally defined. For reasons discussed below, they may be better described as cultural. Ethics taken as "a tool for making the right choices on technology" (as

described in a Danish biotechnology expert ethical task force, Biotik, 2001) does not adequately grasp this problem, that first we have to define 'the right' issue(s) which require collective resolution[2]. Often this prior, framing phase – what are the issues to be addressed? - is simply presumed as a matter of habit, taken as given and routinely enacted in the prevailing institutional culture. Certainly, the predominant accepted definition of the ethical in these technology domains, as about: respect for human autonomy; prior informed consent; human dignity; and justice; does not seem to connect with the issues which are found empirically to invoke public moral judgements about such issues. These forms of ethical frame and judgement are: not focussed only on explicit discrete decisions; are typically about social relations and habituated behaviours than about objects and their (imagined) consequences; are in this sense dynamic, interactive, and evolving, not abstract and ahistorical; and appear to be founded on central issues about adequate human recognition across institutional cultural boundaries. They are ontological and not only (deterministically) rational-epistemic. These ethics do not have their meaning in relation to biotechno-sciences, nanotechno-sciences, or convergent techno-sciences, except to the extent that these specific domains are powerful vehicles for the expression and enactment of *human-relational* imaginations, purposes, interests, aspirations and material commitments which intersect with and enact these. Some of the most important of these human relational dimensions transect and bridge different technical domains such as nano or bio. Thus to discuss 'nanoethics' as if essentially focused on different questions from 'bioethics' is a problem, since they may be united by ethically important relational dimensions which are not bounded by these object-categories, and which may be deleted by their misfit within such artificial but essentialised frameworks. Examples of such cross-cutting ethical issues, recognised often by ordinary citizens, are: scientific- and policy-institutional denial of their lack of predictive control over consequences like risks; externalisation of uncontrolled, unpredicted consequences onto others with no acknowledgement; patronising accounts of citizens; presumptive definition of what counts as public good; and hubris. Such roots of ethical concerns arise from typical citizen accounts of experiences of these new fields in the life sciences and now, nanosciences, and convergent techno-sciences.

KNOWLEDGE-PRODUCTION AS ETHICALLY-IMBUED PRACTICE

While the terms bio- or nano-ethics implicitly acknowledge that there is an endemically human constitution of the material worlds of bio- and nano-sciences and technologies, we have to

[2] As Holm (2003) has noted, in ethics this accepted problem-definition is normally dependent on the ethical theory being used, and is not itself treated as requiring reflective examination and negotiation.

recognise that as mainly articulated and institutionalised, they actually obscure this, as outlined above. Thus a whole domain of ethical questions and concerns, and this inadvertent concealment is all the more effective because of the explicit appearance that ethical interrogation and debate is genuinely addressing these techno-sciences and, crucially, their institutional agents and conditions. It has been one of the acute intellectual and indeed political tensions between the philosophical field of bioethics and other more critical fields such as the interpretive social scientific perspectives like STS/SSK, that the institutionalised disciplinary domain of bioethics in policy - representing the academic field in public policy - has followed science itself in excluding from ethical and social attention, the complex human processes involved in bioscientific or nanoscientific knowledge-*production*. Thus while there has been an extensive ethics of the *impacts* and *uses* of biosciences knowledge, or of biotechnology, there has thus-far been no ethics of the *production* of those techno-scientific knowledges and practices. Only in late-2006 for example have officials of the EU DG Research[3] made the upstream move of talking about the need not only for an ethical dimension of technology assessment, but also for an ethical dimension of knowledge-assessment. If we focus exclusively in the habitual way, we then also reinforce this inadvertent concealment of the more upstream ethics and politics. If it were to be rendered real by recognition of its existence, this latter is for various reasons a different kind of ethics and politics, with different agenda issues[4]. I would call this a more authentic ethics, because it would be grappling with the real collective issues of what human ends are and should we be prioritising in scientific research and knowledge investments, with what imagined outcomes and normative goals and relationships, and with what senses of expected or intended control or freedom to others, human and non-human? Of course, this can be defined as politics rather than ethics – but there are some deeply ethical issues of responsibility involved, perhaps most especially about the apparent hypocrisy of official acceptance of such upstream public engagement, but then its rigid confinement by imposing the tacit practical bounds that ordinary citizens are not fit collectively to define the social purposes and aspired-to benefits from scientific research, but must leave this to their scientific-commercial betters.

All this kind of explicit agenda would be radically different from an 'ethics' which is primarily framed as consequentialist (risks), when a central point of the expressions of concerns about new technologies and their institutional context of regulation is just precisely the inadequacy of

[3] Rene von Schomberg, "From the Ethics of Technology to the Ethics of Knowledge Assessment", DG RTD, Governance and Ethics Unit, EC, Brussels, Oct 2006.

[4] Instead it has largely been bowdlerised by the dominant policy definition of 'upstream engagement' as earlier prediction of downstream impacts, including of public resistance.

predictive-control (risk assessment) claims coming incessantly from scientifically-informed policy institutions. This continual reference to risk assessment, and the associated insistence that the public meaning of the issues is indeed or should be risk (and moreover, 'risk' as defined by institutional science), forces a questionable identity onto 'the public' by insisting that their matters of concern, thus their meanings, be only those recognised by the authorities. Within this hermeneutic strait-jacket, any public refusal can only be interpreted as due to rejection or misunderstanding of science (its propositional claims about the risks defined). As I have explained elsewhere (Wynne 2006), the repeated invention of new versions of this public deficit model for explaining their failure to achieve public acceptance even while proudly pronouncing the death of the deficit model, is an inevitable function of this deeper ethically-weighted institutional-cultural refusal to accept that citizens may have legitimately different, autonomously-cultivated meanings, from those reductionist ones prosecuted by the science-idolatrising policy institutions.

In this paper I attempt to identify some of the substantive issues which arise, once we open this hermeneutic vice-grip which has been gradually and by default tightened round these public issues. Doing this shifts attention, in appraisal of the new technologies imagined and promised in the widely variable and loosely-bounded nano domain, or more so the NBI domain, from only impacts and risks questions, towards upstream innovation issues about what visions of social ends, or of imagined human outcomes, and what deep cultural claims about control (and thus about contingency), are driving and directing the processes of scientific research and knowledge-production in the first place. As Dupuy and Grinbaum (200?, Living with Uncertainty), and Gomes (2005, *Philosophy Today*) inter alia have asserted, this is a matter of digging out and rendering accountable the unacknowledged metaphysical commitments underpinning this techno-scientific-cultural programme.

The upstream shift as a small step on this way has been extensively argued by academic scholars, and has even adopted in discourse at least, by policy bodies such as the EC and the UK government. However its meaning has also been perversely translated, such as in the common influential assumption[5] that the benefit of conducting upstream public engagement earlier in the research-innovation-products-impacts typical lifecycle, is that it allows earlier anticipation of potentially problematic impacts, including public opposition. This almost self-contradictory

[5] For example the London Royal Society, Royal Academy of Engineering report, *Nanosciences and Nanotechnologies: opportunities and uncertainties*, RS Policy document 19/04, London, July 2004.

framing continues to reproduce the prediction-control mythology, and to conceal the normative issues, over: what social ends are invested in what commitments (and what alternative commitments are tacitly neglected)? And what or whose imaginations and promises of outcomes help consolidate emergent coalitions around such commitments, even if these are strictly fictional representations? This discussion of these as-yet under-recognised substantive ethical and social issues within the research and development processes themselves where no ethics or social is supposed to exist, will necessarily range beyond the confines of 'nano' or 'bio', as if these were the salient object-worlds defining the ethical issues, when in my perspective, the main ethical issues are about institutional relations and behaviours, and about the endemic issue of responsibility, in the face of chronic contingency.

PURE (BASIC) AND APPLIED SCIENCE: REDUNDANT CATEGORIES?

One of the general insights from STS is that it makes little sense to refer to science and technology, or pure science and applied science as categorically different, when an applied, technological intent is built into scientific knowledge-production from the start. Indeed as philosophers like Hacking have stated this, manipulative intervention in nature is a necessary precondition of observing its behaviour, and thus of knowledge about it[6]. This does not mean that new and lasting knowledge of basic natural processes is not generated through this; but it does suggest that such basic scientific knowledge can be seen as a retrospective product rather than a prior product of intervention. Social studies of science has here aligned with scientists and historian/philosophers themselves (such as Rheinberger, 1998, 1999) in adopting the term techno-science (Latour, 1987; 1990) to reflect its description of contemporary scientific research as an intrinsically technological-manipulative human project. Here Rheinberger has pushed the account of the normative dimensions of this further, by noting that such structured intervention is not simply a necessary condition of knowledge, but is a designed, purposive one (see below).

Although there is debate over this within the field, by restricting the ethical gaze to the impacts of knowledge, thus deleting from any questioning what goes into knowledge-production, bioethics has tended to reflect the established self-account of institutionalised science. This is reflected in the Mertonian sociological model of an ethically and intellectually-independent republic of

[6] This was the point underlying the Heisenberg 'Uncertainty principle', which as Dupuy (2004) has said, should more accurately have been named the Indeterminacy principle. The significance of this becomes greater the more fine-scale one's attempts at knowledge-manipulation become, eg at nano and genetic levels.

science, whose products are only innocent knowledge, and whose ethical and human dimensions only arise after this, in stages of potential application.

Thus to the extent that ethics has implied a human dimension to bio or nanosciences, this 'human' has almost invariably been tightly restricted to impacts or intended impacts. It has not been extended to questions about the human dimensions of the processes involved in scientific knowledge-production. This mainstream framing of the ethical field in relation to science can be seen to reflect the dominant self-image of science during the huge institutionalisation of scientific influence in proliferating domains of politics and governance in the post-war decades. In this, the "independent republic of science" had to be left to define its own questions and research priorities, otherwise scientific truth would be corrupted. Thus arose the familiar framing distinction between 'pure' (or 'basic') science and 'applied' science, in which pure science only reflected nature, so had no ethical dimensions (other than the internal ethical requirement to perform the Mertonian norms of science), and scientists are not responsible for the ethical or social commitments made only at stages of application.

One of the things I wish to do in this paper is to show how mistaken is this conventional framing of ethics in relation to science in public – and how important is this mistake. Pointing to ways of repairing it is a further task which needs a more collectively exploratory ethos. But a precondition for this is first to recognise the problematic condition in which we find ourselves. It is already apparent that I believe there are dimensions of 'nanoethics' that are nothing to do with the specifically nano scale of the scientific objects of interest in nanosciences. However the debates over nanoscience visions, such as the 'two cultures' of nano which Bernadette Bensaude-Vincent has discussed[7], also indicate that further ethical issues are also raised by this new level of intervention. I will also discuss these nano-particular ethical issues in connection with those which I suggest cannot be intrinsically defined as *nano*ethics, but which nevertheless, being ethical issues of modern technoscience and its cultures in general (albeit ones which have not been recognised by the disciplines of ethics), also have to be addressed for the waxing field of nanosciences and technologies.

[7] Bernadette Bensaude-Vincent, 2004, "Two Cultures of Nanotechnology", *Hyle*, **10,** 65-82.

As protein scientist turned philosopher Hans-Jorg Rheinberger (1998) has vividly shown, from the inside as-it-were, contemporary bioscientific research is a technological project and not an innocent knowledge-project alone:

> "With the possibility of manipulating the genetic production program of an organism by its own, unmodified and modified components, the molecular biologist as engineer abandons the working paradigm of the classical biochemist or geneticist. He no longer constructs test-tube conditions under which the molecules and reactions occurring in the organism are analysed. Just the other way round: ….. he uses the milieu of the cell as their proper technical embedding. The intact organism itself is turned into a laboratory. It is no longer the extra-cellular representation of intra-cellular processes, ie the understanding of 'life' that matters, but rather the intra-cellular representation of an extra-cellular project, the deliberate 'rewriting' of life…This intervention aims at *reprogramming* molecular actions, not just interfering with them"

{*J-P D, on verum factum, ethics paper*} add…..

Rheinberger here describes a double-shift. Not only is scientific knowledge-production a function of a technologically-inspired manipulative intervention in nature. There is also an experimental attempt *to programme and automate* this technological intervention. Moreover experimental practice is not about testing knowledge-hypotheses, but about testing whether we can make an imagined technology work. It is not that what we might call basic biological knowledge does not arise from this. Of course it can and it does. But this is effectively a by-product of the technologically-inspired intervention. It is misleading to describe this as a process in which innocent and neutral scientific knowledge is first produced by experimentally testing intellectual hypotheses, and only once these have been agreed as established scientific understanding do applications issues and commitments arise along with their corresponding ethical responsibilities. Yet this remains the institutionalised, dominant view.

The technoscientific ethos articulated for the life-sciences by Rheinberger is close to the project of the 'remaking' of nature which Dupuy (2005) discusses in relation to Vico's 18th century insight that what is known and what is made are equivalent, and mutually convertible:

> "It is clear that the NBIC convergence presents itself as the ultimate culmination of the *verum factum*. It is no longer merely by doing experiments on it, it is no longer merely by modeling it, that men will now come to know nature. It is by remaking it. But, by the same token, it is no longer nature that they will come to know, but what they have made. Or rather, once again, it is the very idea of nature, and thus of a given that is exterior to the self, which will appear outmoded. The very distinction between knowing and making will lose all

meaning with the NBIC convergence, as will the distinction that still exists today between the scientist and the engineer" (Dupuy, 2005, p.20)

Rheinberger's account of molecular biology is consistent with many others (eg Kay, 1998; Sunder Rajan 2006) and not only of the biosciences. It also reflects the self-conscious epistemic shift in the physical sciences when Bohr and Heisenberg tried to move on from the 'wave-particle' contradiction besetting 1920s quantum physics, by proposing that the meaning or purpose of scientific knowledge-production was not to produce an account of reality – is electromagnetic radiation 'really' wave-form, or particulate? – but to produce working behavioural predictions. Along with a shift of purpose – one with inalienable social intersections – came a significant shift in the epistemic criteria for defining what is to count as valid scientific knowledge; from 'realism' to 'instrumentalism'. One might suggest that the wider cultural lag in this shift in the defining values of scientific knowledge-production has left society still responding to instrumentalist science as if it were defined solely by the disciplined attempt to achieve non-instrumentalist, realist representations of nature.

The effect of this is to undermine any societal recognition of the need to articulate effective ethical and political orientations which frame imaginations of, impinge on, and shape instrumental scientific practices. This is because the false view still prevails, that science itself does not need such ethical and social orientation, only technology – as if these can be sequentially distinguished. That technoscientific research receives such a social-normative orientation in full measure, but unaccountably so, from its embedded stakeholder-user-funder networks and cultures, is obscured. In the main, this false view is vigorously reinforced by scientists seeking to avoid the insecurities of such wider social accountability and dialogue, and to sustain the funding sources with which they have established connections. Thus they continue to attempt tacitly to imagine and anticipate, then to respond to their own imaginations and inferences of the social- and knowledge-priorities of their most important patrons and reference groups. It is identifying, challenging, changing, and diversifying, these practical and imagined human reference-groups, which is a key ethical and practical policy issue for modern NBI techno-sciences.

Much of the animated debate about nanosciences and their epistemic and ethical issues is conducted within this unquestioned instrumental, scientising presumption, in which instrumental extension of control becomes by default an end in itself. Thus for example, the debate between the apparent opposites, of on one hand Drexlerian 'nano-mechanists' who believe that nanosciences can develop new technologies including those of mass-production, by designing and

building from the bottom-up, literally atom-by-atom, and on the other hand the 'biomimetics' advocates such as Jones, who argue that at the atomic-molecular scale we have no ways of overcoming the physically-destabilising effects of endemic physical realities like Brownian motion or surface tension, unless we borrow the biological designs which have somehow done this, like DNA or protein structures and behaviours, overlays a deeper shared commitment. In some respects the biomimetics approach is more modest than the Drexlerian vision, in that it advocates following bio-processes rather than pretending to replace these. But both of these apparent opposites are imbued with the same immodest tacit purpose, and expectation, that of design and synthesis, and control; and wily-nily at more-and-more ambitiously interventionist levels. Moreover as Dupuy has argued, the NBI and related techno-scientific mega-programmes propose than humankind create and reproduce itself, as "synthetic life", thus playing the "God" card in all seriousness. This is idolatry, built right into this scientific programme. Such idolatry has been traditionally regarded as perhaps the most serious of ethical transgressions. These technological prospects need critical examination, with ethical responsibilities in mind. Moreover the normative responsibilities for these kinds of driving imagination for scientific knowledge-production, as distinct from more modest, more accountably-debated and developed, and more socially inclusive possible alternative ones, as collectively-legitimated driving human imaginaries, need to be more energetically and carefully scrutinised for their unrecognised thus unaccountable normative influences.

Thus the instrumental ethic of science lies not only in science's role as means. The same instrumentality also *becomes* an ethic by being installed by-default as the assumed *ends* of scientific knowledge – to enlarge control, to expand technological force and functional relations as ends-in-themselves, impartial to specifics except that control is itself a normative epistemic criterion in defining good science (thereby also suppressing or externalising the 'other', namely spontaneous relations which do not fit with this demand for control). It is difficult to deny these upstream ethical questions for NBI techno-sciences, questions which are focussed on *knowledge-production* processes, when this culture is cultivated instead through the bland rationalisations of 'advancing innocent knowledge', but alongside *de-facto* visions and promises of future technological pay-offs. These are increasingly articulated as a crucial part of the political economy of promise which drives modern techno-science and its funding, including basic science funding.

Thus basic scientific research also has an imagined society, with imagined societal needs and priorities, and deleted ones, inscribed into the formation of its material and intellectual objects of interest, research agenda, and epistemic cultures. This point resonates strongly with Dupuy and Grinbaum's, and Gomes' reference to the metaphysical commitments of modern science which are just blankly and rigidly denied, and thus blindly imposed.

THE ETHICS OF NON-CONTROL AND CONTINGENCY

As Kearnes (2005) has discussed in relation to nano-imaginations, drawing on Conrad (1993. 1997) and Deleuze (1990), there is an always-approximate dimension of the condition of 'control'. It is never absolute; and of course, the more ambitious our technological ambitions over what may be more and more subtle material forms of complexity (such as, nano-bio manufacturing, or 'synthetic life') and operating at the limits of novel technoscientific knowledge-practices, the more substantively important becomes this finitism of knowledge and control. This endemic limitation of control (and of predictive-control knowledge) makes it emergent and conditional, continually being evolved in order to try to cover its unavoidable and undefinable other-dimension of what is left *un*controlled (eg, inter alia, unpredicted consequences). This evolutionary character in the ontological sense that Oyama (2001) has discussed, also brings into question-focus the selection environment in which evolutionary survival and fitness of designed objects are shaped. Contingency of conditions and outcomes is irreducible; and moreover, it is not necessarily marginal or residual.

Here we can also see the return of the dual ontological visions, of matter and energy, in physics. Since they were recognised to be interchangeable from the early twentieth century, quantum physics has recognised the continuity of all 'matter' as continuous with electromagnetic radiation, as continuous fields of energy-potential but stable only at discrete and differentially-condensed energy levels. The salient discontinuity is not between 'separate, individual' particles or corpuscles a la Newtonian mechanics, but between stable energy-levels within the matter-energy continuum. For all its apparent modesty of claiming to 'go with the flow' of nature rather than to reconstitute it bottom-up, a big question about biomimetic nanoscience is whether it can emerge and develop in 'trial and error' fashion (Conrad, 1993, 1997), without producing *monumental kinds* of 'error' when these occur. How might we know before rather than after we make the mistake? And more to the point perhaps, if as a matter of intellectual rigour in face of contingencies we can't know beforehand, then we return rationally to the question: what is the purpose(s) and ethical vision(s) – of human compassion and mutuality for example; or self-aggrandisement - driving this techno-scientific endeavour? This is the fourth-hurdle regulatory

question, that of 'what social benefit is envisaged, and intended?' And how realistically? which has been institutionalised so far as I know only in the Norwegian 1995 Gene Technology Act. It has been rejected in the EU and its member states, as too-threatening to the competitiveness of EU science seen as speedy innovation- and wealth-creator. Yet the rational logic of rigorous knowledge of risk assessment used as regulatory criterion, but endemically unable to eradicate more far-reaching contingency and ignorance, is to ask, why are we doing this? for what envisaged human ends? If these are important and have no other means, we might well collectively accept the unpredicted consequences and develop the readiness to adapt to them, knowing the effort was worth it, and ethically so too. We notice here a point I have made[8] - against mainstream social science (eg, risk perceptions work) as well as institutional policy and science - that the ethical and intellectual, or affective and cognitive dimensions of such issues are not mutually-independent, but are intertwined. Public ethical judgements of institutional hubris of science are based on intellectual judgements and evidence, that risk assessment does not capture all important future harmful consequences (yet a shortfall which science itself effectively denies, by continual reference to risk assessment as public reassurance).

This 4th-hurdle issue is an ethically-loaded but intellectual question, deriving from a recognition of endemic lack of scientific predictive control. It corresponds closely with the points made for years about the inadequacy of scientific risk assessment as an institutionalised means for claiming such intellectual control, thus (consequentialist) ethical validity and public legitimacy through its supposedly full and adequate protection of public safety. As Wynne (1992) noted, 'risk' is only one of several categories of uncertainty over the possible harmful effects of technological innovations. It is the most controlled one, and the others are typically denied, as Schon (1972) suggested, by reducing them and their greater complexities all to 'risk', and residual imprecision. This is summarised in Table 1.

TABLE 1. Different Forms of Scientific Uncertainty:

RISK	Know the probability of harmful event, as well as the scale of harm
UNCERTAINTY	Know the possible consequences, but do not know the probabilities
IGNORANCE	Do not know the possible consequences (is risk assessment even asking the right questions?)
INDETERMINACY	Processes subject to inconsistent outcomes from "same"

[8] See Brian Wynne, "Creating Public Alienation: Expert Discourses of Risk and Ethics on GMOs", *Science as Culture*, 10(1), 2001, pp. 1-40

(do we know?) initial conditions

AMBIGUITY Differences of meaning, and thus of which questions, and which dimensions and variables, thus which knowledge(s), are ***salient***

DISAGREEMENT …..

These categories are not necessarily mutually exclusive

Following and extending Schon (1972), we can note that all of these conditions tend to be reduced in policy discourse-practice, to the most precise and controlled, that is, to risk. It may not be entirely coincidence that as we go in this direction upwards in Table 1, we also move from the more normative dimensions, to the solely propositional – what are the risks? In other words, the typical reduction of meaning to risk referred to here also harbours the typical concealment of open normative questions by implying that they are all only propositional questions. That is, they are for expert discovery, and not for social negotiation. This is a historically cumulative, gradually deeply-routinised technicisation of political and ethical debate about proper public ends, and meanings[9]. It embodies deep ethical issues too, about institutional behaviours and presumed relations of power and control; but these are ones which are not remotely recognised in disciplinary nor institutional ethical discourse[10] .

As an ethical issue for science, this above is not at all unique to nanosciences and technologies and their specific qualities. But I would insist, each field of science - nano, bio, neuro, or whichever including NBI convergence - is involved mutually with the political economic systems and institutions which uphold them and which, in a process of *mutual* reinforcement and

[9] In a forthcoming EC expert group report which BW is chairing, a chapter on normative discourses of ethics in EU science policy, produced from a working paper by Mariachaira Tallachini, describes this same kind of process of depoliticisation of normative public issues going under the name of expert *ethical* discovery, not only notional *risk* discovery.

[10] In fact there are ethical issues recognized, but this is itself significant, and follows the same pattern of denial. In the case of GMOs in Europe as a good example, multiple ethical analysis pronounced that ethics issues were either to be in-effect handed back to risk assessment if consequentialist ethics ('weigh costs against benefits'), or if deontological (eg, 'playing God'), could be privatised as this is an individual ethical matter, and nothing to do with concern about institutional hubris, or institutional refusal to debate benefits – a public matter. Thus individual market choice could satisfy this 'ethical issue' so long as GM products were labelled. There is thus a question mark over institutional behaviour and arrangements, which is systematically deleted as a public ethical issue, and the responsibility for those behaviours therefore also denied. See B. Wynne, "Creating Alienation: expert discourses of risk and ethics in the case of GMOs", *Science as Culture*, 2001, **10,** pp.1-40.

influence, they uphold. Thus nanosciences and NBI, as our focus, surely cannot have their cake and also eat it, by saying that they are funded by this system - on the basis of the questionable promises of benefit which the science projects, in ways which sustain this political economy – they uphold it, and promote the technological innovations which are its economic and political *sine-qua-non*, yet cannot accept any responsibility not only for it, but for the forms of denial and illusion (promises) which keep that political economic techno-scientific knowledge system afloat. Science, including nanoscience, enacts this through its own wilfully-accepted central involvement in that political economic system's economies of promise which keep capital investments flowing into the favoured fields of R&D (Cussins, 2003; Sunder Rajan, 2006) , and through its forms of attempted political legitimation through regulatory processes which claim to perform the public interest through scientific rationality, but which allow no debate of the several dimensions of normative social and ethical commitment that are concealed within that public scientific rationality.

RESPONSIBILITY AND DENIAL: PLAYING GOD - UNDER THE ALTAR

The main dimension of Table 1 that I wish to emphasise and then here develop into ethical questions about playing God, including for NBI technologies and their prospective regulation and risk assessment, is one I have developed before in another context (Wynne, 1992; 2001; 2006). So I only briefly outline the analytic point before dwelling on the ethical implications, about a missing capacity for taking collective responsibility for techno-scientific research and innovation. This arises from the continuing confusion between: on one hand, uncertainty implicitly as *known* uncertainty, and which it is assumed, can be reduced by further research; and on the other hand, ignorance, or unknown uncertainty about possible consequences, which may be reduced serendipitously by research, but may not be. Indeed it could be amplified by (techno)scientific research when this is understood as extending and deepening previous forms of material technological intervention in nature. This confusion reflects the observation of Hacking about the historical confusion which has existed since the birth of statistical probability theory, between ontological and epistemic uncertainty in scientific knowledge representations.

The imaginative and conceptual gulf between known uncertainty and risk, and unknowns, is well-captured in the following excerpt from an exchange which took place in the UK in 2001, between a member of the government strategic advisory Agriculture and Environment Biotechnology Commission, and the decision-licensing scientific committee chair of ACRE, for deliberate release applications for GMOs:

TABLE 2: UNKNOWNS AS (UNKNOWN) SCIENTIFIC OBJECTS

"[AEBC]: Do you think people are *reasonable* to have concerns about possible 'unknown unknowns' where GM plants are concerned?

[ACRE Chair]: *Which* unknowns?

[AEBC]: That's precisely the point. They aren't possible to specify in advance. Possibly they could be surprises arising from unforeseen synergistic effects, or from unanticipated social interventions. All people have to go on is analogous experience with other technologies.…

[ACRE]: I'm afraid it's impossible for me to respond unless you can give me a clear indication of the unknowns you are speaking about.

[AEBC]: In that case don't you think you should add health warnings to the advice you're giving ministers, indicating that there may be 'unknown unknowns' which you can't address?

[ACRE]: No, as scientists, we have to be specific. We can't proceed on the basis of imaginings from some fevered brow…." [AEBC public meeting, London, 2001]

The ACRE scientist was operating under a difficulty, in that in his normal ACRE decision context, he would have been legally forbidden to refuse a release application on the ground that there might be some unknown, hence non-specifiable and non-demonstrable harms. Regulatory risk assessment is legally framed such that only known harms, of certain specified kinds, and for which hard evidence exists, can be used as justification for regulatory refusal. However the AEBC member was addressing a different point, about the severe and yet unrecognised dislocations between this rigidly legal scientific positivist policy account of 'responsibility', and known public concerns about regulators and promoters of GMOs pushing ahead when it was reasonable to judge, given the pace of development and the relative immaturity of the science knowledge in question, that existing scientific knowledge just did not know enough to be able to formulate adequate risk assessment questions, let alone answers. Such unpredicted effects, from beyond risk assessment and *known* uncertainties, had been experienced several times for products which had been through state-of-the-art risk assessment and regulation, and passed as safe because the only later-evident salient questions about possible harms were unknown at the relevant time. The effects of thalidomide on the human foetus was an unknown of this kind. So too was that of CFCs and stratospheric ozone depletion. Such unknown harms would have been just such emotive, 'fevered brow' imaginings – except that they weren't imagined, until it was too late.

The long-established legal stance which the ACRE scientist was tacitly reflecting, is also one which attributes such effects unknown at the time of regulatory assessment and decision, to extra-human responsibility. The position is that if any human actor acted in accordance with state-of-the-art scientific understanding of the time, and there was at that point no evidence of 'prior knowledge' indicating those possible harms, then s/he acted with due responsibility, and the unpredicted effect was an 'Act of God' – even though it resulted from (mis)informed human choice. This term is used in legal practice, to define the institutional boundaries of human responsibility, on the basis of existing scientific knowledge with its finite framing limits.

To raise this as a public issue for scientific policy institutions wishing to claim public authority and trust, is not to ask for more powerful predictive knowledge and control, nor to propose that any innovation whose consequences cannot be fully predicted (ie *all* innovation) should be prohibited. Nor is this the typical public response to this awareness of contingency and lack of control and predictability. It is a predicament, not an exposure of failure. Indirect responses can be adopted even if the traditional reassurance of 'control' can no longer be sought. This brings us to the precautionary principle and its relationships to 'risk', a topic which we come to below.

It is a heavy irony that in a situation where public assertions of scientists playing God, used as arguments against such innovations as GMOs, have been dismissed as unfounded and irrational, this institutional attribution of Godly agency to the unknown consequences of such *human* acts, is precisely an example of such institutions playing God! Moreover this is humans playing God by tacitly assuming complete agency over human interventions and their effects, known and unknown, but then dumping the uncontrolled and unknown ones onto others who were not or will not have been party to the commitments made[11].
However this does not dissolve the reality that public concerns about 'longer-term', unpredicted effects of innovations arising form cutting edge science pushed to innovation and market at ever-more frantic competitive rates, have become impossible to ignore. Thus the long-established regulatory culture of presuming that if any private (or public) actor has deemed any product worth promoting for regulatory approval *by definition* has social benefit, and assessing only its known risks against legally-established definitional criteria of harm and evidence, is showing its endemic logical, ethical and political limits, in face of evident public awareness of the finitude

[11] That it is legal institutions doing this in the process of exonerating the scientists from such public accusations, is only witness to the ways in which science and its surrounding institutions of law, policy and indeed, funding and use, mutually construct and reinforce one-another in ways which make definitions of responsibility of a legal kind, more ambiguous.

and contingency of scientific risk knowledge (indeed, from experience, of any knowledge). In these circumstances, to use risk assessment first as a representation of public concerns as if these were concerns only about risks as defined by science, and second as a reassurance of those concerns, is counter-productive, and hubristic. It is a denial of its own scientific limits of predictive control, thus a significant misrepresentation, and all this in the public name of science.

This fundamental culture of denial and hubris, and in the name of science, also surely carries a large ethical question-mark, even if it cannot be discretely focussed on a single decision-question, nor on any individual scientist or decision-maker. It is a *cultural ethos* that is in ethical question here. Where is the collective discourse of disciplinary or institutionalised ethics that can address this? The inherent unpredictability of consequences which I am arguing the unreflective deployment of the scientific risk discourse only ends up denying, thus being dishonest and untrustworthy, is unlikely to diminish as the extent of ambition of techno-scientific projection, promise, and commitment increases, with convergent NBI technology scenarios, 'synthetic life', and more. These ambitions and promises are egged on by the proliferating political economy of promise-investment competition for global scientific R&D funds, in which science is deeply ensnared.

The more grounded logic of these analytical distinctions between uncertainty, and unknowns or contingencies, is to focus on asking accountable collective questions about imagined benefits, humanly valued social ends, purposes, and priorities, and ways of life and relationship, which producing these risks, and further ignorance and contingencies, is supposed to be for. In effect even if not deliberately, risk discourse, as the presumed defining meaning of the public issues over new technologies, coraals and imprisons all of these teeming, open human social ethical and political questions, under a reductionist and technicist propositional frame of meaning – what are the risks? This institutional discourse-practice carries serious ethical dimensions, focussed more on the institutional culture in which science is embedded and on which it draws for funding, authority (of a certain brittle kind), and influence. Whoever should be assigned responsibility for this, and it should not be science alone, science cannot be altogether excluded, even though it would be difficult to differentiate specific techno-scientific fields in this mutual, networked, habituated form of agency (Bourdieu,).

RECOGNISING 'THE OTHER' AS ETHICAL RESPONSIBILITY: EPISTEMIC AND SOCIAL DIMENSIONS

A final ethical issue I raise from the foregoing analysis of risk and uncertainty starts from an equation I would like to make between two different but connected forms of 'the other', and how institutionalised techno-science in both innovation- and protection-oriented (eg risk and regulation) domains relates to these in a fundamentally similar – and ethically questionable - form. In the way I have outlined the significance of ignorance as an endemic condition of science, the unknowns which come as sometimes drastic surprises to science, and to the society which has depended on science for its predictive risk-assessments, can be seen as an epistemic 'other' – from a different ontology. The evident mystification of the UK ACRE scientific chair when asked to reflect on science's responsibility towards such questions (Table 2), is a vivid illustration of this general condition. Institutionalised science which lays claim to our trust and support seems unable to recognise the existence of this 'other' which lies beyond its control.

. Hastrup[12] has emphasized how a different kind of "other" in the form of suffering and pain challenges a central tenet of natural scientific epistemology, by being simply not knowable apart from subjective experience. As she notes, we can only experience this other through our own imaginative projection, which requires an imaginative capacity and readiness to use it. This imaginative capacity is composed of both emotional and intellectual dimensions intertwined[13].

Despite apparently very different epistemic as well as emotional resonances, Hastrup's insight on suffering can be applied to the problem of ignorance and its denial by institutional science. We cannot know nor specify intellectually what we don't know. Ignorance as a predicament can only be acknowledged *indirectly*, through imaginative allusion, and through *practical* cultural recognition of the limits-in-principle (the actual limits remaining constantly out of reach—that is the point) of our own culture, and of its legitimatory claims and aims of control. Polanyi[14] explained something close to this insight about the profound, unstated ambivalence of practical scientific research toward "what lies beyond" current knowledge. His ethic was to valorise the focal attention on the intuitive, craft-based, apprehension of the unknown which could not be reduced to expert rule-following and formulae. As science becomes more closely entwined with

[13] Of course science has imaginative capacity, otherwise it would not be so creative. However, this scientific capacity to imagine can be said to be highly-channelled and structured by its own forms of strong socialization-training and reinforcing practical cultures that are very specific, selective, control-oriented, instrumental, and rote-based, as well as by a social context that is increasingly commercial.

society through the expectations of commercial benefits from scientific research, and the anxieties about managing social reactions to this relentless innovation production-line, these scientific negations of (epistemic) 'otherness' through risk-discourse denial of ignorance, and thus of responsibility for it, and denials of autonomous social-ontological otherness in the form of scientific-policy construction of publics in their own instrumental scientific image, have become closely correspondent and mutually reinforcing. The anthropological work by Hastrup[15] on hunger and suffering is highly suggestive of the parallels between the unseen cultural limitations of institutional self-consciously rational culture toward "the other" seen either as intellectual unknowns and shocks, or as cultural-human "others."

This digression into an area of anthropology, which at first sight appears to have nothing to do with techno-science, public reactions, and risk, does help fill out some hidden dimensions that much of social science, let alone policy-scientific practice, has not really addressed. I raise these because they are inherent in what techno-science like the NBI convergence agenda has implicitly set out for itself in its aspirations, claims, and expectations of social authority. The expert EC working group set up to reinstall the 2001 Lisbon Agenda aim of making Europe the most competitive knowledge-economy in the world by 2010 (Aho, 2006), asserted apocalyptically that:

> "Europe and its citizens should realise that their way of life is under threat but also that the path to prosperity through research and innovation is open if large scale actions is taken now by their leaders **before it is too late",** and affirmed "the need for Europe to provide an innovation-friendly market for its business (…). This needs actions on regulation, standards, public procurement, IPR and fostering a culture which celebrates innovation."

It thus emphasised a new model of the 'public deficit model' of public as barrier' to salvation, and called for EU institutions to

> "create a cultural shift which celebrates innovation, using the media and other means to encourage citizens to embrace innovative goods and services".

With science seen as the crucial source of technological innovation-knowledge, thus R&D as the crucial step to this, European public alleged innovation-aversity is the supposed barrier since it discourages inward global investment in European science. That those publics may have questions about how unpredicted consequences of those innovations will be handled, an about why they are not even being recognised by the authorities as part of the human-created realities involved, is deleted. Thus the institutional scientific denial of independent 'other' public

meanings, and of the epistemic 'other' of scientific ignorance, or lack of predictive control, can be seen to correspond with each-other. There is an important ethical issue of institutional irresponsibility, hubris, and presumptive imposition of alien identities on wider publics here. It has to be explicated and recognized as a salient public question for science as a public institution which expects – and for society's sake, needs - to be given public authority and legitimation.

In his reflections on the sensibilities of Buddhism and psychotherapy toward ignorance, Mark Epstein[16] recognizes that the harder we struggle to know more powerfully (seen as a singularly positive indeed essential trait by modern rationality-culture) the less we are *able* to know in a deeper sense. As he put it (p. 87),

> The concretisation of experience which the thinking mind is so expert at carrying out, is what [we] call ignorance.

In other words, he notes, modern forms of scientific knowing inadvertently but systematically falsify authentic knowledge — which necessarily includes *knowledge of oneself*, or self-reflexivity, as part of wisdom. They perform this aspect of falsification, because they constitutionally differentiate subject and object, knower and known. This separation is what defines proper knowing in Western scientifically-shaped cultures. Thus paradoxically, the more rigorously (that is, one-dimensionally) we try to know, the more we intensify our own alienation, as knower-subject, from the known-object; thus, the less we are aware of and able to act on the limitations and parochialisms of our "more powerful" (but thus self-centered and instrumental-only) knowledge. The ethical dimensions of this loss of cultural self-questioning, or reflexivity, are deep and pervasive, a problem which is not removed by their incapacity to be precisely specified. Our knowledge-object always embodies a crucial element of ourselves as knower, since we have in some way humanly defined our object(s) of desired knowledge — we have been the silent (of course, never final) authors of meaning, and salience. "Risk" is a key contemporary example of this, where the momentary experience of not knowing is seamlessly deleted immediately the unpredicted and uncontrolled event occurs.

Therefore, it seems that trying to imagine appropriate recognition of ignorance, and performing this recognition responsibly in public policy, can never be a purely cognitive task—it has to be embodied in an appropriate practical public culture. This was the ACRE scientific chair's

problem; he had no cultural context of practice to which he could relate the AEBC member's question, until on the spot he invented his own, "fevered brow" meaning. In so externalizing and banishing any potential for acknowledging the state of ignorance as endemically present "other," he also thus routinely patronized and alienated science's publics yet again, not as an individual scientist, but as institutional agent of a particular culture. In so doing he obliterated the self-regulatory cultural potential that our scientific-technological culture of hubris, and all of the technological products and promises of this culture, urgently needs - and which people seem inchoately to be calling for.

Thus understanding others, in exercises like public engagement with science and "listening-to-the-public" processes, as a precondition of avoiding failure, always has to involve awareness of the problematics, and finite limitations in principle, of our own culture. With science and its false claims to be empty of culture (and of metaphysics), this means recognising its own historical parochiality; that its assumptions and commitments might be legitimately questionable. As Hastrup says for an empathy with others' suffering, and I suggest for an effective awareness of our own scientific parochiality and of ignorance in risk assessment and rational decisions, a collective moral imagination and not just intellectual competence is essential. Otherwise we will be condemned to projecting our own buried and unacknowledged insecurities onto "the other" whom we may be trying but still failing to recognise and hear.

This essential reflexive point has not yet been learnt in all the avalanche of attitudes surveys, public debate, "listening," dialogue, public deliberation, and confrontation that has marked the GMOs controversy as well as other domains. This and the corresponding reflex reaction of explaining public concern as ignorance and vacuity is not only misunderstanding and misrepresenting. It is also committing violence to the publics by violating their civic and human subject-identities. It is not that there are no deficits of public understanding of science — there are too many, including those of scientifically well-qualified citizens. However, this does not mean that these "deficits" are *the cause* of public refusal to accept what are called "scientific" issue-definitions and ensuing policies, as if scientific propositions about risks were the only aspect. More salient is the public experience of the culture of institutional presumption, idoloatry, exaggeration, deafness, and denial. The fact that this is done in the name of science, more recently even of a "listening science," only underlines how easy it is for this negative public reaction to be expressed as if it were against "science," rather than as I suggest it is, a reaction

against a science-policy culture that has overreached scientific knowledge and understanding into what is arrogant scient*ism.*

In the context of the institutional culture's denial of ignorance, I suggest that this apparently purely intellectual shortcoming is much more than this; it is itself a repeated, habitual act of irresponsibility that also preemptively destroys the legitimacy and integrity of the cultural other. This is also, especially with the material powers of modern techno-science to hand which this culture legitimates, a culture of immodest if conveniently externalized *violence*. **There are surely ethical issues here which await further development and integration with salient forms of cultural analysis.**

Crucially these suppressed questions, deriving directly from the uncertainty issue, go beyond downstream impacts-oriented science and risk assessment, to focus instead on upstream *innovation*, and what human forces, purposes, and conditions drive it (e.g., who owns and controls it, for whose benefit, for what imagined human ends?). This suggest a shift from instrumental issues of means, as in the case of concern about security (risk-centered meanings), to include neglected questions of human ends as essential matters of attention. Again, it is hard not to see ethical issues here, and ethical issues addressed to a culture which appears systematically to suppress these questions.

IMAGINARY PRECAUTION

Since the uncertainties in risk assessment of modern technological products like chemicals came to the fore during the 1980s, and the problem of false-negatives in risk assessment and testing was emphasised – that there might be significant harms which existing experimental risk methods could not pick up, even when harmful effects are occurring – the idea gathered force that we might have to intervene to control some innovations in the absence of the usual strength of evidence of harm. Thus the precautionary principle was used, reflecting an at least implicit concern that we might be unleashing such complex interactions, with irreversible effects, that we would never know that serious damage might have been done to something valued, until it was too late. Normal standards of scientific 'proof' might need to be revised in such conditions, to take account of possible error-costs, and the uncertainties in our knowledge of what we were dealing with. The inevitable dilemma for science, that controlled scientific knowledge of the risks

from, say, a given chemical requires it be tested in pure form, alone, for effects on a chosen set of controllable and testable experimental parameters like mouse tumour-incidence, is an artificial representation of the real-world conditions which we wish to know about, in all their complexity, variety, and contingency, remains to be adequately covered. Since many independent environmental agents mix and may interact, thus affecting even the harm-processes we know about in principle in various unknown ways, risk assessment is always a precarious, limited and assumptions-framed scientific project – these assumptions being sometimes not even recognised as such, and sometimes also untestable. The more techno-scientifically ambitious and near to research-front the innovations become for which risk assessment is supposed to predict – and this is a condition exacerbated by the intensifying commercial culture of contemporary science – then the more these intellectual limits of risk assessment are likely to be significant in terms of lack of empirical-experimental testing control, and lack of predictive control, of the likely consequences. As analysts like Krohn and Weyer (1989) have noted in these respects, however much of the best scientific risk assessment is done before licensing societal release and uses, for most new technologies, society (and the environment) is the laboratory.

In the face of such broad realities and corresponding public responses, it has become a commonplace for precautionary principle policies to be adopted, not only in the grand global ceremonial treaties like those on global biodiversity and climate, but also for more routine regulatory issues. This has been an issue of intense dispute between the US and EU especially over GM crops and foods, with the US claiming successfully to the WTO in 2004 that Europe had effected an illegal moratorium on GM licensing and importation between 1997 and 2003, when it re-launched an explicitly precautionary regulatory Directive (2001/18/EEC).

Many analysts (including myself, Wynne 1992) have argued that precaution is a mode of policy which cannot and should not depend on a prior ‘threshold’ decision about the possible harms of a given innovation in order to invoke it, precisely because the whole point is that we cannot know what the possible harms are, thus cannot pass the first gate. On the basis of the differentiations of uncertainty given in Table 1, they have thus argued that risk assessment should always be treated as inadequate for a full regulatory appraisal, especially where there are reasons to suppose that the fields of scientific understanding on which risk assessment is based, are scientifically or technologically immature, and the salient processes complex. Thus if we take the condition of scientific ignorance rigorously, and as science is supposed to, self-questioningly, we have to adopt extra measures to supplement risk assessment alone, and in addition to ensuring that the

risk assessments themselves are based on the best most inclusive and varied bodies of knowledge and experience, and the most attentive identification of unseen assumptions and conditions. The EEA 2001 edited book, *Late Lessons From Early Warnings: The Precautionary Principle in the 20th Century,* gave such extra practical measures for a rigorously precautionary approach, which it argued should be automatic and routine, not dependent on a prior risk assessment. Such measures include where possible building diversity of portfolios into any significant policy trajectory, such that if any one shows later unanticipated harms, there are other options already developed and available to allow the dropping or curtailment of the one showing surprise harms. Others include, logically, asking of any significant innovation, what are its promised or intended benefits to society? Are these realistic, and are they worth the chances of unpredicted harms? (The "4th hurdle" regulatory question). Distributed social capacities for adaptation to unpredicted new circumstances could be another such indirect response to this rigorous treatment of uncertainties and contingencies. Of course, and rightly, these sorts of measure also distribute *responsibility* for such societal commitments. They can no longer be assigned only to science, because they are not only scientific questions. Moreover they are questions some of which reframe the questions science is itself asked to address in risk assessment, since they may redefine what is regarded as salient, to whom.

This rational, analytically-justified approach to complex technologies and their regulation thus exposes further institutional challenges, built around the open recognition of contingency as a condition of science and scientifically-informed policy, as well as other domains. Yet for all its global leadership in institutionalising precautionary policy making, as expressed in its 2001 EC Communication on *The Precautionary Principle*, the EC has defined its approach in a wholly technicist, risk-reductionist way. Thus a risk assessment is required as the threshold measure to determine whether or not a precautionary approach is justified; and precaution is then applied only in the subsequent risk management measures, leaving the risk assessment process as a completely distinct, prior scientific process. One reason given for this, apart from following long-established international habit first articulated by the US NRC in 1983, is that scientific risk assessment is inherently prudential, by definition since it is scientific! Thus the EU, as global leader in precaution and thus by implication also, in dealing rigorously with the epistemic uncertainties underlying regulatory knowledge as well as ontological uncertainties in face of the new complexities and contingencies created through the promoted innovations, has repeated the same basic reduction of meaning, to technical discovery of risk alone, of the public issues for which precaution may be proposed. This again wholly suppresses under a spurious scientific rubric, the human social-ethical issues, about social ends, needs and priorities, about what kind of

social world, under what kinds of relationships, we wish collectively to live? Again we might not wish to constrain such hidden dimensions to disciplinary discourses of 'ethics'; but since anyway the regulation of these kinds of innovation is increasingly being performed under the ethical banner and its existing disciplinary discourses, either those discourses need to be radically enlarged and diversified – politicised one might suggest; or they need to be supplanted by discourses which can do justice to the issues, and which are institutionalised with recognition that these are the matters of concern of typical citizens who pay the experts to pontificate in their name. To continually reduce such complex human issues to rule-based decisions, is to miss their most important points, and to de-skill the public – and scientific, and ethical - processes from being able to address them in ways which reflect, and develop, the public interest.

[Gomes paper in *Phil Today,* re the social within science, and the corollary, the scientific definition and appropriation-control of much that is social, and ethical, and human.]

This is the return of the 4th hurdle Q, and of the *practical* dimensions of the precautionary ethic of non-knowledge, the imagined other. Butler's (1989) attempt to define universalism without having to resort to transcultural normative claims, is interesting here. In defence of Hegel against Derrida's critique of Hegelian thought as that of mastery, she asserts that his phenomenological account of universality (and sovereignty, instead of mastery) defines it as being achievable through mutual recognition across cultural boundaries. Mutual recognition is the key condition, a form of modest understanding which does not involve assumptions or requirements of instrumental control over the other, and which accommodates as normal, the unexpected, the uncontrolled, the contingent – just as does typical civic life-world rationality. Thus as Kerruish (2006: 25) states it, "from the implicit rejection of transcultural norms in this thinking, Butler moves to the performative, cultural translation, as a possible forging of universality which crosses cultures without transcending culture". This is a post-colonial, informal, non-abstracted and 'contextuallly grounded' form of universalism which has so-far escaped any contemporary scientific and policy imagination of precaution, despite its at least implicit ethos of modesty, and freely(internally)-defined, not (external)rule-defined restraint – of sovereign responsibility including for the beyond-control other, rather than the prevalent binary, of control or denial.

This relevant to my discussion of risk, uncertainty, precaution and contingency, in that as institutionalised the precautionary principle, in response to the political requirement of recent

times to take scientific uncertainty about future impacts seriously, has been reduced and sterilised, into another rule-bound decision tool which does not address, indeed it helps conceal, the substantive reasons for its original emergence. In particular, in existing form it deletes any questions about countering the effective hubris of pretending that risk assessment is an adequate form of predictive control over unknown future consequences of our increasingly ambitious techno-scientific commitments. Thus it continues, in the false guise of a new modesty, to prosecute a control-based, colonising material and intellectual culture of public policy and private innovation, one driven by the economic demand to extract value from nature by remaking it by human hand and brain, (including those human hands, brains, bodies, etc) and thereby concentrating ownership and exploiting the ensuing scarcity in time-honoured capitalist traditions. Taken seriously, and rigorously, precaution must also relinquish the currently-embedded claim, and normative expectation, of (predictive) control, - as in risk assessment's automatic implicit claim to provide such control, and tacitly externalise the rest. It must thus acknowledge the contingencies unleashed by our own decisions and commitments – even if we cannot expect to see all the intersecting causal pathways back from outcomes to our original commitments.

In this sense precaution can be an effective universal, but only if its self-professed institutional practitioners can bring themselves to acknowledge and recognise the other, hence also contingency, in Butler's post-colonialist sense; and to do this both epistemically, and socially.

Dupuy (2005: 20) has described a report of scientific use of molecular biological scaffolding to develop nano-manufacturing:

> "In November 2003, scientists in Israel built transistors out of carbon nanotubes using DNA as a template. A Technion-Israel scientist said, "What we've done is to bring biology to *self-assemble an electronic device* in a test tube [...] The DNA serves as a scaffold, a template that will determine where the carbon nanotubes will sit. That's the beauty of using biology."[17] The transitive use of the reflexive verb "self-assemble" speaks volumes about the ambition of nanobiotechnology to capture (i.e. to "enframe," the Heideggerian *Gestell*) the self-organizing properties of living organisms in order to harness them to human ends".

This science is also a *techno*-science a la Rheinberger, ie a technological experimental project of the extension of human control per se, for whatever *specific* human purposes. This is not a basic

[17] Kenneth Chang, "Smaller Computer Chips Built Using DNA as Template," *New York Times*, November 21, 2003: http://www.nytimes.com/2003/11/21/science/21DNA.html?ex=1075525200&en=67948bd27029a142&ei=5070.

science research project. This seems to be the ethic of the NBI convergence techno-scientific agenda, as Dupuy has suggested; the remaking of nature (including 'human' nature) through human artifact. One amongst many big questions here is: What would it be for this to have 'worked'? For example, since all other similar (if inevitably smaller-scale) projects have only *ever* 'worked' by (temporarily?) successful externalization of the uncontrolled, unpredicted contingent effects of the innovation onto others, including future others, where can this process unload and externalize, when all is encompassed by the mega-manipulative mega-programme? If we believe there are no ethical issues here, we may have missed something.

Dupuy's point is important, that the ends of this project, of capturing the self-organising capacities of biology, for advancing whatever specific human ends, is itself a chosen human end with enormous ethical implications, and one which deserves collective question in itself. In addition we can see that the phrasing he notes, also tacitly deletes human responsibility for this yet-further extension of control and any consequences, since agency is attributed instead to "biology".

However a further set of issues is raised here. If we were to commit to developing the institutional capacities to address the sorts of ethical issue about the apparently endless extension of assumed control, and about deletion of our human responsibility for its seamlessly externalized possible consequences which are also beyond our predictive intellectual control, we would assume that reasoned positions are essential to that collective societal capacity. Yet even in consequentialist ethical terms we cannot assume that our – anyone's - reason will ever be powerful enough to be more than crudely broad and rough as to identifying and weighing different imagined potential consequences against others (including imagined possible effects on our own human-ethical subjectivities), and reaching informed democratic resolutions of the conflicts involved. This is already an issue for consequentialist ethics in much more modest domains of required predictive knowledge. Although it is right that ethical stances should be amendable in the light of further knowledge including instrumental knowledge, only the broadest-brush and crudely imprecise principles are inevitable. Whatever flexibility to extant varying circumstances may be achieved with such generic principles, contingency is a condition which haunts the techno-scientific promises and reassurances as much as it does the ethics. It is an ethical challenge that these endemic conditions: (a) of imagined human ends and promises; and (b) of contingency (and the limits-in-principle of reason) and responsibility for them be acknowledged as a public matter for

techno-science and its institutions - and the multifarious and pervasive imagined ambitions, expectations and promises involving science renegotiated accordingly[18].

As a collection on "Embedding Ethics" in anthropological knowledge-production notes (Meskell and Pels, 2005: 4), "the embedding of anthropological ethics requires a rethinking of the practices of producing expert knowledge as well". This would as they emphasise, require that "[we] examine ethical relationships towards peers, public, and the people studied". As for anthropology, so too for techno-science at large. If it is to take seriously the ethical issues and concerns settling on science and the ways it has been socially embedded, this too will involve science's situated reorganizations and reimaginations of its ethical relations with various network actors - funders, patrons, users, publics, technical and natural objects, and so on. This will inevitably mean the revision of its various disciplinary modes of production of knowledge, and its interdependent modes of intervention in nature, and society. Inevitably this would also involve ramifying re-orderings of power, responsibility, and institutional relations, well beyond science itself.

CONCLUSIONS

I have tried to identify some questions about the new techno-scientific and social aganda of NDIC technologies which, if not ethical in the sense of being recognised as the sovereign terrain of one or another academic discipline of '--ethics', nevertheless carry weighty ethical import. Their recognition, definition and proper mode of address or public handling all remain unresolved, even denied – which itself poses ethical questions, inter alia. Most if not all of these 'ethical' questions are deeply cultural – inviting reflection back on the scientific culture of modernity which cannot acknowledge its own cultural dimensions; and which lack of self-reflexivity has generated its own ethical problems: in its own social relations, and modes of self-justification; in its relations with its own non-human objects; and in its relations with its human objects and 'social partners'.

The ethical issues I have tried to illustrate and discuss in modern techno-scientific culture are about 'the ethics of (a particular, and parochial) culture' – for example about how, and why, and to what imagined public benefit we are engaged in the hell-for-leather and virtually

[18] This is surely part of the trap we are in, that these collective human restraints are more appropriately a function of cultural practices beyond the reach of reason alone. Thus we cannot design them, at least not directly. But this does not excuse us from at least recognising the conditions we are in, and attempting to enact the measures we reason might shift our habits and ontologies in ways which approximate more closely towards a more responsible society. Perhaps it is on such grounds, avowedly anti-fundamentalist, that the science-religion debate needs inter alia to be reopened.

indiscriminate pursuit of techno-scientific knowledge which allows us to pretend that we are able to innovate, faster than a growing crowd of global competitors in the supposedly single 'global race', all the imagined and promised but fictional technologies that are on the agenda, while maintaining social integrity, security and manageable degrees and forms of risk. The questions I try to identify are institutional, and relational. They are thus transverse but still very substantially in relation to specific technologies; and they are not usually discrete to specific decisions or 'choices'.

It is good to acknowledge that bioethics as a field has addressed the need to overcome its liberal individualist and rational-decisionist original leanings, for example in recognising the need for collective forms of dealing with such ethical issues as those over genetic testing, when salient risks and questions of valued principles such as informed consent, freedom from invasion of privacy, or avoidance of stigma from relational identification with genetic conditions are inevitably at least familial, and imaginably communal too (Chadwick and ??, 2003). This resonates with the discursive collective ethics of the Habermas tradition, and with work in relation to indigenous cultures and their rights in relation to scientific interventions aimed at exploiting or even protecting, but anyway objectifying collective human interactions like knowledge-practices, or collective identities (Oldham, 2006). In these sorts of situation, communal and essentially open-ended processes of collective ethical self-definition and self-development are involved. Similar collective ethical issues of our own formation as human ethical subjects can be identified, against the dominant institutional framings, in for example the NBIC technological scenarios and their promotional discourses.

However these promising initial steps towards the collectivisation of ethical frameworks, and their integration with political, anthropological and STS empirical and theoretical work, all need substantial further development. This is especially needed through the deliberate opening-up of the hitherto closed-off terrain concealed by false and in-denial ideas of science's own supposed absence of any parochial cultural fabric. There have been ample acknowledgements by applied ethicists (eg Holm, 2003; Chadwick, 2003) of the relevance of social scientific empirical work for ethics, for example empirical work on public concerns, preferences, and so on. However this needs to be extended to include the work from STS focused not on publics but on science, which opens up techno-scientific black-boxes to show the hidden social and ethical in knowledge-production processes. This is a cultural and political-economic research programme with which ethics of technoscience has to identify and integrate.

The enforced opening which STS performs on technoscientific knowledge-practices in-the-making, and the acknowledgement of the range of contingencies which should follow this, would lead logically to the public ethical debate over the proper social needs and priority-ends to which scientific research and resources should be devoted, that is, the long-neglected normative social issues over what innovation and knowledge should be for, and not just over instrumental propositional questions like how we can achieve more and faster innovation, or what are its risks.

Much of this ethical struggle can be seen as one over which meta-narratives of our own society will be allowed to dominate as if natural and given, as if they were not the products of cultural contingency. The usual embedded narrative of the temporality of scientific knowledge is one example. This works to reinforce the potent mythology which I have challenged herein, of science's acultural character, thus exemption from social, historical, ethical and cultural question. Thus the relationship between basic scientific knowledge and its applications is represented as one in which we first (need to) obtain basic scientific understanding, containing no human interests or visions of possible ends, and only then imagine, contemplate and begin to try out possible uses and ends. According to this narrative, it is only after we have obtained validated basic scientific knowledge, and then turned our interest to uses, that ethical questions arise.

Historians and sociologists of science (eg, Edgerton, 2006) have shown how deeply misleading this model is; but a further comment is needed here. The counter-argument to the dominant mythology[19], that visions of application often come before basic knowledge has been produced, as in the Rheinberger version given before, has been received as if it were anti-realist – as if saying that there is no such thing as 'basic scientific understanding of natural processes'. Yet just because this perspective says that all research knowledge-production is imbued and shaped by human imaginations of ends and possible outcomes, and is technological in spirit from the

[19] It should also be remembered that scientists are typically led to confuse expected outcomes with actually enacted outcomes, as Kuhn noted. I was involved in a critical examination of such confusions where it really mattered, in global energy policy models which were said by their authors to 'predict' the 'scientifically demonstrated' need for large-scale and sustained fast-reactor nuclear futures. Yet the models on which this 'scientific' assertion was made, had not actually been successfully run. See the special issue of *Policy Sciences*, **18(3),** 1984, on "The IIASA Energy Models", papers by Brian Wynne, Will Keepin, and Mike Thompson

start, since its basic end and rationale is *greater control* of one kind or another[20], it does not follow that basic knowledge and understanding cannot be and is not produced in the process. It can be and it is *retrospectively* derived from the techno-scientific interventions which constitute scientific research; and it can accumulate; and it may then within material and imaginative limits be flexibly directed towards other technological ends.

The key point is however, that this basic scientific knowledge does not innocently *precede* imagined and practised application and technology, as the prevailing mythology claims. This is the key breach, since even though we can have basic scientific understanding which can be witnessed to work empirically, there is still a large human and ethically-debatable world of commitment, promise and responsibility which has framed and preceded that basic knowledge, but which has been concealed by the still-potent 'basic science precedes applications' mythology. Because if the power of this mythology, we have no collective capacity to even begin to debate these obscured issues collectively. We urgently need to develop this, as an ethical and an institutional agenda. Understanding and exploring the deeply cultural constitution of (techno)science, and learning how to interrogate this and ourselves as its subjects, is a crucial part of this ethical agenda.

REFERENCES (to be completed)

Butler, J, 1989, "Commentary on Joseph Flay", in W. Desmond, ed., *Hegel and his Critics: Philosophy in the Aftermath of Hegel,* Albany NY: SUNY Press, 163-178

Conrad M, 1993, "Emergent Computation Through Self-Assembly", *Nanobiology*, **2**, 5-30.

Conrad M, 1997, "Origin of life and the Underlying Physics of the Universe", *Biosystems*, **42**, 177-190,

[20] There are two distinct aspects to this, each with different implications. One is the issue that particular normative imaginations of ends or applications are being exercised with no accountability or debate of their social and ethical dimensions; but the other is the more general point that the instrumental epistemic ethic of science gives unquestioned licence to the extension of manipulative control of whichever domain is at issue, regardless of whatever specific uses may be imagined or attempted. This general purpose also has its own ethical questions, as for example in its ways of routinely externalising responsibility for uncontrolled consequences, and thus effectively dumping these on others with no debate or acknowledged responsibility. Of course, the suggestion that we should question the automatically free extension of this epistemic and material impetus of (always limited) control, is tantamount to suggesting that the sacred cow of 'the freedom of science' might be placed in jeopardy. However I believe that *de facto*, it already is, and that society has to learn how to develop this as a more deliberate institutional capacity.

Holm, S, 2003, "The Role of Moral Theory and Empirical Research in Applied Ethics", NWO, Netherlands, conference, *Ethics and Public Policy,* Utrecht, May 2003.

Kearnes M, 2006, "Chaos and Control: Nanotechnology and the Politics of Emergence" *Paragraph,* **29**(2), 57-80.

Kerruish, V, 2006, "On Restaging the Universal: Butler, Hegel, and Contesting the Closure of Logic", *Dilemmata: Jahrbuch der Altonauer Stiftung fur Philosophiche Grundlage,* **I,** 23-60.