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CRITICAL DISCUSSION NOTES

# Developments in the Debate on Nanoethics: Traditional Approaches and the Need for New Kinds of Analysis

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**Abstract** This paper aims to review different discourses within the emerging field of ethical reflection on nanotechnology. I will start by analysing the early stages of this debate, showing how it has been focused on searching for legitimacy for this sphere of moral inquiry. I will then characterise an ethical approach, common to many authors, which frames ethical issues in terms of risks and benefits. This approach identifies normative issues where there are conflicts of interest or where challenges to the fundamental values of our society arise. In response to the limitations of this approach, other commentators have called for more profound analysis of the limits of our knowledge, and have appealed to values, such as sustainability or responsibility, which should, they suggest, inform nanotechnological development (I will define this approach as a "sophisticated form of prudence"). After showing the ways in which these frameworks are limited, I will examine more recent developments in debates on nanoethics which call for the contextualisation of ethical discourse in its ontological, epistemic and socio-economic and political reflections. Such contextualisation thus involves inquiry into the 'metaphysical research program' (MRP) of nanotechnology/ies and analysis of the socio-economic, political and historical reality of nano. These ideas offer genuinely new insights into the kind of approach required for nanoethical reflection: they recover a sense of the present alongside the need to engage with the past, while avoiding speculation on the future.

**Keywords** Nanoethics · Ethical aspects of nanotechnology · Metaphysical research program · Responsible development of nanotechnology

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## Nanoethics: In Search of Legitimation

In 2003 the Canadian researchers Mnyusiwalla, Daar and Singer published a paper in which, denouncing the paucity of serious published research in the nanoethics field, they invited scholars to write on this topic and to learn from the issues raised by the GMO (Genetically Modified Organisms) debate [100].[1] For better or worse, their call for papers acted to shape debate, focusing attention on questions of whether there is a need for a special 'nanoethics' and where the novel issues are (if, indeed, there are any) in comparison with

[1] Mnyusiwalla and co-authors [100] analysed literature published between 1985 and September 2002, using survey databases and searching for articles containing 'nanotechnology' as a keyword. The articles were then screened for the keywords 'ethics' and 'social implications'.

previous debate on other technologies.[2] Ethicists interested in nanotechnologies soon faced the challenge of justifying their work through giving classifications and definitions of the field of ethical consideration of nanotechnology. They rapidly began to take up positions on the question of the existence of a new, autonomous field of nanoethics (cf. [5, 71, 74, 91, 92]). Grunwald [74] has for example identified four arguments used by supporters of 'nanoethics' as an autonomous disciplinary field: first, a large amount of money has been devoted to nanoethical issues and it would be impossible that these do not have an object of inquiry; second, it is not necessary that nanoethics should reflect on something completely new or different from other fields; third, in as far as nanotechnologies have been developed from the convergence of different disciplines in natural sciences, nanoethics can also be seen as arising from the convergence of subdisciplines in ethics; and fourth, even if many issues in nanoethics are not new, they show newly challenging dimensions. Grunwald judges all these arguments as biased and criticises them (see [74], pp. 108–112). Questions around autonomy and legitimacy of 'nanoethics' have been discussed by various groups around the world, although the debate was started in Europe and the US.[3]

The dispute around 'nanoethics', or the 'ethics *of* nano', and 'ethics *in* nano' is more than simply a problem of naming. It can be seen as a reflection of the difficulty of dealing both with a new, not very well defined, scientific field, and with different views of ethics and its role in debate on technology. Many questions about the label 'nanoethics' have emerged as a consequence of there not being an unambiguous definition of nanotechnology: it is not clear whether nanotechnology exists on its own, or if it is merely an amalgamation of several existing disciplines, such as chemistry, biology, physics, materials science, engineering and information technology, amongst others (cf. Allhoff and Linn [2], cf. [3]). As a matter of fact, up to the present day there is no commonly shared and general definition of nanotechnology beyond a general identification of the study and control of matter at the molecular and atomic scales (i.e. a definition which gives a precise range, or which refers to fields of application).[4] Even though today it is common to describe 'nanotechnology' with reference to length—such as it being research on and technological development of structures which have at least one of its dimensions within the range 0.1–100 nanometres [4, 65, 107]—every tentative delineation of this scale remains very general. With very few exceptions, it is difficult to find any kind of matter that would not qualify as an object of such nanoscale research: every branch of experimental science and technology nowadays deals with material objects structured at the nanoscale ([144, 145]; cf. [147]).[5] The range in which a particular piece of research is defined as being at the nanoscale seems arbitrary [101], a problem which has no short-term solution [93]. This ambiguity is also apparent in official documents: the US National Science Foundation [108] initially defines the nanoscale as being between 1 and 100 nm, but says later that it can, in some cases, be both below 0.1 nm and above 100 nm. Furthermore, the European Commission [50] refers only to the scale of atoms and molecules, without giving any numerical limits.

Disputes and open questions on the definition of nanotechnologies, and consequently of what 'nanoethics' is, present both ethical and epistemological

[2] Discussion on the challenges posed by nano began in the USA with the publication of a National Science and Technology Council report on '*Shaping the world atom by atom*' [106], which both anticipated utopian dreams of a better world and gave rise to fears and nightmares of a destructive future. The launch of a programme on 'converging technologies for improving human performances' was also particularly important [135]; this was followed by a response by the European Union [78].

[3] A number of conferences and meetings were particularly important in this initial debate: a Nanoethics conference in March 2005 at the University of South Carolina, USA (see also [25]); a workshop on Converging Technologies organised by the European Commission ([78]; cf. also [26]); and a clustering 'workshop on the ethics of nanotechnology', held in Brussels in November 2006 with the aim of coordinating current European projects on the ELSA of nanotechnology. Further interesting groups are the 'NanoCenter' at the USC Columbia (since 2001) in the USA; the 'Working Group for the Study of Philosophy and Ethics of Complexity and Scale (SPECS)' at the University of South Carolina; the Nanooffice at the University of Darmstadt; the Nanoethics Network based at the Danish University of Aarhus; and the recently founded S.NET (Society for the Study of Nanoscience and Emerging Technologies).

[4] For a precise explanation of the different notions of nanotechnology see [141, 108].

[5] As a consequence of this generality, Schummer [144] considers the self-proclaimed common ground of the length scale as being too weak to enable different disciplines (such as chemistry, engineering, and material sciences) to integrate so as to achieve interdisciplinarity.

features. The absence of a commonly accepted definition of nanotechnologies has precise *epistemological* implications, because it influences the setting and legitimisation of scientific research areas and therefore the scope of the research (cf. [86]). The setting of goals clearly has *ethical* implications, because goals and aims are shaped by society and because goals are matters of research policy—in particular through priority-setting. The definition of 'nanotechnology' varies depending on research priorities of different countries: unlike the US, Asian countries such as China, Japan and Korea tend to emphasise material sciences and electronics, while African and Latin American countries focus on environmental sciences and medicine (as it is there that the most urgent research priorities are perceived, [161], cf. [144, 147]). Nanotechnology therefore appears difficult to define "as long as it is something that awaits determination or as long as it is a space that waits to be occupied by human beings with human purposes" ([112], p. 18).

Understanding of the characteristic issues of 'nanoethics' similarly depends on disciplinary and methodological characterisation of the field, which is based on general ideas of what 'ethics' is and how it should be analysed. As a consequence, the search for the legitimisation of nanoethics is attached to broader considerations of the roles and meanings of the ethics of technology (including, for example, exploration of the field's relationship with bioethics[6]).

Authors who focus more on issues of the individual, such as questions of autonomy and privacy or of risk perception and the legitimacy of changing 'human nature', often see the nanoethical debate as a development of a more general bioethical framework: Ebbesen et al. [43] argue, for example, for the incorporation of many issues typical to the bioethical debate (and in particular to the debate on genetic engineering) into nanoethics, calling for the use of principles of biomedical ethics in untangling the challenges of nano. For the European Group on Ethics on nanomedicine [44], even if developments in nanomedicine, such as human-machine interfaces and biocompatible materials, offer new possibilities, they also raise issues which are already present within debate (such as questions of privacy, autonomy, the increase of social security costs and the possibility of unequal access to nanomedicine). For Ball, nanoethics as a new field of ethical inquiry would be "a grave and possibly dangerous distortion" given that the questions are the same as in the field of biotechnology ([6] p. 8).

The framework proposed by Susanne et al. [157] similarly promotes more robust attention to biopolicy issues: while admitting that ethical reflection on nanotechnology (they do not use the term 'nanoethics') is not entirely new, they describe it as a *new* challenge *for* bioethical reflection. This newness is precisely due to the fact that issues such as 'mechanisation' of humanity, manipulation of living beings, management of complex technological innovations, public engagement and the social determinacy of science, and distributive justice are in this case particularly challenging.[7] Similarly Allhoff [1], while arguing that none of ethical issues raised by nano differ in any relevant way from issues raised by other technologies,[8] highlights the need for ethical attention *to* nanotechnology as well as for public and political forums (justified pragmatically by the fact that these technologies will have multiple social impacts, posing ethical challenges in new contexts; cf. [3]). On the other hand, Cameron [22] insists that nanoethics should rediscover broader biopolitical issues precisely by progressively detaching itself from the bioethical tradition.[9]

[6] Keiper [91] describes, for example, the discipline of nanoethics as being modelled on the development of bioethics.

[7] Susanne et al. [157] are, however, critical of current bioethical debate, and describe two typical pitfalls it falls into: a technical prejudice which argues for the solution of almost every question through new techniques; and a philosophical prejudice which tends to solve everything through speculative, *a priori* arguments.

[8] Allhoff [1] points out that if we consider, for example, issues of distributive justice, we have first of all to figure out which account of distribution we want to follow, then establish whether that account would be violated by a particular application: in doing this there is nothing new with respect to other debates on technologies.

[9] For Cameron [22], contemporary 'bioethics' is experiencing a crisis because it is withdrawing from substantive questions to focus on procedural concerns which concentrate strongly on individual autonomy and 'informed consent'. In this way it leads to efforts to privatise ethical decision making and assume an atomistic view of society. Cameron sees in the twinning of bioethics and biopolicy the possibility of a "nanoethics that builds a vision for the common good—on the basis of shared convictions about 'human rights and fundamental freedoms', and with a flipside in approaches to biopolicy that are not shy to encourage appropriate regulation" ([22], p. 294).

Other authors who deny the novel character of 'nanoethics' (even extending this to the denial of the existence of a separate field) still stress the need for reflection on the goals and visions that shape these technologies. Grunwald [71–74], for example, argues that claims of novelty are exaggerated and that they draw attention away from thorough analysis of the issues involved: this, on the contrary, should involve assessment of the visions underpinning nano (to be developed alongside technological development, cf. [70]). This concept of ethics as '*Begleitforschung*' (accompanying research) is important to him for three reasons: because speculation and visions have real consequences; because we should prepare ourselves for worst case-scenarios; and because, in doing this, we have an opportunity to learn about ourselves (and can fruitfully apply some of these conclusions to other technological fields, [71, 74]).

However, other authors who do not classify nanoethics as a new stand-alone discipline explicitly want to avoid reflection on visions, and call for analysis of problems directly connected to research and development (R&D) activities in nanotechnology. Other questions, such as transhumanism, are seen as distracting from more urgent questions [159]. Wynne [172] argues that we do not have to conceive of ethical reflection on nanotechnology as reflection on nanoscale objects or processes, but rather that it is best seen as "reflection on human relations, imaginations, meanings, commitments, and normative visions of valued ends which human knowledge and technology-making should be devoted to" ([172], p. 2). It is important to him to scrutinise aspects other than conflicts of interest in specific areas of technological applications: it is essential to consider the ways in which public reactions to these technologies are shaped and how they are regulated [172].

It is possible to defend the novelty of nanoethical issues using a number of different arguments. For Berne [11] and the authors of the *Encyclopaedia of Science, Technology and Ethics,* nanoethics has to be understood as inquiry on specific problems posed by emerging nanotechnology, i.e. as a "relatively new field" which can be seen as similar to other fields of so called 'practical ethics' such as computer ethics and biomedical ethics. For the US Under-Secretary of Commerce Philip Bond [14], nanotechnologies pose new problems but at the same time represent such an extraordinary opportunity for development that it would be 'unethical' not to support them. On the other hand, Dupuy [40] sees nanotechnologies and converging technologies as representing important challenges, such as the triumph of Vico's ideal of *verum factum*[10] and a rebellion against the finitude of the human condition, which require new ethical understandings.[11] Furthermore, a recent report from the Woodrow Wilson Center clearly inscribes ethical reflection as part of the promotion of responsible technological development, since "the goal or any emerging technology is to contribute to human flourishing in socially just and environmentally sustainable ways" ([138], p. 6).[12]

In order to overcome these difficulties in talking about nanotechnology, various authors have proposed distinguishing between nanotechnolog*y* (in the singular) and nanotechnolog*ies* (in the plural) (cf. [33, 40, 110, 129], among others). Nanotechnolog*y,* in the singular, is perceived as *a unified program of research*; an ideograph, a unique scheme of innovation, which informs the framing of ethical issues and expectations of these technologies. Nanotechnolog*ies,* in plural, consist of the applications of this new technology within their different contexts, such as, for example, the life sciences ('nanobiotechnologies') or medicine ('nanomedicine'). In entering these fields, nano can be re-shaped and assumes different connotations because it is oriented toward particular goals. In this sense, nanotechnologies (in the plural) are based on particular ideas and embedded in values connected to (but

[10] The principle '*Verum et factum reciprocantur seu convertuntur*' or '*verum esse ipsum factum*' ('the true and the made are...interchangeable,' or 'the true is what is made') was formulated for the first time in 1710 as part of Vico's work *De Italorum Sapientia,* and then reformulated and applied in *Scienza nuova seconda* in 1730, where it is connected with the doctrine that the civil world (history) is made by man. This principle states that human beings can only truly know the things that they have made. Rejecting Descartes' knowledge principles, which are constructed upon the idea that natural science and mathematics need a 'metaphysical explanation', Vico argues that these disciplines demand an analysis of the causes (the activity) through which things are made.

[11] See also Bond's speech, entitled 'Responsible nanotechnology development', at the SWISSRE Workshop [159] and quoted in [158].

[12] In this respect, ethical and social issues associated with emerging nanotechnologies are characterised by the following distinctive features: they are determinate, distinct, immediate (because now is not too soon to consider them), significant and actionable—meaning that now is the moment for certain actors to take steps to address some of the issues ([138], p. 8).

not completely identifiable with) the characteristics of the area of application.[13] However, it is important to note that this proposed distinction between 'singular' and 'plural' nanotechnology has to be understood as reflecting two modalities of framing ethical discourse, and not as two *de facto* distinct areas.[14] Nanotechnolog*y* and nanotechnolog*ies* are profoundly intertwined and continually shape one another, rendering a rich picture of many different research programmes.

## Nanoethical Reflection as a Narrow Form of Risk Assessment: Consequentialist Versus Deontological Frameworks

It is not only that different ideas on the scope of ethical reflection on nanotechnologies have rendered debate multi-faceted: nanotechnologies have also been, from their earliest stages, an explicitly socio-technical phenomenon. Schummer [148] recently argued that the real novelty of nanotechnology is not its technological specificity but its expression of a vision of the role of science and technology in society. The specificity of nano, for him, takes the form of a unique playfulness around socially established boundaries (such those between living and non-living, natural and artificial, and even social and natural sciences).

However, at first glance the discourse of the debate follows a pattern which is very common in bioethics: an opposition of deontological and consequentialist normative frameworks, often ending with the clear dominance of the consequentialist position. Here ethical questions arise from possible applications of nanotechnologies and tend to be identified with possible ethical consequences (cf. [158]). Even if talking about consequences is not the same as being consequentialist, as we will see, the majority of the early papers which analyse the ethics of nano provide a list of possible conflicts of interests and polarise judgement by either calling solely for analysis of the consequences (consequentialism) or promoting universally accepted values (deontology, cf. [54]). Although virtue ethics is an important part of the ethical tradition, it has been under-developed in the context of applied ethics and bioethics. There are very few published articles by virtue ethicists in this context in comparison with the two other dominant approaches (cf. Stanford Encyclopaedia of [153]).[15] Recently there have been publications on the values of natural scientists who work in the nano field (both in private and public sectors) which explore the cultural context in which these values arise and thus further develop a tradition of analysis begun in the late 1980s examining the ethical conduct of research and the accountability of science (see, amongst others, [31, 95, 118, 125, 134]).[16] Even if there is increasing debate on the importance of trust in nanotechnology, the majority of analyses concentrate on how trust informs public opinion about risks and, more generally, its effects on the process of risk assessment (cf. among others [7, 12, 17, 24, 96, 97, 151]). A rigorous unpicking of the ways in which trust informs the work of scientists, affects their social embeddedness, and plays a role in the social construction of technology is still lacking.[17]

The dominance of consequentialist frameworks is particularly evident if we consider the centrality of issues linked to the risks of nanodevices (especially nanoparticles) in the debate. If, on the one hand, it is clear that toxicity issues and questions of public engagement with risk discussions are important (as is recognised by all involved in the debate), there is on the other hand a strong tendency to see risk as the sole issue emerging from nanotechnological applications. Other problems are then reframed as dependent upon the magnitude of risk. In other words, many authors redescribe issues such as distributive justice, enhancement or even the need for the public to be fully and properly

[13] This distinction is a working hypothesis similarly used by the European DEEPEN (Deepening Ethical Engagement in Emerging Nanotechnologies) Project, a EU Sixth Framework Programme funded project and Europe's leading partnership for integrated understanding of the ethical challenges posed by nanotechnologies (see http://www.geography.dur.ac.uk/projects/deepen). I would like to acknowledge productive discussions around this topic with the other DEEPEN partners.

[14] On the one hand, general visions of what nanotechnology is and what it can provide (i.e. nanotechnology in the singular) inform discourse on each specific application and influence the framework for concrete questions in a specific area. On the other hand, the particular questions that emerge in contexts of application (nanotechnologies in the plural) also go back and re-shape global visions of these technologies.

[15] Exceptions include an anthology edited by Walker and Ivanhoe [164] and recent efforts to develop virtue ethics arguments in the context of environmental discussion (see for example [139]).

[16] See, among others, [165, 104, 173].

[17] The work of Poortinga and Pidgeon [122], which refers to technologies in general, is interesting with regard to this. A number of other publications refer to the field of biotechnology [123, 85].

informed as *part of the traditional risks and side-effects of technological development*. A consequence of this form of ethical assessment is thus that central ethical problems are seen merely as a matter of willingness (or unwillingness) to accept these risks.

A paradigmatic example of this identification of ethical reflection with consideration of the ethical implications of risks is the view proposed by the SWISS RE Report [159], which suggests that there is a need to avoid consideration of long-term and visionary (science-fiction) applications of nanotechnology, such as the notion of self-assembly. The primary goal of the report is to create strategies for the governance of nanotechnology so that the most urgent and realistic topics are the ones to be discussed. For Shrader-Frechette [150], debate on risks is the *conditio sine qua non* for us to start proper ethical discussion on nanotechnologies. For her, nano-product risk disclosure (in particular regarding risks connected to nanoparticles) requires revealing to citizens both what is known and what are the relevant uncertainties, thus fulfilling basic conditions for citizens' informed consent. In her article she refers in particular to the situation of risk-related research in the US, which is characterised not only by a lack of funding—compared to Europe, where the European Commission have funded many projects on nanotoxicology (see [116])—but also by the fact that much existing nanotoxicological research is done by those who would like to gain from nanotechnology related business. Such work, she suggests, involves a clear conflict of interest [150].

Grunwald [72] suggests that the only really new aspects of the ethics of nano lie in the risks posed by nanomaterials. These questions around the risks are particularly important, not because these risks are ethically relevant *per se*, but because they become so when existing risk regulation may be insufficient or inadequate, so that the possibility of applying the precautionary principle emerges [73]. In further consideration of the debate Grunwald [74] even defines debate on ethical issues posed by nanotechnologies (he explicitly does not use the term 'nanoethics') as the discussion *on normative uncertainties* posed by these technologies, implicitly attributing an essential role to the risk dimension. Grunwald [74] embeds his definition of ethics of nano within a larger view of ethics of technology as centred on the notion that ethical issues arise only where normative uncertainties exist. He thus explicitly excludes all motives and critiques which have nothing to do with uncertainty.

One of the principle difficulties of a consequentialist risk-assessment framework involves the difficulties of making predictions about scientific and technological development. Due to what is commonly described as the random and unpredictable way in which scientific research works, it is frequently pointed out that, along with recognising our cognitive inadequacies in reasoning about the future [66], we should try to use models alongside careful and thoughtful analysis (such as the vision assessment proposed by [74], or processes which analyse likely future events through the consideration of possible outcomes). One of the modern science-policy instruments which seeks to deal with the unpredictability of the future is the precautionary principle, which ends up, for better or worse, as profoundly intertwined with the ethics of new technologies. Although there are many concurrent definitions of this principle,[18] it can be summed up as being a principle or procedural rule which aims to facilitate decision-making under conditions of *uncertainty.* Recourse to it assumes that potentially negative effects have been identified but that it is impossible to quantify the risks in question, because of an lack of data or their inconclusive or imprecise nature (cf. [27]).[19]

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[18] The first international endorsement of the Precautionary Principle is contained in the World Charter for Nature 1982, which was successively ratified in the famous Rio Declaration, in which, in article 15, the Precautionary Principle is defined in the following terms: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=78&ArticleID=1163). In 2000 the European Commission developed a communication on the precautionary principle (http://ec.europa.eu/environment/docum/20001_en.htm), in which two aspects were distinguished: on the one hand the political decision to act or not to act, which is linked to the factors which trigger recourse to the precautionary principle; on the other the affirmative aspect—i.e. the measures which result from application of the precautionary principle. There is a very broad literature of this topic; for an overview, see [75].

[19] The principle offers a basis for a different kind of decision-making process to that traditionally proposed by risk assessment: whereas the latter is based upon the idea of balancing harm and benefit, in a precautionary decision-making structure evidence regarding alternatives and of the magnitude of possible harm from an activity are also considered (cf. [160]). In this sense, the principle can be defined as proposing a 'state of mind' that may help decision-makers avoid false negatives [119] and as a "salutary spur to greater humility" which draws attention to a broader range of non-reductive methods and which reveals the normative and contestable basis for decisions ([154], p. 312).

The applicability of the precautionary principle is the object of much critique. In its strongest form, this comes from supporters of generally permissive approaches to technologies: such supporters identify the principle with the promotion of conservative fears—which usually rely on deontological argumentation ([16, 79], cf. [79])[20] but which can also be rejected from a pragmatic point of view[21] (cf. [27, 156])—about technological development. Such different diverse evaluations of the precautionary principle as it is applied to emerging technologies shows that the ethical dimension of problems arising from these is connected both to uncertainty about the future and to our difficulties in dealing with these technologies' risks and side-effects. Very often those who oppose the application of the precautionary principle are confident that society's capacity for self-regulation will successfully avoid negative situations [94], and judge the principle unhelpful or biased [79]. Put simply, the fact that in many disputes the dominant debate is around defending or rejecting the precautionary principle presupposes that a risk assessment framework is dominant. Even those who claim a more balanced view or middle way, such as Phoenix and Treder [120], remain attached to the logic of risk assessment and do not move beyond it. For them, the creation of a single molecular nanotechnology programme that would permit the widespread but restricted use of the resulting manufacturing capability would mean proposing a programme based on a careful balance of risks and benefits. It is particularly intriguing, when considering the precautionary principle, that we are facing an epistemically new situation characterised by *uncertainty*, *ignorance* and *ambiguity* (see, for example [154]). As I describe below, such characteristics cannot be entirely grasped by risk assessment frameworks.

The focus on risk in the debate as a whole is reinforced by various initiatives which seek to involve the public as well as to investigate their ethical stances (see, amongst others, [63, 90, 121, 167]). Public responses appear rich because they present ambivalent perceptions of technological progress, but their complexity is often not fully grasped and tends to be framed in terms of the identification of clear yes or no answers to particular applications. Again then, this richness is forced into a risk assessment framework (cf. [33]). The situation is then rendered more complex by public "re-enactment of a classic morality play", characterised by both fascination and opposition to technology, which seems not to fit into the new situation created by nanotechnologies [57].

Finally, there is also a more subtle way in which relevant issues are reduced to a matter of risk assessment (with the exception of conflicts of interest in clinical cases, and privacy issues raised by nanotechnologies in the field of information). 'Risk' is also understood as encompassing problems connected both to the dual use of technologies (such as therapeutic/non-therapeutic uses and peaceful or military uses) and to distributive justice. One, heavily disputed, example is provided by the debate on human enhancement, which takes the form of a struggle between a libertarian/consequentialist approach and a conservative/deontological one [53]. The work of Harris [76, 77] and of Bostrom [15], for example, is a clear case of an explicit use of a consequentialist framework. The significant point is, however, that opponents to human enhancement frame the issues in the same way, simply reaching different conclusions. Opponents of human enhancement interest themselves in the same type of question as proponents: they merely argue, in general, that the Promethean aspiration to recreate nature, including human nature, to serve human purposes takes a mistaken view of the 'giftedness' of the world ([126]), and that enhancements are a form of cheating which only give superficial solutions to fundamentally unsatisfied human beings who are unable to accept their limits (see also [62]), rather than defending prospects of amelioration through technologies [15] and claiming that this move is a moral duty (cf. [76]). Thus both consequentialist defenders of enhancement and their deontological opponents centre what is at stake around the question of the legitimacy of changing human nature [53]—around, in other words, the question of whether we can accept technological

[20] Hull [80] distinguishes three kinds of critique of the precautionary principle: the claim that the principle is not scientific; that it ignores the risks of regulation; and that people make irrational decisions.

[21] Sunstein [156] argues, for example, that the principle is incoherent "not because it leads in bad directions, but because read for all its worth, it leads in no direction at all. The principle threatens to be paralyzing, forbidding regulation, inaction, and every step between. It provides help only if we blind ourselves to many aspects of risk-related situations and focus on a narrow subset of what is at stake" ([156], pp. 14–15).

change and its risks. In this way the dispute about mankind's future is reduced to the question of who is offering the best foresight. This renders the debate simultaneously increasingly aggressive and exclusive (you can't be on both sides), but also simpler, in that you can rely on straightforward answers of yes or no to everything that is at stake.

## Ethics as a Sophisticated Form of Prudence: Uncertainty and Epistemic Limits in Nanotechnologies

More and more authors have realised the narrowness of the consequentialist framework and its inability to capture the richness of the challenges nanotechnologies present. This framework remains focused solely on the level of the individual: even when it speaks of challenges for groups or for society, it does not really pay attention to cultural implications or to the social embeddedness of technological innovation. Many authors, therefore, point out the need for increased attention to the motives and scope of technological development, and propose consideration of aspects such as sustainability and responsibility, as well as the uncertainty that is linked to the profound epistemological limits of the knowledge that can achieved through nano. For this reason I label these approaches 'sophisticated forms of prudence': for these authors, ethical problems are no longer understood as a matter of balancing negative elements (risks) with advantages (benefits) but as an attempt to cope with (nano) technological uncertainty in a ethical manner. Indeed, prudence is historically a *virtue* rather than a principle or law, and is similarly not immediately connected with the consequences of action.[22] In a manner analogous to the virtue approach, then, these analyses direct attention to the complexity and holistic dimensions of the challenges raised by emerging nanotechnologies.

In a key UNESCO report, it was suggested that ethical reflection should be pushed beyond risk assessment to reflection on the very structure of science (including issues of intellectual property, secrecy, and the legitimacy of scientific results), and that topics of public trust and accountability should take a central place ([161], p. 17–19). Similarly, the Ethical Committee of Quebec proposed reflection on these challenges in the light of the promotion of *sustainable development*, an approach which seeks to take into account the interests of future generations and which searches for a balance between ensuring benefits for the greatest number of people and respecting the environment. Interestingly, the first recommendation of the report refers directly to the application of the precautionary principle from the perspective of sustainable development. Focusing on the notion of the 'life cycle', it stresses a holistic approach to assessing the benefits and risks of technologies, involving assessment of the impact of a technological innovation "from the cradle to the grave" ([29], p. 38–39). In this report the Commission, writing in a vaguely personal manner, takes a moderate tone, not expressing strong critique or confident support but rather inviting people to together find the right way for the 'sustainable development' of these technologies. In a recent paper of the Commission it is stated "The Commission feels that nanotechnology's potential impact cannot be minimized and that caution must therefore be used in implementing the measures needed to ensure responsible management thereof. (…) However, the Commission also feels that one should not assume that nanotechnology can only lead to doom and ruin. (…) Nevertheless, those involved in nanotechnology must be willing to discuss the objectives being pursued and the actions to take for these benefits to be enjoyed by a vast majority, because it is often society as a whole that must deal with the consequences." ([30], p. 86–87 ;cf. also Nordmann and Schwarz [114]).

The call for the *responsible development of nanotechnologies* (responsibility has progressively taken the place of sustainability in these discussions) characterises a substantial part of current debate on nanopolicy, especially in the European Union and the USA, and represents a new element in science policy programmes and articles devoted to the ELSA of

[22] Perhaps an idea from the virtue ethics approach would be helpful in framing this differently: in virtue ethics the rightness of the action is determined by the character traits of the person performing it, or by their intentions.

nanotechnologies[23] (for example National Research Council [13, 105]). Many institutional documents agree on the importance of responsible development and view public engagement exercises[24] as having a fundamental part to play within it.

One widely discussed example is the Code of Conduct on nanoresearch adopted by the European Commission in 2008 (and amended in 2010, see European Commission [51]).[25] This Code of Conduct encompasses several principles (such as meaning, or that all research should be comprehensible to the public; precaution; sustainability; inclusivity, or openness to all stakeholders; and transparency and respect for the public's right to access to information) on which universities, governments of Member States, and private companies are invited to take concrete action. Although an extensive discussion of the Code is not possible within this article, it is relevant to the immediate discussion in that 'responsibility' is taken as a general framework for the different principles. As a matter of fact, responsible development of nano is constituted within this Code as resting upon the idea that virtually all stakeholders, with their different interests and needs, should participate in the process of responsible development. This was also indicated concretely through a two month public consultation process which took place prior to the final approval of the Code[26]. However, precisely because the Code is articulated so as to express different needs and interests, its framework—responsibility—remains vague and imprecisely defined (cf. Nordmann and Schwarz [114]). At the same time, 'virtuous' behaviour is an implicit result of responding to the obligations expressed through these different principles. Furthermore, the Code acts on a voluntary basis and thus is typical of a soft law regime which has become popular in the regulation of new and emerging technologies;[27] it implicitly suggests that *ethical* values (in the form of moral obligations) rather than legal ones (such as obedience of binding laws) are guiding scientific and technological development (thus the discourse is of *responsibility* rather than *accountability*). Taking a closer look, it is important to notice that even though this type of activity is not binding, the actors who choose to undergo it are raising expectations which are, in a sense, *politically* binding. The fact that responsibility—a ethical value—is taken as a governance framework transforms it, then, into a

[23] On 14th and 15th July 2005 a meeting exploring 'responsible' research and development, organised by the European Commission and held in Brussels, took place in order to discuss and further develop the 2004 dialogue launched by the European Commission Communication "Towards a European strategy for nanotechnology" and the June 2004 international meeting held in Alexandria (USA) and organised by the National Science Foundation (see ftp://ftp.cordis.lu/pub/nanotechnology/docs/intldialogue_background.pdf). In the 2004 NSF meeting it was stated that an ongoing dialogue should enable and maximise beneficial contributions of nanotechnologies to society as well as addressing the concerns of the public in reducing risks. However, this appeal to 'responsible development' is ambiguous in its description of risk as the only public concern and in its avowed effort towards the maximisation of benefit.

[24] In 2004 the European Union called for a dialogue with the public on scientific issues (European Commission [50], and under the 6th Framework Programme extensive projects were funded to explore ways of involving citizens in dialogue and participation (see Science and Society program, http://ec.europa.eu/research/science-society/index.cfm?fuseaction=public.topic&id=356). In the UK, partly as a result of recommendations by the Royal Society [137], large numbers of 'upstream public engagement' activities (involving constructive and proactive debate on the future of nanotechnologies) have taken place (including Nanojury UK, Nanodialogues, and initiatives organized by the Nano Engagement Group; cf. [63]).

[25] On the Code of Conduct see: http://ec.europa.eu/nanotechnology/index_en.html (cf. [103]). In the US there is a similar voluntary measure, the US Nanoscale Materials Stewardship Program (NMSP): http://www.epa.gov/oppt/nano/stewardship.htm.

[26] The consultation process was open from July 2007 to September 2007 and was based on 10 sets of questions (the consultation Paper can be found here: http://209.85.129.132/search?q=cache:3at3mqRFs2kJ:ec.europa.eu/research/consultations/pdf/nano-consultation_en.pdf+responsible+development+nanotechnology+governance&hl=de&ct=clnk&cd=1&gl=de&client=firefox-a). From that a draft was formulated, which was again opened to public consultation from September to November 2007 (see http://www.responsiblenanocode.org/documents/ResponsibleNanoCodeConsultationDraft17September07.doc).

[27] One of the major difficulties, in the case of nanotechnologies, is a lack of appropriate regulation at governmental level, so that 'voluntary measures' such as Codes of Conduct involving private companies have become more and more important. These include the UK Responsible NanoCode, promoted by the Royal Society, Insight Investment and the Nanotechnology Industries Association (cf. also [136]); the Code of Conduct developed by BASF; the Nanocare Initiative promoted by a number of chemical companies; the Code of Conduct developed by the Swiss retailer's association IG DHS; and the 'Nano Risk Framework to Aid in Responsible Development of Nanotechnology' developed by Dupont and the NGO Environmental Defense (EDF; [35] and cf. for paragraph 4.2). For an overview of this governance landscape see [89].

strategic tool for the promotion of the development of these technologies and for the commercialisation of nano [89].

In a recent report by the Woodrow Wilson Center's Project on Emerging Technologies, edited by Sandler [138], the role of ethics in the responsible development of nanotechnologies is identified with five areas of inquiry: with the elucidation of what constitutes justice, human flourishing and sustainability; with the identification of opportunities for nanotechnologies to achieve the goal of responsible development and to identify possible impediments to its doing so; with the development of standards for prospective nanotechnologies; with the provision of "ethical capacity (i.e. tools and resources that assist individuals and organisations to make ethically informed decisions) to enable society to adapt effectively to emerging nanotechnologies" ([138], p. 14), and, finally, with the identification of the limits to how the goal can be achieved. Here then, there is a key difference to previous work on 'nanoethics': in more recent debate, the legitimacy of ethical reflection specifically on nanotechnologies is no longer at stake. The real challenge seems now to involve rendering 'ethics' as a general framework for technological development: in the report by Sandler, this perspective is justified by the fact that all technologies aim at the promotion of human flourishing (significantly, 'human flourishing' is a term developed within the virtue ethics tradition).

We should notice that general appeals to moral obligation (as in calls to the notion of responsibility) within scientific and technological development run, for many authors, the risk of promoting benevolent and over-indulgent attitudes toward these technologies. Furthermore, as different stakeholders[28] have been identified and recruited for shared, constructive dialogues on nanotechnologies, a general sense of reliance on the future seems to have developed in much nanotechnological governance. Thus it seems that 'responsible development' is possible precisely because we all engage in such dialogic processes and because our efforts are orientated towards it, so that we no longer need to fear anything from these technologies. This process, or new attitude, in the governance of emerging technologies (not specifically the Code of Conduct) has been identified in the Report of the Expert Group on regimes of innovation [52] as a profound form of ambivalence characteristic of the governance of *new technosciences*,[29] and by Nordmann and Schwarz [114] as a form of *power and seduction* (the 'lure of the yes') in the governance of nano.[30]

Beyond the call for general engagement towards responsible development, many authors have highlighted the need for reflection on the epistemological problems raised by nanotechnologies—in particular, on the profound significance of uncertainty and the limits of knowledge when referring to the molecular and atomic scales. A broader approach with respect to questions of risk also means pushing beyond the search for empirical evidence in dealing with uncertainties: Schomberg [142] has highlighted the importance of collective responsibility, which includes both being personally responsible and developing transpersonal assessment mechanisms, in particular for unintentional consequences and collective decisions. A starting point for such exercises of collective responsibility should be *foresight knowledge assessment*, based on the need to find a method or approach for assessing the quality of knowledge. Here the aim is to scrutinise effective strategic policy, but in a fundamentally new way, since this knowledge appears '*not verifiable* in nature' (it does not lead to any representation of empirical reality) and has a high degree of complexity and uncertainty (and thus shares a typical hermeneutic dimension of the social sciences and the humanities). Furthermore, foresight knowledge assessment takes an action-oriented perspective

[28] The term 'stakeholder' (which literally means a person or organisation that has a legitimate interest in a project or entity, in our case a technology) comes from business ethics and the debate on corporate social responsibility. Interestingly, the exercises which identify different stakeholders in a particular situation—in our case the development of a technology—imply that a person has particular interests which are different from those of others, depending on his or her specific role in society: it seems that a consumer has different interests from an entrepreneur or scientist. However, this fragmentation of societal roles can be considered fundamentally problematic, in that an individual in a society always takes a number of different roles and positions (an entrepreneur, for example, is also a consumer and a citizen).

[29] This report sketches a particular regime of the economics of technoscientific promises (ETP), characterised by taking public opinion into account, whereas the development of dialogue on benefits and concerns ends up taking the form of polarised interactions between those for or against these technoscientific promises [52].

[30] It is not possible, in this article, to further investigate the implications of this new regime of responsible development. For further analysis of this topic see [103, 132,133].

and combines normative targets with socio-economic feasibility and scientific plausibility ([142], pp. 14–15; cf. also [117]).

The NGO ETC Group, in its 2003 call for a global moratorium on the sale of products containing nanotechnologies (and in particular nanoparticles), clearly linked its appeal to the uncertainties surrounding the toxicity of these products. In its revision of this call, in 2007, the ETC Group used other arguments, embedding their reasoning in a more profound critique of the logic that surrounds nano (cf. [102]).[31]

Many authors have further developed this STS analysis of the different dimensions of risk, highlighting that, due to the special knowledge achieved at the nanoscale, the present situation of nano R&D is characterised not only by uncertainty, but also by *ambiguity* and *ignorance*. Ambiguity occurs when possible outcomes result in problems because they are connected with different imaginings of what are, for example, social and economic harms. Ignorance refers to a situation in which not only the probabilities, but also some possibilities, may be unknown ('we do not know what we do not know'; cf. [154, 172]). In his critique of the nanotechnological project (in particular as framed by Drexler [34]) as reductionist and deterministic, Hunt [82] calls for more profound consideration of the novel properties discovered within the nanosphere, which is characterised by fundamental complexity and unpredictability. Hunt argues for a change of strategy in nanotechnological research along what he calls 'nanology principles'.[32]

Moreover, deliberations on nanotechnologies is rendered more complex by their epistemic features—i.e. the lack of a homogenous definition, the variety of fields of application (cf. [131]), and the fact that many applications are still visionary. Dispute around this last feature (in the form of whether, in nano, the theoretical representation of knowledge can or cannot be dissociated from the material conditions of knowledge production) has influenced the way in which certainty and uncertainty are perceived and thus how risks are conceptualised (cf. [54]).

Although issues of responsibility, public engagement, and sustainability, alongside epistemic reflection on the limits of our knowledge, are important steps in going beyond a polarised debate between deontological and consequentialist frameworks, some authors have also argued for developing further forms of ethical reflection which can fully grasp the complexity and new utilities of these technologies. They have proposed focusing on the historical and philosophical roots of nanotechnologies, as well as on larger issues regarding the place of science and technology in our society and in development.

## Inquiry into the Metaphysical Research Programme (MRP) of Nano

Dupuy and Grinbaum [42] see the real challenge of nanotechnologies and converging technologies being posed by the *uncertain* dimension of the risks posed by these technologies, which are characterised by a profound indeterminacy. For them, the precautionary principle (or the form of prudence proposed by it, which is based upon the essential predictability of the future) is no longer useful for nanotechnologies, because it is based upon an old and now invalid conception of time [38]. This metaphysics involves the time of history: time is conceived of as constituted by paths that bifurcate. In contrast, if we highlight the fact that there is co-evolution of science, technology and society (that is, that nanotechnology evolves in a determinate social, political and economic context and that it simultaneously shapes this context, in other words the lesson of social constructivism of science and technologies; cf. [128]), we perceive the need for a different metaphysics of time, the temporality of *projected time* ([37], cf. [39]). This is centred upon the idea that there is a self-referential loop between the present and the future: the way in which we *describe* the future will determine *how* the future will be.[33] For this reason, Dupuy and Grinbaum [42] argue

[31] However, already in its first call for a moratorium the ETC Group highlighted the tension between, on the one hand, a lack of research on the toxicity of nanoproducts, and, on the other, the rapid commercialisation of these products: "No one expects the scientific community to have all the answers at this early stage; every consumer would expect, however, that scientists and regulators get it right before nanoproducts are sold or released in the environment and before they potentially endanger the health of workers in labs" (ETC Group [46], p. 6).

[32] These principles are abbreviated in the acronym CHISEL: criticality, holism, interaction, self-organisation, emergence and long-termism [82].

[33] Dupuy [37] proposes abandoning the traditional metaphysics of time typical of modern science, which has its highest rational expression in Leibniz's philosophy and which underpins the theory of rational choice ([37], p.162 ff). In contrast, he highlights the importance of Bergsonian metaphysics of time.

that we need a different mode of doing ethics; an 'ethics beyond prudence', which they call *ongoing normative assessment*. This ethical assessment proposes a balanced view (which they call enlightened doomsaying) between the extremes of optimism and catastrophism,[34] which consists in obtaining, through research, public deliberation and other means "*an image of the future sufficiently optimistic to be desirable and sufficiently credible to trigger the actions that will bring about its own realization"* ([42], p. 21). The future of nanotechnologies depends, then, on the ways in which society will react to concrete anticipation of its future. In order to understand the fundamentally uncertain dimensions of nanotechnologies, we should not remain at the surface, looking for possible consequences, but rather investigate the metaphysical research programme (MRP)[35] which informs the nanotechnological project. Inquiry on the MRP should not be confused with metaphysics, or with the important question, within classical ethics, of the role of ontology (i.e. questions about an ethics "with or without" ontology,[36] cf. [127]). This concept is similarly not the same as arguing that ethical questions emerging from technologies have to be based on a particular metaphysics. Rather, it suggests a *heuristic* for analysis, saying that, in order to understand and properly discuss the ethical challenges posed by technologies, it is first necessary to explore, disentangle and scrutinise the sets of visions, ideas, and representations of nature and the human being which inform them. In other words, this approach proposes highlighting the 'practical' dimension of challenges posed by technologies via an investigation into the social and cultural dimension of the images carried and promoted by particular technologies. Once these visions and ideas have been appropriately disentangled, we can develop a discussion around their acceptability.

Dupuy [40] identifies the MRP of nanotechnologies, as well as of converging technologies more generally, with the project—which goes back to the visions of cybernetics—of the 'mechanisation of mind'. Informed by the identification of knowing with making (or the idea that it is through remaking nature that a human being can perfectly know it), nano's MRP brings with it a loss of any significant distinction between the scientist and engineer, because it identifies the search for knowledge with an intervention with or transformation of it (cf. [36, 41]). The fundamental philosophical roots of the project of the mechanisation of the mind can be reconstructed along a continuum that reinterprets first nature, then the human body, and finally the mind as a computational model. This line of thought stretches from

[34] They argue that if, on the one hand it is not credible to be too optimistic, on the other we will end by undergoing the catastrophe if we close ourselves off in cognitive paralysis. In this sense the methodology of ongoing normative assessment can be seen as a conjunction of inverse prescription [42].

[35] The notion of a metaphysical research programme goes back to the theories of Karl Popper, who highlighted that every scientific theory relies on a set of values and worldviews which are built on general presuppositions about the structure of the world. In his work, 'metaphysical' assumptions are ones which are non-falsifiable, i.e. those which cannot undergo empirical testing. In the 'Metaphysical Epilogue' to his work *Quantum Theory and the Schism in Physics* (originally 1982), Popper pointed out that, in almost every phase of the development of science, metaphysical ideas not only determine which problems of explanation we choose to attack, but also the kinds of answers we consider satisfactory additions to our knowledge ([124], p. 161). Popper followed the lead of Emile Meyerson's *De l'explication dans les sciences,* originally published in 1927 (see [98]). The fact that he chooses the word 'programme' serves to stress the fact that these metaphysical ideas tend to cluster together and support each other in various ways. He then uses this notion to identify and criticise ideas within rival theories such as determinism, justificationism, subjectivism and essentialism. In Popper's opinion, these rival metaphysical research programs are basic categories of thought that operate as invisible boundaries, dictating the types of problems that scientists choose to work on, the way that they are formulated, and the kinds of solutions that are accepted.

[36] The expression 'ethics without ontology' is taken from a series of lectures by Hilary Putnam [127]. Putnam argues that 'ontology' is not meant as a synonym of 'metaphysics' but rather is a part of it: that concerning the 'science of Being'. Putnam then distinguishes the so-called 'inflationary ontologists', such as Plato or Moore, and 'deflationary ontologists', who are further distinguished as reductionists and eliminationists. Putnam, who here refers clearly to the nature of discursive entities, rejects every kind of Ontology (with a capital 'O', as he writes) and defends "what one might call pragmatic pluralism, the recognition that it is no accident that in everyday language we employ many different kinds of discourses, discourses subject to different standards and possessing different sorts of applications, with different logical and grammatical features—different 'language games' in Wittgenstein's sense—no accident because it is an illusion that there could be just one sort of language game which could be sufficient for the description of all of reality!" ([127], p. 20).

McCulloch and Pitts (who in the 1940s argued for the identification of the human brain with a computational machine) to Max Delbrück and the phage group (who identified life with a computational machine), and finally to Marvin Minsky, who, in the late 1960s drew upon a mechanistic view of nature (cf. [36]).[37] In his preface to the 2009 edition of 'Mechanisation of Mind' Dupuy argues that the engineer, far from seeking mastery over nature, is now meant to feel that his enterprise will be crowned by success only to the extent that the system he has created is *capable of surprising him*. The radical nature of the nanoproject is seen precisely in its search for self-assembly; for self-organising systems which are capable of being autonomous. Dupuy [41] reinterprets what other authors describe as the fundamentally technoscientific character of nanotechnology in terms of the triumph of cybernetic mechanicism and reductionism.

Other authors similarly emphasise the need to disentangle the visions embedded in nanotechnologies (even if they do not always explicitly use the idea of an MRP), but give different interpretations of the ethical implications of technoscience and of the identification of knowing with intervening. For Wynne [172], the moment of knowledge production is not only a function of a technologically inspired manipulative intervention into nature, but is also an experimental attempt to *programme* and *automate* this technological intervention. For Nordmann [112], nanotechnology is not interested in representations of nature or in devices that work, nor in substances with novel properties or even in its own methodological self-awareness. *Functionality* of devices or the *usefulness* of properties are its fundamental goals (cf. [109]). The paradigmatic example of this inseparability of discovering the world and intervening in it is given by nanotechnology's most famous instrument, the scanning tunnel microscope (STM), in which the *scanning* of the surface represents a way of intervening with the object [109]. This focus on intervention into nature brings with it an ontological reconfiguration of nature and technology: the 'incredible tininess' of nanotechnological devices gives not gives only the illusion that they are acting in the background, but also that they are, *de facto,* the fundamental component of reality [110]. The uncanniness of nanotechnologies, which do not become objects of experience but remain unconsidered and unconceptualised within our world, results in a process of *naturalisation of technology*: nature seems to take on the character of technology, which invisibly penetrates the environment and becomes part of the 'already-there' nature. This characteristic of naturalised technologies has particular social and ethical consequences: the 'freestanding' nature of these technologies, which are capable of acting below the threshold of perception and responsibility, means that they readily become objects of mistrust and sources of a deep fear and sense of reluctance [110]. Furthermore, the mechanistic way of describing nature leads to a *technologization of nature*.

Visions of nature are particularly important for a thorough understanding of nanotechnologies, and have increasingly become a matter for analysis by many authors (cf. [8, 9, 10, 82, 166]; cf. [41]), as has their connection with questions of control (cf. [55, 88]). Although it is not possible within this article to give a detailed overview of the different interpretations put forward, it is interesting to note that epistemic visions of what nature are are profoundly intertwined with visions of what technology can do and how it can intervene in nature itself. Furthermore, these epistemic conceptualisations clearly influence perceptions of the ethical issues at stake and of the relationship between science and society (cf. [110]). In other words, the way in which nature is conceptualised relies on ideas about the significance of life and the role of knowledge, which have ethical implications: in constructing the way in which nature is perceived, we also determine what the most relevant problems are and how they can, in principle, be solved. If we take an example from nanotechnologies (in the plural), the field of nanodevices designed for application in the life sciences is permeated with different conceptualisations of 'machine' and with a general mechanistic description of nature. The discourse of this field is, for example, full of references to 'molecular machines' and 'nanometre-sized factories' when describing cell components or nanobiodevices (cf. [19]). For many authors, nanobiotechnology represents the next stage of biotechnological development, as now, through the

[37] Dupuy [40] sees many of the same tensions, contradictions, paradoxes, and confusions as he found in cybernetics and within cognitive science in the philosophical foundation of converging technologies—in particular within the NBIC's conception of these, although he sees, in this new project, more far-reaching and dangerous consequences because it is an entire programme founded upon acting upon nature and mankind.

achievement of reaching the atomic level and having the possibility to change it, a new level—the ultimate level—in the complexity of organisms has been reached and, therefore, better and more precise manipulation is possible (cf. [32, 64]). However, a more dynamic view of a creative and autonomous nature is also strong in this field, and (especially in approaches to self-assembly) is conceived as something to be imitated. Nanobiotechnologies are therefore dominated by two different epistemic cultures: that of the engineer, in which nature is understood in mechanical terms, and that of the chemist, in which nature is considered as having autonomy and the capacity for self-renewal (cf. [8, 9]). Beyond these two cultures, it is also possible to see common features in ideas of nature embedded in nanotechnologies: nature is, for example, seen as a plastic engineer (cf. [55]). On the one hand, plasticity is necessary for justifying the ambition of manipulation of every component at every level. On the other, the engineer reframes nature: natural processes are now described as if they were processes of a machine. The metaphysical research programme is therefore both permitting these visions of nature to emerge and disentangling their connections with concrete research plans.

A similar need to disentangle the profound cultural and social dimensions of nanotechnology is expressed by the idea, proposed by Rip, of taking the nano-project as an ideograph for envisioning the future ([129, 130, 132, 133]; cf. also Van Lente's description of technological promises and their dynamics as an ideograph in [162, 163]). In this conceptualisation of nanotechnology it is important not only to disentangle the dynamics of expectations but also to monitor their quality, from both a scientific and an ethical point of view. Taking promises and expectations as a point of departure, projections of the future of current nano R&D help to articulate different scenarios about the future and therefore to enable the discussion of, for example, the possibility of applying the precautionary principle (cf. also [18]).

## The Importance of Socio-economic Context and Reflection on Nanotechnologies for Development

Recently, academic scholars and some non-governmental organisations have proposed, independently from one another, deeply critical views of nanotechnologies. These are particularly interesting because they are the result of ethical analysis done using different criteria from those used in traditional approaches to ethical or political discussion. Different kinds of argument are used, but these authors share the idea that the questions commonly discussed in the debate, such as the legitimacy of nanoethics as an independent discipline or whether these technologies pose ontologically unique challenges, are not only distracting and uninteresting but also biased, because they eradicate from the consideration of technology more fundamental topics: socio-economic, cultural and historical contexts. These authors therefore move from particular problems specifically connected to nanotechnologies towards drawing general conclusions on the role of technology in our society and on its contribution to development. Similarly, they have tended to highlight the weaknesses of current decision-making processes on science and technology.

For Foladori and Invernizzi [58], because technological development is driven by forces which shape socio-economic context (rather than the other way around), properly understanding the challenges posed by nanotechnologies means that we must consider them as possible products of concrete existing conditions rather than in isolation. Nanotechnologies can be understood as disruptive: due to their ubiquitous character (they can be applied to virtually any manufacturing process) they will produce new divisions of labour, new forms of toxicity, and larger degrees of monopolisation of production processes. They will insert themselves into existing trends of privatisation and monopolisation, which have increasingly been characterising emerging technologies over the last decades [59]. In particular, nanotechnologies with applications in the food and agricultural sectors have been developed and, with the same logic that has characterised biotechnologies, enable the concentration of economic power in big multinational companies—which becomes a form of social coercion [59]. The analysis developed by the ETC Group is similar. They have produced a number of dedicated studies on the problems of monopolies which result from patenting, in particular in the nanobiological sector [47], and on the possible implications of such practices for the global South ([48], cf. [83]). Even if this potential for negative impacts—such as this question of patents—is not something that arises for the first time with nanotechnologies, it may be amplified and assume different characteristics precisely due to their ubiquitous and enabling character. The ETC Group [48] defines patents in the nanotech area as 'second-order' patents, because the monopoly will not just be on life (as the in case of biotechnology) but on 'all of nature'. Patenting will cover all sectors of nanotechnological development, including applications in the life sciences (see the report of the ETC Group on precision agriculture and the possible effects of patenting in the agricultural and food sectors; ETC Group [47]); the medical field;[38] and material sciences.[39]

As a consequence, this analytical framework profoundly differs not only from that of consequentialism, which is oriented towards perception of problems as side-effects or 'risks' of technologies, but also from discourse on 'responsible development' in which an ethical approach is tied to emerging technologies which aim to promote human flourishing in socially just and environmentally sustainable ways (cf. [138]).

A sense of inevitability, of fascination with nanotechnologies, and the reduction of debate to questions of toxicological risk are all products of an important theoretical concept in the philosophy and sociology of technology. Such thinking relies on a number of assumptions: first, that the benefits which derive from a technology flow more or less automatically from research; second, that negative effects are solely outcomes of factors external to science; and third, that it is impossible to predict in detail the uses and outcomes of technologies in society, as well as their course[40] (cf. [140]). This framework is problematic because it implies that no defensible claim can be made about benefits or disruptive effects based on the attributes of the research and the internal characteristics of the scientific enterprise. In contrast, the idea followed in this approach is that we not only need careful analysis of the particular characteristics of new technologies, but also of the concrete context in which they have been developed and in which they will be organised and distributed, since science and technology work within a broader set of social, cultural, political, and economic conditions.

Appeals to the precautionary principle and calls for a moratorium on the commercialisation of products containing nanotechnologies can be defended in a number of ways. While such calls have been interpreted in the debate as the result of a strong version of the precautionary principle [120] or of an exaggerated fear of new technologies [23], the arguments used by the broad international coalition of civil society, public interest, environmental and labour organisations[41] which goes under the name of NanoAction [102] are different to earlier calls for a moratorium (cf. [45, 46]).[42] A ban on the commercialisation of nanoproducts is no longer justified by sole reference to the not-yet-carefully-analysed toxicological potential of new nanomaterials, but also by referring to the fact that broader issues, such as the socio-economic impacts of these technologies, have not yet been assessed or the public

[38] [145] points out, for example, that the trend of patenting DNA sequence databases similarly has doubtful benefits.

[39] For this reason, in analysis of possible impacts of these technologies on a global scale the race for control of patents and the question of consumption of material resources (since the economies of developing countries largely depend on mining and exporting these materials to industrialised countries) are of fundamental importance (cf. [145, 146]). The latest changes in intellectual property rights are in the field of materials—since 2000, all existing and aspiring member countries of the World Trade Organisation (WTO) have to sign the Trade Related Intellectual Property Rights agreement (TRIPs). Such legislation seems to have particularly negative side effects on developing countries, because the impact of property rights now depends on the imitation/innovation capacity of developing countries. Whereas the know-how gap between rich and poor countries was certainly large enough previously, and developing countries could neither imitate the products of developed countries nor compete with their innovations, before the development of nanotechnological materials TRIPs was not especially influential on the economy of these countries. Now, its impact on welfare is expected to produce clearly negative effects, especially for the least developed countries with little innovation but some imitation potential [145]. Furthermore, for Schummer [145, 146] many nanotechnologies promote the substitution of material resources for more expensive and 'technological' ones and are clearly following a long-term trend—begun in the late 19th century—which has been proven to have drastic effects on national economies.

[40] In particular this idea is highly visible in those papers which try to manage the tension between unexpected developments in science and technology and the necessity of preventing and minimising side-effects (see for example [65]). The problem with such thinking is that it refuses to analyse the development of new technologies in a historical manner, for example by comparing them with earlier, similar technologies or with technologies developed in a similar socio-economic context.

[41] See [49, 69]; [61, 102] and IUF [84].

[42] As already mentioned, in 2007 the ETC Group changed its strategy on its call for a moratorium on nano-products.

appropriately engaged in the discussion ([102], IUF [84], cf. [57]):

"Social science analyses of nanotechnology's implications should take place alongside that of the health and environmental sciences. Social impact, ethical assessment, equity, justice and individual community preferences should guide the allocation of public funding for research. A significant proportion of this research should be community-based and designed to encourage public participation. (…) The current excessive funding of military research and meager funding for research on nanotechnology's social challenges, and possible risks to the health of the public, workers and the environment, is unacceptable" ([102], p. 10).

The principles proposed by this coalition have been also formulated as a response to the 'Nano Risk Framework to Aid in Responsible Development of Nanotechnology' promoted by the multinational company Dupont together with the NGO Environmental Defense, who have been collaborating since 2005 and who have created a multidisciplinary team of experts in law, engineering, business and sustainability (Dupont and Environmental Defense [35], see also footnote 28). This framework offered a six step approach to assessing the risks of nanomaterials and devices (description of material and its applications; profiling lifecycles; evaluation of risks; risk management; decision, documentation and action; review and adaptation) which concentrated on the assessment of scientific risks for human beings and the environment. It did not, however, take into consideration the social, political and economic context of the development of these new technologies or questions about public participation in decision-making processes.[43]

In contrast, NanoAction [102] proposed the following eight principles for the oversight of nanotechnologies and nanomaterials: a precautionary foundation; the necessity of mandatory nano-specific regulations for the classification and oversight of nanomaterials; protection of health and safety of workers and the public; environmental sustainability (assessed through a full lifecycle approach); transparency; public engagement; inclusion of broader impacts, including ethical and social factors, in the analysis; and the accountability of manufacturers for liabilities incurred from their products [102]. Although some of these principles (such as sustainability or transparency) are not new within this debate, they have been developed within a broader context and link to each other in a particular way: for concerns around worker safety, for example, they recommend that representatives should be involved in all aspects of nanotechnology safety issues in the workplace without fear of discrimination or retaliation; that transparency should be achieved not only by product labelling but by workplace right-to-know laws and protective measures; and that a publicly accessible inventory of health and safety information should be developed. NanoAction views voluntary initiatives as inadequate for overseeing nanotechnological developments, because they lack incentives for actors who do not have the safety of the environment or of workers and consumers as their primary interest, particularly in the case of long-term effects (and thus implicitly criticise the Code of Conduct and similar voluntary initiatives from industry). Furthermore in the case of Code of conduct it is not clear which kind of sanctions could follow from the infringement of the principles stated.

Furthermore, their point about public engagement is actually quite different from actual public engagement exercises in Europe and the USA. It is requested that, besides an open and meaningful process (it should involve all affected parties and be upstream), public engagement should also be rendered able *to inform decision-making at each stage of development*.[44] There is clear reference here to one of the key problems within governance of science and technologies: the fact that the process is organised from above and that scientists as well as citizens do not play a direct or active role. Such engagement is also necessary for avoiding the sense of inevitability of nano R&D that permeates many discourses. This call for a moratorium is thus clearly a message not only against the rapid trend of commercialisation which characterises current policy on the development of technology, but also an appeal for more cautious action while impacts have not been independently

[43] For an analysis of the Framework proposed by Dupont and Environmental Defense see [89].

[44] It therefore requires "democratic involvement for the entire range of processes by which nanotechnologies are developed and used and is necessary at each stage of development on a continuing basis to ensure that public concerns, values and preferences inform and guide nanotechnology oversight" (NanoAction p. 9).

assessed, so that the contribution of the public and the transformation of science and technology decision-making processes can be incorporated. Instead of starting with an assumption that technology aims at human flourishing, and that we should develop it in a responsible manner with the help of ethical reflection (cf. [138]), they propose beginning with careful analysis of the concrete conditions of the development of these technologies and then taking decisions about their governance through transparent and comprehensive processes (cf. [102]).

Beyond the debate on the disruptive potential of nanotechnologies, the important point highlighted by these authors is that studies on the social dimensions of nanotechnology should take into account the historicity of the different practices, communities, and institutions involved in the development of these technologies. In this framework, proper nanoethical analysis cannot remain on an abstract level to question the legitimacy of particular choices in and of themselves, but has to disentangle the context of their development—both in their historicity and particular regional character.

## Going Beyond Speculation: Re-appropriation of the Present and the Past

If we now go beyond particular interpretations of embedded ideas and values in nanotechnology, both the idea of an MRP and reflections on the implications of nano for development are particularly interesting from a methodological point of view. Both offer a heuristic for ethical inquiry which permits the conceptualisation of nanoethical issues in a way that contrasts with the approaches described earlier. Ethics is then no longer only a matter of anticipated judgement of possible future consequences, but *a reflection on the present*, looking at where values and visions come from. Nordmann [111, 113] broadly criticised current nanoethical debate precisely because of this orientation towards speculation: ethical issues are framed in the form of responses to possible scenarios (and expressed in hypothetical forms). This runs the risk of distraction from more concrete issues which are often left unclear and vague, such as, for example, concrete identification of the addressees of ‘responsibility’ or more ‘scientific’ distinctions such as that between physical and technical possibility [111]. Nordmann and Rip [115] further broaden this idea in an article in *Nature Nanotechnology* which refers explicitly to the title of a paper by Mnyusiwalla et al. [100]. In order to fruitfully ‘mind the gap’ of nanoethics, ethicists should first subject the objects of their reflection to a ‘reality check’; that is, they need to determine with other experts (including natural scientists, policy-makers and media experts) which nanointerventions are most scientifically plausible and likely to be developed. Second, ethicists should distinguish between general ideas, visions and values connected with nanotechnology (in the singular) and the wide variety of different applications of nanotechnologies (in the plural). In this way they can, on the one hand, broaden reflection on the role of science and technology in society and, on the other, concentrate on important questions which are left behind in current debate, such as—for example—the transformation of doctor-patient relationships due to nano-enabled remote monitoring in nanomedicine[45] ([115]; cf. [152]).

The MRP analysis implicitly invites rediscovery of the complexity of the present. One example of analysis of nanotechnology (in the singular) regards the hype surrounding these technologies, which influences both the visions and the goals discussed. In this debate there is both a temptation to disconnect discourse on nanotechnology from reality and a clear discrepancy between revolutionary promises and the products currently sold (cf. also [28, 168]). Pessimistic or optimistic[46] attitudes toward nanotechnologies directly influence ethical debate because they indirectly say something about the acceptability and desirability of these technologies, and push discourse

[45] For Nordmann and Rip [115], the implications for this relationship are more concrete and urgent than questions about personalised medicine, an idea which, due to the difficulties of establishing causal links between genetic data and disposition to disease, still seems too speculative.

[46] In the USA, for example, positive promises and great visions for nanotechnology have been a matter for political support, first under Clinton [107] and then under Bush (who signed the 21st Century Nanotechnology Research and Development Act in December 2003), and have been seen as constituting powerful economic motors. The US debate on nanotechnology is characterised by an alliance between ‘visionary engineers’, science-fiction authors, business people and transhumanists. It takes technology to be a “given mysterious and autonomous force with one way impact on the society” [143], and sees cultural and social scientists as marginal actors in the debate.

on risks in a favourable or unfavourable direction. Therefore, in analysis of metaphysical research programmes, questions of risk also find their place but are seen and explained as reflexes of more profound convictions and ideas on technological development. From this perspective, the orientation of these technologies and their epistemic features are also fundamental for considering ethical challenges. The reinterpretation of questions of risk and the dispute over the precautionary principle in this approach implies posing diverse and new questions, such as: what are the different dimensions of risk and uncertainty connected to these technologies in relationship with the knowledge gained (in research)? What are the ideas and values carried by them? In particular, what is the social significance of "innovation" and what are the motivations beyond it? And what does precaution concretely mean in research and in commercialization? The idea of nanotechnology as an ideograph also suggests a disentanglement of promises and expectations in order to judge possible future development. Even if this approach is more oriented towards the future than analysis of the MRP, it links the future to the present because future scenarios are constituted in the present through assessment of the epistemic and ethical quality of promises (cf. [130]) .

*Reclaiming the past* is also an important message from authors who point more directly to the need for consideration of the socio-economic context of nano. The comparison with biotechnology appears to be particularly fruitful, not only because it was similarly proposed as an industrial revolution (and, in the case of agriculture, as a 'green revolution'), but also and most importantly because in many cases the multinational companies now involved in nanobiotechnologies are the same as those engaged in biotech (cf. [60], Wullweber 08). These authors therefore use the comparison with the GMO debate in a very different way from other scholars, who tend to be interested in it mainly for its relevance to questions of public perception (cf. amongst others [63, 99, 171]) or for how it is used in institutional documentation (through the slogan: we do not want to repeat the same errors of GMO; see, amongst others, Royal Society [137], BMBF [20, 21]). According to this interpretation, nanotechnology is a technological label which is imposed by companies and which imposes hegemonic structures which work in their favour—following a very similar pattern to biotechnologies [47, 170]. The ETC Group [47] has even claimed that nanobiotech tries to circumvent the controversy over GMOs by taking agriculture from the battleground of GMOs to the brave new world of what they call Atomically Modified Organisms (AMOs). It is important, therefore, in discourse on new and emerging technologies, to refer to comparable technologies from the recent past, which have already been analysed in some detail.

Analysing the production of GMO bananas in Uganda (a similar case to future nanobiotechnological applications in agriculture), Hull [80] has identified different approaches—'Heideggerian' and 'Autonomist-Marxist'—to positions that denounce the disruptiveness of this technology and argue for the application of the precautionary principle. Even if these approaches come to the same conclusion (a strong critique of this technological 'solution'), they propose divergent views of the role of technology in society and therefore different ethics of technology. In the Heideggerian version, the 'technological world view' (as exemplified by GM technologies in agricultural production) promotes the subordination of nature to human causality and the disruption of nature's own temporal processes: this is the reason that GMO bananas are only an apparent solution. In contrast, the Autonomist-Marxist version of the principle, which is based on the idea of the triumph of capitalistic mechanisms on society, would not consider the question of control over nature but rather that of how and by whom technological power is controlled. For Hull [80], this last approach would also analyse the cultural specificity of values associated with a technology, so that it emerges that choices are influenced by a community's past cultural experiences (he explains different attitudes to GM food in the US and Europe in these terms). Similarly, this approach highlights the importance of democracy, in terms of the willingness of a population to accept a technology. Apart from presenting such different analytical perspectives, this analysis is interesting in that diverse considerations of and conclusions about the applicability of the precautionary principle appear attached to *systemic problems*, because they are determined by (different) representations of what technological development is. Hull [80] therefore also proposes putting ethical assessment of a technology into a broader context, so that technological dynamics can be historically and geographically reconstructed. By doing this, it is possible to recognise shared attitudes (for example, in the case of GMO, a shared critique) behind different motives and perspectives (cf. [68]).

Wullweber [169, 170], on the other hand, is more explicit in his approach, which he defines as post-structuralist and neo-Gramscian. Similarly, NGOs involved in the nano debate, such as Friends of the Earth or the ETC Group [47], as well as Foladori and Invernizzi [59], propose engaging explicitly with past technologies and their socio-economic context so as to indicate the different interests that guide the actors involved and the political and economic orders that nanotechnological development is an expression of. Gould [67] argues that nanotechnological innovation, which promises to greatly accelerate the treadmill of production, runs contrary to the principle of sustainable development and will result in the exacerbation of existing socio-environmental problems and generate new forms of ecological disruption, posing significant public health problems and increasing domestic and international socio-economic inequality. He therefore suggests making nanotechnological research and development subject to democratic controls at the earliest stages, in order to guarantee the maximisation of democratically established social benefits.

These authors clearly give negative evaluations of the trends embedded in nanotechnologies, but, more importantly for the debate, they offer a different view of the issues at stake. They promote an analysis which acts through the categories of power and which takes historical development and socio-economic context as important points of reference. It would be particularly interesting to disentangle the various implications and embedded values of the so-called knowledge-based economy, since it appears that the economic approach is linked to the idea of the knowledge society ([52], cf. [56]).

## Conclusion

Nanotechnologies as new and emerging technologies have developed in a context in which, at both a theoretical and political level, ethical and social reflection has achieved a broader degree of recognition than in the past. In just a few years the debate on ethical and social implications or aspects of nanotechnologies (ELSI or ELSA) has intensified strongly and much more quickly than in the past, at both institutional and academic levels.[47] Strand [155] has identified three main reasons for this intensification: first, there has been a change in public attitudes toward science and technologies in industrialised countries, with natural sciences partly having lost their high authority; second, there has been an intensification or ‘progression’ in the study of the relationship between science and society, mostly due to new directions in philosophy of science which emphasise the importance of the relationship between culture, society and science and the emergence of STS; and, third, there are signs of growing concern about ethical and social aspects of science amongst scientists themselves.

Precisely because of the recognition of the central role of ethical reflection, nanoethics has been accompanied by a need for profound reflection on its own role in the debate, as well as on its relationship with bioethics, an already consolidated field of so-called applied ethics. The variety of meanings attributed to nanotechnology has represented both a difficulty and a source of enrichment for ethical debate. On the one hand ‘nanoethics’ has struggled to find a clear meaning, since it can be used to indicate the normative assessment of issues of health, a sort of ‘engineering ethics’, or the entire range of non-technical issues raised by nano (cf. [22]). On the other hand, the debate around the novelty of nanoethical questions has also stimulated reflection on an appropriate framework for nanoethics.[48] Therefore the different responses given to questions about the

[47] See for example the initiatives of the European Commission in [81]; in the USA the US Nanotechnology Initiative (http://www.nano.gov/). See also, amongst others, the project Observatory Nano which has prepared an ELSA literature on nanotechnology (http://www.observatorynano.eu/project/filesystem/files/Literature.doc) and the Nanoethics Bank (http://ethics.iit.edu/NanoEthicsBank/popular_search.php?cmd=search&words=ethics&mode=normal).

[48] To summarise: for some authors, these issues are extraordinarily new because they involve new technological possibilities, but do not need a new framework of reflection [11, 70, 71, 73, 74, 159]. For others, these issues are new and therefore need new ethical insights because of the extraordinary transformative technological power of both nature and the human being [14]. For others again, these issues are old because they touch traditional ethical questions raised by technological development and so can be fruitfully analysed using established frameworks such as approaches in bioethics [43]. Finally, for some these issues are old problems which need new kinds of reflection, because traditional ethical frameworks do not appear to satisfyingly capture the issues at stake (see [172, 40]).

novelty of nanoethical issues show that the different conceptualisations of the role of ethical reflection on technologies themselves determine different perceptions of the nature of the issues at stake.

Even if this renewed attention to the science and society relationship has vastly enriched analysis, in the initial phases of the nanoethical debate we can see forms of resistance opening up to new modes of conceptualising the normativities of these technologies, a process which has turned large parts of the debate towards focusing on questions of risk (cf. amongst others [72, 74, 150, 159]). Even those authors who oppose consequentialist solutions for the most pressing questions concentrate, through reference to commonly shared values such as human rights, on evaluating possible consequences of technologies without deeply disentangling the social and cultural embeddedness of technological visions. They often, therefore, end in engaging in speculation about the future. The reduction of ethical and social discourse on science to a refined form of risk assessment runs the risk of playing a game tied to a reductionist conception of ethics, and so to bring debate on the future of society and technological development down to the question of who gives the best predictions. This ends up overlooking the fact that science and society are not two separate enterprises, but rather co-evolve, continuously shaping one another. These frameworks remain too attached to the dichotomy of techno-optimism/pessimism and offer critical analysis only on the possible future consequences of nanotechnologies (cf. [158]).

A stronger emphasis on sustainable or responsible development has also become an important concept for the governance of nano. This has been conceptualised as a means of broadening the focus of debate and of increasing sensitivity about the complexity and relatedness of the various issues at stake, as well as of questioning the assumptions and general values conveyed by nanotechnologies (cf. the EU Code of Conduct and Sandler [138]). However, these last frameworks also run the risk of falling into stereotypical ethical arguments, since this discourse is often black-boxed through the ambiguity of appeals to these values (both in the case of sustainability, cf. [149], and even more so for responsibility). As a matter of fact, a preliminary question is whether the fact that many—virtually all—stakeholders are engaged in the debate automatically transforms the process into a virtuous (responsible) one, if the actual decision-making process remains untouched. Furthermore, the appeal to responsibility explicitly enters the political arena, operating as a strategic tool for promoting nanotechnological development (cf. [89]). The appeal to ethical values is therefore transformed into a political strategy which favours nano-commercialisation. The strong opposition from the broad coalition of NGOs and trade unions 'NanoAction' can, then, be seen as a response to this strategic use of values (such as sustainability and responsibility) through the promotion of a different kind of analysis and understanding of these values which do not presuppose an aim of commercialising nano.

If we want to take this renewed reflection on the mutually shaping relationship between science and society seriously, we need to perceive it as a fundamental turning point within ethical reflection. Nanotechnology has been assessed on the one hand by adapting the notion of nano to the concerns, fears and anxieties of the public [87] and, on the other, through making it the engine of a new industrial revolution. Recent developments in the debate—such as inquiry into the MRP of nano and reflections on its role in development—have brought to the fore the need to contextualise and reconstruct the development of nano in a broader cultural, historical and political context, as well as to analyse concrete policy processes on science and technology. Both approaches share an emphasis on the need to move away from speculation about possible futures, which indirectly give credit to the questions raised by techno-enthusiasts. The idea is to concentrate effort upon the present and on a critical confrontation with past technological experiences. *Understanding the importance of the present* means understanding that, in the political economy of technological innovation, deep reflection on modes of governance and the social context in which policies on nano are developed constitute the unavoidable point of reference for understanding the ethical issues at stake. *Reclaiming the past* means that we can learn from past experiences: not only from errors (and here it would be helpful to open a discussion which makes the errors of the past concrete), but also because it offers us a more detached view of social and political dynamics.

If we do not concentrate solely on possible consequences, but rather struggle to understand the complexity of the relationships between visions, values, political and economic issues, we can conceptualise nanoethics as, first, an opportunity to reflect on some of the limits of standard ethical assessment frameworks for technologies. Secondly it can be a way to deepen understanding of the complex relationship between technology and society; and, finally, we can view it as a moment in which to profoundly reflect on the implications of current decision-making processes in science and technology.

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