

# From Speculative Nanoethics to Explorative Philosophy of Nanotechnology

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**Abstract** In the wake of the emergence and rapid development of nanoethics there swiftly followed fundamental criticism: nanoethics was said to have become much too involved with speculative developments and was concerning itself too little with actually pending questions of nanotechnology design and applications. If this diagnosis is true, then large parts of nanoethics are misguided. Such fundamental criticism must surely either result in a radical reorientation of nanoethics or be refuted for good reasons. In this paper, I will examine the critics' central arguments and, building on this scrutiny, formulate an answer to these alternatives. The results lead to conclusions which allow explaining and unfolding the thesis of this paper that instead of speculative nanoethics we should better speak of and develop explorative philosophy of nanotechnology.

**Keywords** Applied ethics · Nanoethics · Nanotechnology · Speculativity · Opportunity costs · Epistemology

## Introduction and Hypotheses

In the wake of the emergence [22] and rapid thematic development of nanoethics (e.g. [11, 21]), there swiftly followed fundamental criticism [20, 24, 25, 27].<sup>1</sup> Although this criticism acknowledged that gap diagnosed at the start of nanoethics had been more or less closed—a gap between the rapid progress of nanotechnology and hesitant ethical reflection [22]—it claimed that a new gap had instead opened up in its place: nanoethics was said to have become much too involved with speculative developments and was concerning itself too little with actually pending questions of nanotechnology design and applications: “... but a new gap has opened up because most nanoethics is too futuristic, focusing on nano-enabled devices that can read our thoughts, for example, at the expense of ongoing incremental developments that are more ethically significant” [25, p. 273]. The DEEPEN project put it into the phrase: “Move away

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<sup>1</sup> In this paper some quotes are taken from Nordmann and Rip [25] which is a two-page editorial rather than a full research paper. However, this editorial summarizes earlier work of the authors. It is grounded on research (e.g. the recently finished [6] project of the European Commission) and summarizes very sharply and precisely the criticisms. That makes it attractive to take quotes from it.

from speculative debate! Return ‘ethical concerns’ to the sphere of politics!” [6, p. 7].

If this diagnosis is true, then large parts of nanoethics are misguided and concern themselves with irrelevant and purely speculative ideas, while the really important developments are not taken into consideration. Such fundamental criticism must surely either result in a radical reorientation of nanoethics or be refuted for good reasons. In this paper, I will examine the critics’ central arguments and, building on this, formulate an answer to these alternatives. In so doing, I will develop the following hypotheses:

- a) The diagnosis that “most nanoethics is too futuristic” [25, 273] is one-sided. It conceals the fact that a substantial part of current nanoethics is indeed concerned with concrete questions concerning current developments.
- b) The critics’ central argument, which is based on a consideration of possible opportunity costs—the concern with (irrelevant) speculative nanoethics is claimed to take resources away from the concern with relevant ethical questions in nanotechnology—cannot be sustained.
- c) We should distinguish between philosophical reflections on more speculative questions in nanotechnology (‘explorative nanophilosophy’) from ethical inquiry of more practical issues (‘applied nano-ethics’).
- d) It is the task of this explorative nanophilosophy to prepare the ground for future debates conceptually, theoretically and methodologically, e.g. by analysing and reflecting alternatives in creating, regulating and using new technologies. These debates can indeed take on a speculative character to some degree.
- e) Such explorative philosophy must be epistemologically informed instead of being merely speculative. At this point, the criticism developed in this paper converges with one of the central demands raised by the critics of speculative nanoethics.

In order to expand and substantiate these hypotheses, I will first reconstruct and critically analyse the central arguments raised by the critics of speculative nanoethics (Section 2). The results lead to conclusions that seek to explain and reinforce the title of this paper ‘From speculative nanoethics to explorative philosophy’ (Section 3).

## Arguments and Counterarguments: Analysis and Assessment

Arguments criticizing ‘speculative nanoethics’ have been put forward by several authors (e.g. [20, 24, 27]). In the following the summary of the arguments given by Nordmann and Rip [25] will be taken as point of departure. The arguments will be scrutinized with regard to their structure, premises and validity. This approach allows for a more in-depth analysis of the arguments given by the critics of nanoethics, compared to the analysis given by [27].

### The Main Diagnosis “Most Nanoethics is Too Futuristic”

My criticism starts from the critics’ diagnosis, namely that “most nanoethics is too futuristic” and that “There is now a market for ethics of nanoscience and technology, and ethicists and others have responded to the demand for nanoethics with an over-supply of nanoethics” [25, 273]. This diagnosis criticises two facets of quantitative relations (“most” and “oversupply”):

- a) “Most” nanoethics are too futuristic. This criticism applies to the largest part of nanoethics (“most”). It takes a critical view of the proportion of speculative nanoethics in the entirety of nanoethics.
- b) There is an “oversupply”. In this criticism, the “supply” of speculative nanoethics is compared with a “demand”. This results in a completely different argument.

The critical examination of these assertions is difficult because the diagnosis is not sharp. (a) No clear criteria are provided to determine the border at which a nanoethical study is “too futuristic”, and no quantitative analysis is attempted to determine how many studies are above this threshold and how many below it. (b) The authors do not describe how an “adequate” measure could be determined for the supply of nanoethics or where it would be, something that has to be known in order to diagnose an “oversupply” between supply and demand.

Nordmann/Rip’s initial diagnosis is presumably meant in a much more elementary sense, namely that there is simply ‘too much’ speculative nanoethics *per se*. The critics create the impression that there is hardly anything else in nanoethics—they do not mention the

more concrete issues of nanoethics in any way. This itself produces, however, a false impression. A glance in the relevant anthologies (e.g. [2, 3], [34], [19]), monographs [13], and journal articles (see the previously published issues of “Nanoethics”) makes it easily possible to determine that the proportion of nanoethics that is not speculative is quite considerable. It includes above all the ethical analyses of the handling of uncertain environmental dangers and health risks from nanomaterials, which are frequently based on environmental, health and safety (EHS) studies (e.g. [14, 36]), and the consideration of questions of fairness, which are now present in numerous varieties, such as the significance of nanotechnology for developing countries (e.g. [9, 17, 31]).

At this point, I do not want to contradict Nordmann/Rip’s diagnosis that there is much speculative ethics. What is not clear, however, is whether there is *too* much, and if so according to which criteria—these are not given by the critics. A fair diagnosis would at least have to acknowledge that nanoethics do not consist exclusively of speculative considerations.

#### The Speculative Nature of ‘Speculative Nanoethics’

The central criticism levelled by Nordmann and Rip ([25], see also [20, 24]) at current nanoethics is that it is ‘too speculative’. They explain what ‘too speculative’ means by referring to the implausible nature of the developments that nanoethics assume to come from nanotechnology. According to Nordmann and Rip [25, 273], nanoethics even goes so far that it apparently takes developments into consideration that contradict the laws of nature.

The critics show convincingly how what was originally a conditional if-then chain gradually and unnoticeably becomes presumed expectations or even certainties: “As the hypothetical gets displaced by a supposed actual, the imagined future overwhelms the present” ([25], 273; see also [13], ch. 10; [27], pp. 318ff.). Indeed, it is not unusual for a discussion of the consequences of nanotechnology to include a second- or third-level conditionality, namely when these consequences might occur as a consequence of the use of nanotechnical products that themselves only *might* or *could* become reality, and then only if the respective technical development *would* take place in the direction envisaged. As a rule, in multilevel

conditional sentences of this type it is also possible for the result to be just opposite of what is assumed, and it would then be impossible to decide which of the contradictory alternatives should be given preference and for which reasons.

The methodological criticism of speculative nanoethics is then clear: nanoethics is based on mere speculation that cannot be validated and employs ‘mere possibility arguments’: “I will use the term mere possibility argument (MPA) to denote an argument in which a conclusion is drawn from the mere possibility that the choice of an option, behaviour, or course of action may lead to, or be followed by, certain consequences” [16, pp. 317f]. According to this methodological criticism, there seems to be nothing firm in nanoethics to consider. It reflects on objects that are pure speculative bubbles: “nanotechnology takes as its subject a science still aborning; many of the ethical and social ills it seeks to address are mere speculations” [20, p. 55]. In part, this takes place without any consideration of whether the objects concerned are even theoretically possible according to the laws of nature. Nanoethics itself is before its time: “Nanoethics [...] bears all the signs of prematurity. Its time may come some day but it is too soon to say just when and how” [20, p. 67].

The philosophical debate that followed the publication of the “Imperative of Responsibility” [18] demonstrated, however, that the simple possibility of thinking something cannot be employed as an argument or part of a chain of arguments, but only leads to aporias. If the future conditions that ethics reflects on were in a radical sense purely speculative, then the ethical advice that might follow from this reflection could not lead to anything of consequence. If the consequences and side effects of technology could not be evaluated prospectively *in any manner whatsoever*, the question of responsibility would be superfluous: that which is not known cannot be subjected to any *ex ante* ethical reflection, and no one can be held responsible for it. The object of ethics would get lost in the speculativeness of the considerations of consequences, making ethics obsolete: ethics would not set limits on technology, but technology—as a result of its uncertain future—would set limits on ethics. This was diagnosed as early as 1993 [4], long before the criticism of speculative nanoethics [24].

The question is, however, what follows from this statement. It would definitely be a hasty and inappro-

prate conclusion—which by the way Nordmann/Rip do not make—to believe that ethics is only supposed to concern itself with developments that are certain to materialize. It would then run into the opposite and frequently mentioned trap of always providing advice too late and missing opportunities for influencing developments, which are precisely in the early phases and when developments are still uncertain (see the criticized ‘ethics last’ model in [23]). Thus the only result from the accurate diagnosis that there is high degree of speculation in parts of nanoethics is the demand that procedures be developed in order for us to be better able to judge the degree of speculation (e.g. as vision assessment, see [10, 12]). The simple diagnosis that some nanoethics is speculative in nature does not (yet) have a direct consequence on the orientation of nanoethics. To this end, Nordmann/Rip need two additional arguments: (a) a concern that some objections to nanotechnology might be artificially created (see Section 2.3) and (b) the opportunity-cost argument (see Section 2.4).

#### The Concern that Artificial Concerns Might Be Invented

It is of course possible to ask what the consequences are of the speculative nature that has been diagnosed for many nanoethical works. The answer provided by Nordmann/Rip includes an argument that stood at the beginning of nanoethics, namely the anxiety that unanswered ethical questions could cause nanotechnology to lose acceptance. At the beginning of the debate about the risks of nanotechnology it was noted that nanotechnology and the ethical reflection on it developed at two very different speeds [22]. The concern, which was referred to as one over a ‘policy of innovation’, is that the grave and growing gap between rapid advances in nanotechnology and its inadequate ethical appraisal could lead to a development in which the expected advantages and opportunities promised by nanotechnology might not be achieved, for example because of public rejection: “We believe that there is danger of derailing NT [nanotechnology] if serious study of NT’s ethical, environmental, economic, legal and social implications [...] does not reach the speed of progress in the science” [22, p. R9]. Study of the ethical issues and of the consequences of nanotechnology is thus regarded as being necessary in order to be able to introduce

innovation in modern societies. Its absence might otherwise result in the threat of public resistance, which would hinder both progress and the social utilization of the expected advantages and benefits of science and technology: “The only way to avoid such a moratorium [following ETC [8], A.G.] is to immediately close the gap between the science and ethics of NT. [...] Either the ethics of NT will catch up or the science will slow down” [22, p. R12]. The conviction behind this diagnosis is the following: the earlier that the possible ethical problems from nanotechnology innovations are recognized the more possible it might be to avoid them constructively.

Nordmann/Rip turn this argument around. They fear that the supposed arbitrariness of speculative nanoethics could lead to completely unfounded and unjustified ethical problems which then could become issues for nanotechnology in the real societal debate. These issues could inflict serious damage on the further development of nanotechnology even if being completely artificial: “...worries about the most futuristic visions of nanotechnology can cast a shadow on all ongoing work in nanoscience and technology” [25, 274]. A premature and thus inevitably, at least in part, speculative handling of the ethical questions of nanotechnology would produce artificial problems, whose communication to the public might cause damage to innovation policy in the field of nanotechnology and could prevent exploiting its chances.

[25] conclude that nanoethics should deal with ‘realistic’ concerns rather than with speculative ones. However, the problem here is that it is hard, perhaps impossible to decide *in advance* which concerns are justified and which are not. Decisions of this type are confronted with high uncertainties, and as history shows, full of surprises and unexpected developments. The result of discontinuing speculative nanoethics and of shifting the focus to ‘truly pressing’ problems (leaving open the question of who determines which problems are truly pressing) might be that we overlook significant problematic developments and are unprepared for e.g. an emergency or an unexpected problem.

On the other hand, it would really be probable that nanoethics in its speculative version will (also) discuss problems which will show themselves as unnecessary from a future perspective. But who is to know *in advance* which problems will really be

relevant in some future and which will not? This decision—here mere speculation and there justified concern—cannot be grounded. However, this shows the need for developing criteria and procedures for better being able to distinguish between mere speculations and more plausible futures—the degree of rationality of an assumed future concern obviously has direct ethical and policy implications (see Section 3 for some thoughts in this direction).

Within the framework of a ‘reflective science’ [33], the argument that artificial problems might be raised and could even inflict damage on innovation policy in nanotechnology is not an argument against speculative nanoethics even if this case were to actually occur in reality. In other words, this is not an argument even if, for example, speculative discussions of cyborgs were to endanger the chances of nanomaterials in lacquer (although this case does not seem to be very probable). The other way round, pushing this argument could be regarded as giving implicit preference to a ‘wait and see’ strategy instead of dealing with consequences (which would of course be uncertain) in a precautionary manner.

### The Argument of Opportunity Costs

To turn to a different argument against speculative nanoethics: Isn’t it the case that if a (too) large a portion of nanoethics is concerned with speculative questions then there will be insufficient resources (people, time, money, creativity, attention, etc.) for the nonspeculative and nonetheless ethically relevant aspects of nanotechnology? Nordmann/Rip formulate the opportunity-costs argument so: “There are good reasons to think that the opportunity costs of speculative ethics are too high, with less spectacular but more ‘here and now’ ethical issues not getting the attention they deserve...” [25, 273]. Ethical reflection on speculative visions of nanotechnology would according to this argument tie resources, making them unavailable for other issues (see also [24]).

This argument, despite its apparent intuitive plausibility, is not as strong as is asserted. It is based on two premises of doubtful validity:

1. Apparently literally following the term ‘nanoethics’, Nordmann/Rip consider the entire speculative debate about nanotechnology to belong to *applied ethics*. They draw a good portion of the

intended strength of their argument precisely from this (misleading) categorization: if applied ethics focuses too much on nano-speculations, then there might not be enough resources left for fields closer to real application, which is the actual topic of applied ethics. Yet many of the studies about speculative aspects of nanotechnology can in no way be attributed to applied ethics if the participating persons, the arguments employed, and the literature used are taken into consideration. Many of these studies stem, to give several examples, from the philosophy of technology, anthropology, philosophy of mind, and the theory of artificial intelligence.

2. The persuasive power of the opportunity-cost argument depends fundamentally on the finiteness and constancy of the variable ‘available resources’. Metaphorically, a model based on a pie diagram is being used, and if a larger part of the pie ‘nanoethics’ is used for speculative topics, then there will be correspondingly less for the nonspeculative topics. But this model is not adequate in this case, which is related to point 1. It is precisely the speculative topics in nanotechnology that have motivated philosophers and STS researchers from outside applied ethics to concern themselves with the questions of nanotechnology. The new visions of nanotechnology have attracted *additional* resources from parties interested in such issues (philosophy, STS). The pie has grown considerably. The opportunity-costs argument thus does not hold up.

Summing up: the opportunity cost argument is not tenable at all.

### Resume

According to the preceding analysis, Nordmann/Rip’s criticism (based on [6, 20, 24]) is valid for one but *only* for one sore point. The valid criticism points to a problem of a possible “pure speculativeness” of speculative nanoethics, in which statements might run the danger of being *purely arbitrary* (Section 2.2). This is the point at which the further debate should begin, and this is the object of the considerations in the following sections.

The premise that “most nano-ethics is too speculative” can itself however be considered problematic.

It is also possible to reject the opportunity-cost argument (Section 2.4) and the concern rooted in innovation policy about the negative effects on the further development of nanotechnology and the exploitation of its potential (Section 2.2). As a result, not much remains of the *fundamental* criticism—more differentiation is needed.

### Explorative Philosophy Instead of Speculative Ethics

The debate considered gives, at first, rise to recommend a separation between different philosophical reflections on nanotechnology. Not every philosophical analysis looking at societal issues of future developments in nanotechnology and its possible applications is belonging to Applied Ethics. Insofar the term “nano-ethics” [1, 13, ch. 5] is a misleading umbrella term. It includes work clearly being Applied Ethics such as equity issues in benefiting from nanotechnology or precautionary issues in the release of nano-particles to humans and to the environment [14, 36]—but also the more ‘speculative’ work on cyborgs and hybrids or other field touching the human/technology relationships. My proposal is to denote the latter by ‘explorative nanophilosophy’ and to show that, given specific conditions, this type of reflection has something valuable to contribute to future nano-debates.

#### Explorative Philosophy and its Relation to Ethics

Since the very beginning of ethical reflection in science and technology there has been an ongoing discussion about the adequate relation in time between scientific-technological advances and ethics. Ethics often seems to pant helplessly behind technical progress and to fall short of the occasionally great expectations. The rapid pace of innovation in technization has the effect that ethical deliberations often come too late, namely when all of the relevant decisions have already been made, when it is long since too late to shape technology. In responding to this diagnosis, ethics joined the move towards ‘upstream engagement’ in the field of STS. The hope was and still is that addressing more directly the earlier stages of development would allow for a greater contribution to shaping the technology. At this point, however, we must be aware of the Collingridge dilemma

from technology assessment [5], according to which it is in principle easier in the early phases to influence the course of events, but in the early stage of development the required knowledge is absent that would enable one to intervene in a constructive manner. Nordmann/Rip’s criticism can be read as a diagnosis that nanoethics, in order to avoid the Scylla of the Collingridge dilemma (namely of coming to late), must fall victim to the Charybdis (i.e. inevitably being too speculative).

The Collingridge dilemma is exaggerated. The question of whether ethics should start early or late, whether it should be prospective or only start when reliable statements about consequences are available poses a false alternative. The issue here is not an either-or but a differentiation of ethical reflection in line with the problem at hand and with the validity of the available knowledge of the consequences. Ethical reflection differs conceptionally and methodically depending on whether it is concerned with measurable consequences of technology or with just imagined or even merely speculative ones. Above all, it also serves *different purposes*. The question, for example, as to whether it is responsible to permit nanoparticles to be included in food is a concrete question to be considered in the context of regulation, labelling requirements, corporate commitments or individual responsibility. In contrast, early thoughts about synthetic biology or human enhancement serve rather to promote the conceptional understanding and clarification of the issues from a normative perspective or to facilitate the development of clear terminology and ethical alternatives, but without there being anything immediate to be regulated.

The initial question is which purposes ethical reflection on nanotechnology is supposed to serve. Only then would it be possible to determine whether and under which conditions ‘speculative nanoethics’ might help to satisfy at least some of these purposes, or to find that it is obsolete. There is no difficulty in determining sensible purposes of ethical reflection, even for a rather speculative form of ethical reflection. The character of the latter would rather provide orientation but not any direct guidance for action [13]:

- A tendentially speculative reflection on nanotechnology that operates with experimental ideas is confronted with the danger of being arbitrary with regard to the future (Section 2.2). However, if its purpose is not to provide concrete orientation for

action but rather to prepare science and society for possible future developments (e.g. an emergency case) or to provide a preliminary conceptual and substantive structure for a possible future field of ethics, then the argument of pure speculation misses the point. Such explorative reflection would certainly not be applied ethics in the sense of dealing with pressing problems and aiming at urgent decision-making [6] but perhaps the *preparation* for future applied ethics.

- Early philosophical reflection on a new technology can draw attention to aspects which can only be judged after better knowledge of consequences becomes available. It could point to critical questions that require more precise examination in the future. In this manner, it could contribute to identifying gaps of knowledge which should be filled in order to make better assessments and judgments possible—this could then feed the agenda-setting processes of science and inform funding policies. Despite its partly speculative nature, early and explorative reflection could, therefore, even have concrete consequences for today’s decisions, such as with regard to research funding or the scientific agenda. The debate about stem cells was conducted, for example, in part as explorative ethics, namely inasmuch as interventions in the rights of embryos were being weighed in part against very uncertain expectations regarding the possibility of being able to use the results of research on these embryos to heal severe illnesses or to lessen their impact.
- By means of early (and in part speculative) and explorative philosophy we can learn something ‘about and for us’ today: “What do these visions tell us about the present, what is their implicit criticism of it, how and why do they require us to change?” [24, p. 41]. A good example is ‘human enhancement’, much of the debate about which can truly be called pure speculation. The debate has however beyond a doubt already led to a more intense consideration and better understanding of ongoing developments ‘beyond healing’ (e.g. in reflecting about an ‘enhancement society’ [37] where we already might be part of [29]).

The purpose of the reflection changes with the degree of speculativeness of the objects being

considered. The more speculative the considerations of the consequences, the less they can serve as orientation for concrete (political) action and decisions. Conceptual, pre-ethical, heuristic and hermeneutic issues then become, on the contrary, more significant. The primary issue is then to clarify what is going on in the speculative developments being considered, what is at issue, which rights might possibly be compromised, which images of man, nature and technology are formed and how they change, which anthropological issues are involved, and which designs for society are implied in the projections for the future: “Epistemology, moral philosophy, and natural sciences have always benefited from thought experiments on future technology” [32, p. 362].

This makes it clear that it is certainly not sensible to classify such very early reflection (which Nordmann and Rip diagnose as speculative nanoethics) as applied ethics. The proportion of ethics in it is rather small, while considerations that are conceptual, hermeneutic, philosophical (philosophy of technology) or anthropological play a large role. Ultimately this leads to the recommendation not to speak of ‘speculative nanoethics’ but to consider these forms of reflection as elements of an explorative philosophy of nanotechnology with an own justification, with own rationales and objectives, and with a different methodology.

#### Fields of Explorative Philosophy of Nanotechnology

Such an explorative philosophy, which is concerned with very early and in part unavoidably speculative evaluations of new developments in science and technology and of their consequences for man and society, is in no way supposed to provide orientation for action in areas of concrete developments. It is neither competition for nor part of applied ethics (which is precisely the reason that Nordmann/Rip’s opportunity-cost argument does not work; see Section 2.4). Its task is rather to *prepare* for possibly coming debates, in a conceptual, theoretical and methodological sense as well as with a view to basic distinctions and relationships from the philosophy of technology and anthropology such as man–technology, life–technology or nature–technology. Existing work—which sometimes is subsumed under ‘nanoethics’ and then could be criticized as speculative—might against this background be better classified as

explorative philosophy of nanotechnology in the following fields.

### *Nano Epistemology*

The emergence of nanotechnology has raised expectations of a new unity of science [28]. Nanoscience as the science of ‘Shaping the World Atom by Atom’ should, following these expectations, integrate the former classical disciplines of physics, chemistry, biology and the engineering sciences into a new type of science. Obviously, these projections challenged the philosophy of science and philosophical epistemology in order to uncover the underlying assumptions of those expectations and to question the conditions of their validity. The assumptions could be traced back to a naturalistic understanding of atoms as something similar to bricks or stones in the macroscopic world. ‘Shaping the World Atom by Atom’ would then mean building up new structures from atoms in a complete analogy to building systems from macroscopic elements like bricks. Epistemological reasoning questioned the validity of this simple analogy and the ‘atomic reductionism’ behind it [30, Ch. 2].

### *Nano Anthropology—on the Relation Between Humans and Technology*

Nanobiotechnology is emerging at the interface between bio- and nanotechnology. It bridges the gap between inanimate and animate nature, and aims at combining biological modules on the molecular level, as well as producing functional building-blocks on a nanoscale with the inclusion of technical materials, interfaces, and bounding surfaces [30]. The point of departure is the fundamental belief of life processes taking place on the nanoscale, because essential building-blocks of life have just this size (as, for example, proteins or DNA). The processes in a cell can be analyzed with nanotechnological methods and be rendered technologically utilizable. In nanobiotechnology, the language of mechanical engineering is applied to describe the mechanisms and parts of cells: cells and their organelles are interpreted as micro- or nanomachines. Literally speaking we see a nanotechnological infiltration of molecular biology, genetics and neurophysiology. In this manner, all are integrated under technical points of view. The nanotechnical (possibly feasible) duplication of fundamental life processes is the

essential prerequisite for crossing the borderline between technical and living systems.

Transferring this process to the relation between humans and technology speculations about the convergence of humanity and technology emerged. The concept of ‘cyborgs’ as technically enhanced humans or as humanly enhanced technology can be raised. An aspect turning up frequently in visions of nanotechnology is related to borders between humans and technology with respect to their transmissibility. This aspect on fact deeply affects our self-understanding, and consequently, our distinction between human being is, and what he/she creates with the help of technical achievements and applications. These developments—they are no more than a concept at present, in spite of their widespread presence in the ethical discussion—obviously pose questions of the type, whether and to which extent this would increasingly summarize human beings under the realm of technology [15]. The presence of such questions also indicates, however, that a new reflection of our self-concept as human beings and our relationship to technology needs to be done.

### *Nanotech Hermeneutics—Philosophical Interpretations of Nanotechnology*

The fascinating new opportunities of manipulating matter provided by nanotechnology but also the many visions related with societal issues of nanotechnology motivated thinking about deeper changes in human culture and its relations to nature and technology. Roughly, three different positions have been expressed so far ([13], Ch. 2). First, there are assumptions of a new Baconism coming up. Nanotechnology in the attitude of ‘Shaping the World Atom by Atom’ as the National Nanotechnology Initiative put it, is interpreted as a new optimism in making everything technically possible. Based on the idea of an “atomic reductionism” (see above) restrictions to human intervention are regarded as completely disappearing parallel with the availability of the new nanotechnologies. This would be the ultimate triumph of *Homo faber* who should then be able, according to these ideas, to control everything based on his or her control at the level of atoms and molecules. Humans would become ‘engineers of evolutionary processes’ and divine makers of the world [7].

Second, the opposite story also exists. Nanotechnology is frequently seen as “enabling technology” in

innovation respect. That means that nanotechnology itself will not lead to new products and systems but will be crucial to enable new products and systems in many areas of application. This ‘enabling’ character has far-ranging implications because in researching nanotechnology it will generally not be possible to know *which* new products and systems could be enabled because of simple but crucial problems of prediction. This situation would lead to a complete non-knowledge about societal impacts and consequences of the new products and systems which themselves would not be known. The openness of nanotechnology with respect to applications leads, in this consideration, to the highest possible uncertainty with respect to societal consequences, chances as well as risks. Everything could be possible—and probably nothing could be controlled.

The third story takes the obvious and complete contradiction between the two stories as point of departure and tells a further story: nanotechnology is regarded as a ‘cipher of the future’ which serves as a catalyst for societal, philosophical and scientific debates on issues like the future relation between humans and technology and the future of human nature avoiding strong substantial claims about controllability or other issues.

All of these fields are speculative in a sense. However, thinking about these issues seems worthwhile though no direct policy actions will depend on their results. It is more to understand what’s at stake and issue, a contribution to a ‘hermeneutics’ of possibly changing elements of *condition humana*. In this way, explorative philosophy can prepare the groundwork for applied ethics and for the technology assessment of the developments when they become more concrete. Ultimately this promotes a democratic debate on scientific-technical progress by investigating alternative approaches to the future of humans and society with or without different nanotech developments.

### The Epistemological Fundament of Explorative Philosophy<sup>2</sup>

What remains is the justified point of the critics of speculative nanoethics that if those reflections would

be addressed to merely speculative and arbitrary futures then no legitimate conclusions could be drawn (‘mere possibility arguments’, cp. [16]). Explorative philosophy must, in order to circumvent this criticism, not be epistemologically blind but must develop methods and procedures of assessing pictures of uncertain futures with respect to their degree of rationality. It needs clarification of the cognitive and normative content of the partially speculative future conditions and consequences of nanotechnology: “Instead of welcoming without scrutiny anyone who cares to add to the stock of promises and concerns about nanotechnology, we need to encourage discussions about quality of promises” [25, 274]. In this framework, a ‘vision assessment’ [10, 12] would examine both the cognitive and evaluative content and the consequences of technology-based visions. Its central task is an epistemological ‘deconstruction’ of these future conditions in order to be able to qualify the object of a subsequent ethical reflection with regard to its applicability and validity. ‘Vision assessment’ would be a building block of an open, cognitively informed and normatively oriented dialogue, such as between experts and the public or between nanotechnology, ethics, research funding and regulation.

Making epistemological analysis of uncertain futures including nanotechnologies work requires thinking carefully about the structure and the grounds of any nanofutures such as visions [12], scenarios and projections [7]. One of the anthropological characteristics of human beings (an element of the human *Sonderstellung*) is that humans are able to think about futures: to make plans, to predict future developments, to create scenarios, to develop visions, to express hopes and fears. These futures are imagined as pictures of a future which we do not know and which we cannot access empirically by direct observation. Futures thus cannot be discovered as something existing in our world but have to be *created* by humans, individually or in teams, for example by scientists or journalists, by writers and policy-makers. Each future we are talking about is a *construction*: an extrapolation of current trends, a vision promoted by scientists, a scenario developed for the purposes e.g. of urban planning or in the climate change context, or a prediction of demographic change. The familiar notion of ‘scenario-building’ reflects this property of futures.

<sup>2</sup> There are some similarities in the arguments given above with the analysis of [27]. Emphasizing the need for an epistemological view on futures in this section, however, goes beyond her approach.

This view on futures is in a certain sense trivial but has far-ranging consequences. At first it makes clear, that futures (and that is the reason why the plural ‘futures’ should be used) are inevitably part of the respective present time in which they are constructed and communicated. Secondly, it demonstrates that we do not have any direct access to the future as it really will be in due time. We only can think about futures according to our present-day’s knowledge, our values, fears and expectations—and according to our way of ‘constructing’ pictures of the future. This leads to the third aspect: the way how futures are constructed and which ingredients are used (in form of pieces of knowledge, models, values, ad hoc assumptions, *ceteris paribus* conditions etc.) is decisive for their content. Finally, this implies that any assessment of the ‘quality’ of futures—whatever this would mean in detail—has to consider the construction process and the ingredients used. It does not make sense to use the probability of matching real future developments by present images of the future as a quality criterion because this cannot be made operable.<sup>3</sup> If we want to compare different, possibly diverging futures we have to look at them as constructions and to assess the quality of the construction and its elements. Any epistemology of futures is a kind of ‘deconstruction’: disassembling the elements of those futures such as pieces of knowledge, uncertainties, ad hoc assumptions, values and other elements as well as the ways of their “composition” into one picture of the future, assessing the validity or plausibility of those elements and then assessing the overall “rationality” of the considered picture of the future compared to the rationality of others.

The epistemological analysis of future conditions would initially have to uncover the cognitive content of the visions, i.e. the portions of knowledge and lack of knowledge that are involved, their respective premises and the way they are combined to form coherent images of the future, such as scenarios. An important aspect would then be to examine the conditions for the realizability and the periods of times that are involved. Furthermore, the *normative content* of the visions would have to be reconstructed analytically: the images of a future society or of the development of man, and the possible diagnoses of current problems, the solution to which are supposed to be facilitated by the visionary developments of

nanotechnology. In substance here, I agree completely with Nordmann/Rip (but believe that the notion of ‘reality check’ is misleading when used to refer to an argumentative examination of future visions).

In particular, it would be a task of a vision assessment to directly confront the different and in part completely diverging images of the future in all of these phases with one another. On the one hand, this can take place by means of analytic work, but on the other the representatives of diverging futures should directly discuss their different assessments with one another in order to clarify their respective premises and assumptions. Procedures have been developed in different approaches to conduct such evaluations between experts of different provenances or between experts and laypeople (e.g. [26, 35]).

## Epilogue

Precisely in the context of nanotechnology and new biotechnologies, the concept of ethics has been broadly diffused in recent years. During this process, it has increasingly become impossible to recognize its meaning. Today nanoethics is often taken to refer to any attempt to describe social aspects of nanotechnology (see for example the anthology [2], in which only a few chapters are concerned with specifically ethical issues despite the fact that its title is Nanoethics). The criticism of ‘speculative nanoethics’ could, in a certain sense, be related to this conceptual maceration. On the one hand, people think in the categories of applied ethics, which despite certain ambiguities is a clearly circumscribed subdiscipline of philosophy. On the other, the extremely loose concept of nanoethics given above is used when the diagnosis is that it contains too much that is speculative. The application of the concept of explorative philosophy suggested here might possibly prevent some such misunderstandings.

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<sup>3</sup> The cost-benefit analysis approach discussed by [27].

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