

# No Future for Nanotechnology? Historical Development vs. Global Expansion\*

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[Au2] Abstract

[Au3] Keywords

The implications of nanotechnologies are often assumed to be like those of genetically modified organisms. One might also compare them to the introduction of plastics. Either way, nanotechnologies are said to be profoundly transformative. Whether one envisions the cure of cancer by 2015,<sup>1</sup> another industrial revolution, or a new renaissance,<sup>2</sup> much and perhaps everything will change and nothing remain as it is now.

But what does it mean and what should one do when told that everything will change? First, one might want to know with greater detail just how likely it is that this or that will actually change within our lifetimes or beyond. In particular, one might wonder how the envisioned changes affect our sense of self, in which ways and to what end they expand human powers, or how they might reconfigure the constellation of society, nature, and technology. Second, one might want to resist the threat that is implied by the assertion that everything *will* change and that we better brace ourselves for what lies ahead. This implied threat of an ineluctable technological future has motivated publicly commissioned philosophical reflection

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\*This paper is a translation, updated and expanded revision of “Wohin die Reise geht: Zeit und Raum der Nanotechnologie,” in Gamm and Hetzel (2005, pp. 103–123). It is profitably read alongside other contributions to this volume, especially those by Gerhard Gamm, Jean-Pierre Dupuy, Christoph Hubig, Jutta Weber, and Ingeborg Reichle.

<sup>1</sup>As does, for example, the brochure *Cancer Nanotechnology: Going Small for Big Advances*, US Department of Health and Human Services, National Institutes of Health, National Cancer Institute, January 2004. Only in March 2006, Sidney Wolfe of the Public Citizen’s Health Research Group spoke out against the insensitivity of such promises to the hopes and fears of cancer patients.

<sup>2</sup>See especially the introduction to Roco and Bainbridge (2002)

F. Jotterand (ed.) *Emerging Conceptual, Ethical and Policy Issues in Bionanotechnology*, 43  
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and social science research of the ethics of nanotechnology and “human enhancement,” in particular.<sup>3</sup> Such research thus operates in a paradoxically defined space as it explores degrees of freedom in the face of apparent inevitability. Against the unrelenting “will change” one might want to reclaim political space for the deliberation of a genuine choice in the matter.<sup>4</sup> The “will change” finally prompts a third response and it is the focus of the following reflections. Are we to imagine a more or less distant future for which we must assume responsibility now, or else, are we already implicated in this change, is it taking place as we speak?

On first sight, this third issue appears to be a matter merely of roadmaps and timelines. If expanded memory storage and technically enhanced computational capacity of the human brain will be achieved no sooner than 2100, this transformative change would seem to affect future generations and not the present. Accordingly, we would need to conceive our current research programs with a sense of responsibility towards the future. Beyond roadmaps, however, one might argue that this change is already happening. Experiments are being conducted now to explore the possibility of brain-machine interactions, the once fundamental distinction between organic and inorganic, living and dead matter has been undermined for some time, and some are already cursing the present and the shortcomings of their own bodies for being born too early – in light of what they envision for a merely hypothetical future.<sup>5</sup> Thus, whether we envision nanotechnological change in terms of the future or of the present is not a question of roadmaps and timelines alone.

After rehearsing different ways of conceptualizing the progress and future of nanotechnologies, the following reflections recommend a change of perspective, suggesting that the advance of nanotechnologies should be considered in terms of global expansion or the conquest of space, that is, as a process decidedly in and of the present.

## The Futures of Nanotechnology

The English acronym “TA” for “technology assessment” has been rendered in German in a somewhat restricted manner that introduces a further dimension. Instead of translating the concept literally as “*Technikabschätzung*” or “*Technologieabschätzung*,” German TA is conceived as the assessment of the implications, consequences or effects of technology (“*Technikfolgenabschätzung*”). When a

<sup>3</sup>For a critique of such speculative ethics, see my “If and Then: A Critique of Speculative NanoEthics” (2007b).

<sup>4</sup>This point was emphasized in discussions at the NanoEthics conference (Columbia, SC, March 2005) by Mickey Gjerris.

<sup>5</sup>Compare Dupuy (2007). Ray Kurzweil’s desperate attempt to build a bridge towards the time at which nanotechnology will give him immortality is an example of this “promethean shame” (a term coined by Günther Anders, that is, a present feeling of deficiency in comparison to what we might make of ourselves in the future, see Anders (1980) and Kurzweil and Grossman (2004).

German TA researcher like Armin Grunwald reflects the extent to which the development of nanotechnology is subject to social shaping, he must do so in the horizon of history and begin by probing conceptions of technology's relation to the future. Indeed, he juxtaposes three rivalling conceptions.<sup>6</sup> The *prognostic* approach to technology assessment assumes a knowable future, a future that is already given and thus impervious to our interventions. It accords with a view of technological determinism and the claim that what is technically possible will sooner or later become realized. The *constructive* or *social shaping* approach posits an open future that is up for grabs and yet to be determined by us. Only our decisions and actions make the future.<sup>7</sup> Finally, the *evolutionary* approach places the future in a genuinely historical perspective. In one respect at least, the future of technical development will be like its past: Historical analysis shows that it was never possible to predict, let alone derive the future from the past. This will surely hold for our attempts to predict the future, too. From the point of view of the past, the future is always open. History also shows, however, that the present is always indebted to the past, that the explanations of the present lie in the past, and that the present is hardly open to arbitrary shaping. From the point of view of the present or of the future, these are to a large extent determined by the past. An evolutionary understanding would therefore consider the future undetermined but also deny that we can shape it at will. The evolutionary approach to technology assessment will identify its underlying social dynamics and discover sites for intervention and debate. As for determining the future, it can influence the discursive landscape or economic environment in which further technical development unfolds. For example, the concept of 'sustainability' serves to frame but not to plan technological development, partly because it is itself subject to public contestation.

There is no clear-cut criterion for the correctness of one or the other conception of the future. Grunwald does not call for a choice between them but demands for the sake of transparency that pertinent presuppositions about historical development are rendered explicit in societal deliberations of technology – especially in the case of nanotechnology that thrives on representations of its imagined future.<sup>8</sup> He introduces a normative consideration where he emphasizes the distinction between

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<sup>6</sup>Grunwald (2003), also Grunwald (2006).

<sup>7</sup>Grunwald does not present this as a characterization of "constructive technology assessment" which pays close attention, for example, to "emerging irreversibilities" and thus starts from an analysis of the space of actions and actors. In regard to nanotechnology, see Rip (2004) (European workshop on Social and Economic Research on Nanotechnologies and Nanosciences, Brussels, 14–15 April 2004).

<sup>8</sup>Here, Grunwald's position comes close to that of Rip who might consider the three conceptions of technological development as folk theories that may or may not be shared by enactors (typically actors who promote a technological development) and comparative selectors (typically their many publics who think of themselves as having a choice in the matter). A first step in constructive technology assessment (CTA) is for CTA actors to clarify the status and strategic role of such folk theories of technological development. See Rip (2005, pp. 15–24). Grunwald offers the term "vision assessment" for this process of clarification.

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the perspective of actors and observers.<sup>9</sup> While the three approaches to the future may appear equally credible or valuable to observers, actors have to follow what one might call an imperative of the political and must suppose that technical development is subject to shaping.<sup>10</sup> A heuristics of precaution, of a prudential cost-benefit calculus, or of sustainability can set critical limits or establish positive goals, even if it were the case that the participants' faith in their ability to shape technological development will ultimately be exposed as illusionary.<sup>11</sup> Though only one or the other of Grunwald's three "futures" may prove adequate in any given instance, all three have this much in common: The future is in any case just that which will happen at a future time.

For Jean-Pierre Dupuy, in contrast, the future of nanotechnology is not what in the course of time turns out to be this way or that. The future of nanotechnology is what corresponds to its *logos* and what is already contained in our conception of nanotechnology. In a sense, this future is already prefigured, for example, in the program of a "bottom up" approach that avails itself of principles of self-organization and that views our presently given world as an aggregate of attributes that can be manipulated at will.<sup>12</sup>

Dupuy introduces this conception of the future as "enlightened dooms saying" or "catastrophisme éclairé."<sup>13</sup> Of the three approaches presented by Grunwald it has greatest affinity on first sight to the prognostic view in that it posits the future as already given and therefore not subject to prudential shaping. Grunwald comments

<sup>9</sup>Cynthia Selin complicates this picture in two essays. In discussions of the future of nanotechnology, there is not a definition of nanotechnology on the one hand and different interpretations of its future-orientation on the other. Different conceptions of time (evolutionary vs. revolutionary, the medium- or the long-term, a future that is inevitable or open to shaping, etc.) inform the dispute over what nanotechnology is in the first place. On the one hand, the competing conceptions of time co-exist indefinitely, on the other hand they enter into conflict over the proper conception of nanotechnology. Selin refers to Brown et al. (2000), compare Selin (2006, 2007).

<sup>10</sup>Here, perhaps, Rip and Grunwald part company. By distinguishing enactors and comparative selectors not in terms of social location but as engaging in two types of activity, constructive technology assessment questions the opposition of inside and outside perspectives. All parties are actors and for their actions they draw strategically on folk theories of technical development. As Rip points out, for example, enactors who promote a technical development often do not believe that the technology can be shaped but believe instead that the conditions of its reception (public acceptance) can be shaped.

<sup>11</sup>Pace Selin (note 10 above), these critical limits and positive goals need not be oriented toward more or less general, more or less speculative or contested conceptions of nanotechnology. They engage the scope of technical action that at any time has already been constituted through instrumentally mediated interventions. Instead of defining nanotechnology as concerning everything molecular or everything in a certain size regime, the domain of nanotechnology is defined by Grunwald as that domain "where machines stand ready to analyze and manipulate at the nano-scale" (personal communication). Grunwald's conception owes to Peter Janich, e.g. his "Wissenschaftstheorie der Nanotechnologie," in Janich (2000).

<sup>12</sup>See Dupuy "Some Pitfalls" (note 6 above), also "Complexity and Uncertainty", in (Dupuy, 2004).

<sup>13</sup>Dupuy (2002).

on this view: “The inner connection between prognosis and determinism leads to the absurd situation, that if an optimal prognosis were possible, it would have no use.” It is a virtue of Dupuy’s approach that he confronts this absurdity or paradox. In a sense, the paradoxical uselessness of saying what the future holds prompts an abhorrence that makes us shy away from this otherwise inevitable future.

According to Dupuy we cannot shop for a palatable future by choosing a preferred pathway according to the criterion of sustainability or the like. If one imagines the future as something that can be adapted to prudential considerations and if one imagines that there is always a choice between more or less sustainable but equally possible futures, one will never find credible the impending catastrophe. Moreover, we cannot even assign meaning to the word “future” if the future is as of yet undetermined, one of various scenarios that might become realized. Instead, there can be only *the* future, our one and only future, and it attains meaning precisely because it is what and who we will become. That one future is already determined, not however by being uniquely predicted through extrapolation from the inner logic of technical development. Instead, it is determined in the sense of a prophetically projected future that is envisioned or claimed by the *logos* of nanotechnology.<sup>14</sup> Such a projected future, Dupuy argues, is implicit not only in his prophetic warning but also in all attempts to create a positive feedback loop between projection and realization. In the latter case,

it is a matter of obtaining through research, public deliberation, and all 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. It is easy to see that this definition can make sense only within the metaphysics of projected time, whose characteristic loop between past and future it describes precisely. Here coordination is achieved on the basis of an image of the future capable of insuring a closed loop between the causal production of the future and the self-fulfilling expectation of it.<sup>15</sup>

If the analysis of the *logos* of nanotechnology does not suggest a desirable image of the future, however, all we can hope for is a negative feedback loop such that the promise of a catastrophe can break the self-fulfilling cycle of expectation and causal production. Both, positive and negative feedback begins with an image of the future that does not need to be articulated in detail. On the one hand, the future of nanotechnology appears indeterminate; on the other hand we can know that it signifies a catastrophe. This only apparent tension is easily resolved by Dupuy in that he derives nanotechnology’s catastrophic character immediately from its objective indistinctness or indeterminacy. This indeterminacy is objective because it does not depend on our presently and contingently limited state of information. It is not merely epistemic because it comes with systematic unpredictability at the nanoscale. We encounter this systematic unpredictability, for example, in the complex systems that are described by non-linear dynamics. These systems cease at so-called tipping points to change in a gradual manner that is strictly proportional to the

<sup>14</sup>This is how Dupuy’s differs from the prognostic view that was identified by Grunwald.

<sup>15</sup>Dupuy (2004, p. 91) (note 13 above).

causal influences upon them. As they reach a tipping point, they suddenly shift into a new state of organization. In other words, at their tipping points these systems behave catastrophically. Dupuy describes this as follows:

Beyond certain *tipping points*, they veer over abruptly into something different, in the fashion of phase changes of matter, collapsing completely or else forming other types of systems that can have properties highly undesirable for people. In mathematics, such discontinuities are called *catastrophes*. This sudden loss of resilience gives complex systems a particularity which no engineer could transpose into an artificial system without being immediately fired from his job: the alarm signals go off only when it is too late. And in most cases we do not even know where these tipping points are located. Our uncertainty regarding the behaviour of complex systems has thus nothing to do with a temporary insufficiency of our knowledge, it has everything to do with objective, structural properties of complex systems.<sup>16</sup>

This behaviour of complex systems occurs in nature most prominently where technical advance, excessive consumerism, exploitation, over-population and pollution overtax the resiliency of eco-systems. Such situations might also be produced through the creation of quasi-natural technical systems that enter into complex interactions which introduce further instabilities.<sup>17</sup> And precisely this appears to be implied by the program of nanotechnology. Its bottom-up approach aims to recruit principles of the self-organization of complex systems. Also, the pervasive integration of technical systems into the environment promises to increase complexity.<sup>18</sup> In both respects, the hybridization of technology and nature may produce an increase of objective unpredictability, ignorance, and catastrophic instability by way of ‘complexification.’

According to Dupuy, if there is a way to avoid catastrophe, it does not consist in prudential measures like prevention and limitation, exercises of preparedness, improved sensors, strict legislative oversight, or the like. As perhaps with Heidegger and his students, a possible escape could only consist in a dramatic change of course that shies away from catastrophe. This would amount to a historical accident or singularity prompted by a negative feedback-loop:

It is a matter of achieving coordination on the basis of a negative project taking the form of a fixed future that *one does not want*. [...] to obtain through scientific futurology and a meditation on human goals an image of the future sufficiently catastrophic to be repulsive and sufficiently credible to trigger the actions that will block its realization.<sup>19</sup>

Dupuy invests some work to establish the conceptual possibility of such a singularity. Historically, he finds it in the history of the arms-race where the prospect of an

<sup>16</sup>Ibid., pp. 80f.

<sup>17</sup>Compare my “*Noumenal Technology: Reflections on the Incredible Tininess of Nano*” (2005). It was inspired, in part, by Dupuy’s critique.

<sup>18</sup>While the attempt to do so is clearly part of the program of nanotechnology, it is not at all clear yet whether science and technology will actually be able to harness these processes.

<sup>19</sup>Dupuy (2004, pp. 91f.) (note 13 above). Dupuy goes on from here to resolve an apparent technical difficulty in his account of time: “*If one succeeds in avoiding the undesirable future, how can one say that coordination was achieved by fixing one’s sights on that same future?*” (On Dupuy’s account, of course, “that same future” is our one and only future.)

[Au6] accidentally triggered “mutually assured destruction” may have prompted a turn towards arm-control.<sup>20</sup> With explicit reference to Hans Jonas, Günther Anders, and Hannah Arendt, Dupuy thus recommends a heuristics not of prudence or calculation, but of fear.

With explicit reference to Ernst Bloch, George Khushf finally pursues a heuristics of hope with regard to nanotechnology.<sup>21</sup> For him, the future is neither what will happen at some future time, nor is it what is already contained in the *logos* of nanotechnology. Instead, it is an anticipation, foreshadowing, or adumbration of a potential that needs to be realized responsibly. For Khushf, this potential is contained in the notion of a “technological convergence” that is rooted in nanotechnology, Bloch refers to this potential as “allied technology,” that is, technology allied with nature [*Allianztechnik*]:

Just like the final manifestation of history, so the final manifestation of nature lies in the horizon of the future, and toward this future are oriented the categories of mediation of the concrete technologies that we can safely expect. The formative powers of frozen nature will surely once again be unleashed to the extent that in place of a merely external technology an allied technology will become possible, that is, a technology that is mediated with the co-productivity of nature.<sup>22</sup>

While Dupuy warns of any technology that unleashes the self-organizing, formative, potentially catastrophic forces of nature – forces that have no interest in the human species as such –, Khushf bets on these forces and as such also on the ethical and developmental formation (*Bildung*) or co-evolution of humans and nature.<sup>23</sup> While Dupuy pursues a negative project that does not allow for precautionary prevention or anticipatory remediation but demands a radical break, Khushf’s project is directed positively at the realization of a new world that is already announcing itself. And while Dupuy takes ethics to be rooted in an acknowledgement, even loving embrace also of human frailty that can radically challenge and doubt itself (Kant’s warped wood from which man is made<sup>24</sup>), Khushf views ethics as an affirmation of freedom that consists in the reflection and bringing-forth of the good.

Khushf delineates the task of responsibly conceiving the future in lecture on “The Ethics of NBIC Convergence for Human Enhancement.”<sup>25</sup> At any given time

<sup>20</sup> Jean-Pierre Dupuy, personal communication.

<sup>21</sup> The complementarity of Jonas’s “heuristics of fear” and Bloch’s “heuristics of hope” was identified by Wolfgang Bender in (Bender, 1996).

<sup>22</sup> Bloch (1973, p. 807) (my translation).

<sup>23</sup> Compare *ibid.*, p. 810, where Bloch envisions a technology that accords with Kant’s characterization of the arts and of a creative imagination that acts like nature and can be regarded as another nature. In “Nooumenal Technology” (see note 18 above) I identify the character of naturalness that is assumed by certain genetic or nanotechnologies and relate this seeming naturalness to the apparent uncanniness of these technologies.

<sup>24</sup> Kant (1983, p. 34).

<sup>25</sup> Khushf (2004a). Khushf provides a more sustained analysis in (Khushf, 2003), also (Khushf, 2004b). The following presentation of his approach is also based on a number of personal conversations.

in history there obtains an equilibrium between technical capacities, conceptions of the good life, and ethical norms. Even continuous and gradual technological development can disturb this equilibrium, enable new conceptions of the good life and occasion new ethical norms. If technological development is radically discontinuous this does not signify a relatively smaller or larger departure from equilibrium. As indicated by theories of non-linear complex dynamics, it requires instead a spontaneous reorganization at a higher level. In the normal case where there is a mere departure from an equilibrium that needs to be restored, ethics lags behind as it identifies the presenting problems and ties them back into traditional discourses. However, the visions of nanotechnology and of the convergence of nano-, bio-, and information technologies intend a radical transformation of the organization of research, of life and nature as subject to wilful and creative shaping. They aim for an equilibrium at a higher level and thus challenge ethics to proactively take part in the creation of what shall be.

This ethical project unfolds in parallel at all the levels at which the formative powers and complex dynamics of nature are unleashed. On one level, nanotechnology aims to exploit the bottom-up self-organizing principles of nature. On quite another level the very same structural paradigm of self-organization brings about a new configuration of academic disciplines that no longer divide nature among themselves in a classically hierarchical manner (fundamental particles to social organizations). Finally, on the third level, the new technologies effect a profound reorganization of all aspects of human life, livelihood, economy, sociability and health. According to Khushf, ethics enters the game just as soon as one takes seriously the nanotechnological claim that it will radically transform the organization of knowledge and of society. One is then always already implicated in the possibly competing conceptions of how to “truly integrate humans with nature.”<sup>26</sup> The same process unfolds on all three levels in parallel and this similarity or mutual mirroring serves to integrate the research process. This constitutes a kind of reflexive circle that incorporates and internalizes at a higher level what initially appears as an external disruption. Here the notion of physical and social formation explicitly links up with the educational notion of *Bildung*, that is, of an ethical development of the self. In the course of personal development, after all, traditional norms are first encountered as external rules and then incorporated into a mature self-understanding, a process that satisfies the general scheme of self-organization:

There is an important difference between the way a child and adult approaches ethics. For children ethical norms are external, impositions on wants and will. Rules prevent you from having candy, taking John’s toy, or playing instead of going to school. For the adult those rules are internalized and become an expression of one’s own life, sustaining vitality and orienting practice so that individual and communal flourishing coincide. The external rules about candy, stealing, and school are transformed into wisdom about how to eat, relate to others, and progress in knowledge and understanding. Adults transform the rules so they become an inner guidance for their life, the tools by which they craft in a responsible way their own future. In the face of the ethical challenges associated with

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<sup>26</sup>Bloch (1973, p. 817).



NBIC convergence, we need to enter maturity, developing that form of reflection that characterizes an adult. Only as adults should we enter the radically new world that opens up in front of us.<sup>27</sup>

In the self-education of humankind, the future thus appears in its infancy but already announces its mature personality. The shaping of this maturation process Khushf considers as a kind of formation or *Bildung* such that the outer formation of a radically new world is accompanied by implicit and explicit inner commitments also of the researchers and developers. The convergence of diverse technologies and disciplines is therefore quite distinct from the mere unleashing of science and industry's powers of productivity:

Here the character of the task, and the opportunity to craft the future we now enter, all come into view. Appropriately understood, the NBIC initiative [of converging technologies] does not just drive into the future, with engines of science and industry running full throttle; even beyond this, NBIC convergence, with a newly developing form of ethical reflection, can responsibly lead into a future, where the engines of growth are also the engines of self-regulation, reflection, and mature governance.<sup>28</sup>

At the end of this survey, Armin Grunwald enters the conversation one more time with a strategy for dealing with "nanotechnology as a cipher of the future." If the future is a medium for the communication of and about nanotechnology,<sup>29</sup> one needs to consider closely how the future appears in these communications. Different representations of the future require different assessments. Constatative statements that confidently pronounce what the future holds may prove more or less credible depending on how far-fetched or attainable this future is. In contrast, statements that posit a future in order to create positive or negative feedback-loops need to be judged perhaps in ethical or political terms, perhaps under the aegis of the precautionary principle. And yet again, a hypothetical mode of presenting uncertain possibilities calls for public engagement in a process of shaping nanotechnological development. Grunwald concludes:

This may sound sobering, but the function of nanotechnology as cipher of the future is *not* to show us the future. Its function is also not to display alternative futures that we can choose amongst as in the shelves of a supermarket. Instead, the function of ciphers of the future is to draw our expectations of the future into our current thinking, to reflect them there, to communicate and reach understanding about these reflections, and to finally render all of this fruitful for current actions and decisions – for, these require conceptions

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<sup>27</sup> Khushf (2004a) (note 26 above). This passage indicates that, as opposed to Dupuy, Khushf considers the formative powers of nature to be subject to shaping. In his own work, Khushf seeks innovative ways to shape such processes, for example, by reframing research in collaboration with molecular biologists, geneticists, medical researchers, bioethicists such that the reflexive circle can become productive in the creation of new and shared concepts. – This perspective on the formation of a new generation of natural and engineering scientists is less pronounced but still present in Khushf's paper on "The Ethics of Nanotechnology" (note 26 above). Here, too, this formation is said to contribute to the maturation of humanity.

<sup>28</sup> Khushf (2004a, p. 5).

<sup>29</sup> See Lösch (2006).

of the future. Nanotechnology is a cipher of the future – but by being precisely this, it casts us back upon ourselves and our present.<sup>30</sup>

Indeed, once we take this detour through the future, we need to adopt Grunwald's proposal and analyze various ways of talking of the future as a means to articulate our current expectations and demands. However, the following reflections challenge the notion that this detour is really necessary and that we need conceptions of the future to deliberate decisions at present. These decisions, one might say, concern what our world is like and how our world should be – quite irrespective of time or history. Accordingly, the critical analysis of nanotechnology as a cipher of the future should be supplemented, perhaps preceded by an effort to deflect talk of our nanotechnological future and to redirect it toward a consideration of claim of the various nanotechnologies on our world and our lives.

### From Time into Space

If nanotechnologies take us into the future or confront us with an image of the future, that future eludes our grasp in a variety of ways. It remains unclear, first of all, whether our relation or orientation to this future should be conceived in Grunwald's terms as prognostic, constructive, or evolutionary, as projective in Dupuy's sense, or formative, even self-expressive as suggested by Khushf. Furthermore, according to all those ways of relating to the future it remains quite unclear what this future actually holds, which of our current programs will have been realized, how future developments ought to be taken seriously in today's policy decisions, or how they might engage our cultural conversations.<sup>31</sup> Even Dupuy's projective fixing of a catastrophic future construes our relation to it as ultimately metaphysical.<sup>32</sup> On all these conceptions, the future of nanotechnologies is a horizon of expectation in which something unheard-of or unspeakable will appear.<sup>33</sup> Indeed, all this confusedness regarding the future serves as a first argument for

<sup>30</sup>Grunwald (2006, p. 78).

<sup>31</sup>Valerie Hanson therefore warned in her presentation "The Role of Anticipatory Rhetorics in Discussions of Nanotechnological Ethics" firstly, that attention to the realization of future-oriented programs may obscure presently problematic aspects of nanotechnology, and secondly, that the training of ethical sensibility to emerging situations may preclude us from engaging seriously with present reactions to nanotechnology.

<sup>32</sup>On the one hand, there is a trust that nanotechnology can indeed realize its *logos*, for example, that it will actually become capable of technically exploiting processes of self-organization. On the other hand, the human condition is taken not merely as our frame of reference for making sense and assigning meaning, it is absolutized as the only conceivable frame of reference. Though it is indeed perverse to posit and desire an ill-defined post-, trans-, at any rate non-humanity, and though ethical and political debate is ill-served by speculations about future ways of being someone other than ourselves, there ought to be some other way out of this predicament rather than universalizing how we now find ourselves.

<sup>33</sup>Compare Kaminski (2004).

abandoning an orientation toward the future. This could be done either by way of a critical analysis that refers us back to the present or, better yet, by way of ceasing to speculate altogether about the future of nanotechnologies.<sup>34</sup>

In respect to the unspeakable or unheard-of that lurks in the future, there is no Archimedean vantage-point that would allow us to pinpoint it or to subject it to a normative assessment. Hans Blumenberg characterizes this predicament by speaking of the coincidence of the “not yet” and the “no longer.” Confronted with technology as promise and fulfilment, societies typically transition immediately from the sphere of mere promise where one cannot ask critical questions as of yet, to the sphere of accomplished fact in which one is already implicated and which one cannot question anymore.<sup>35</sup> On this side of technical innovation we do not know as of yet how it will challenge us culturally, politically, or ethically.<sup>36</sup> And on the other side of technical innovation we have already become different people and can no longer invoke standards that now belong to our technical and cultural prehistory. The notion of (accelerating) progress does not allow for any middle ground between such a before and hereafter. As a matter of principle, however, political subjects ought not to place themselves into a temporal frame of reference that systematically deprives them of a decisive, real or merely assumed moment of possible intervention.

<sup>34</sup>This abandonment of an orientation toward the future concerns only a *historical* conception of time. In the course of history, the historical subjects (persons, nations etc.) undergo a change. This is not the case in a *technical-empirical* temporal succession. Of course, all “space travel” takes place in time, but its subject is thought to persist unchanged on its trajectory. This (admittedly, idealized) juxtaposition ought to be complemented by a concept of the future that no longer conceives of the future historically but as a space which we come to occupy in the course of our travel through time. It is just this dehistoricized “future” that makes for the ambiguity of the popular conception of a “nanocosm”: What we see at first is only a conquest of space, but this space is supposed to represent also the future that awaits to be occupied and settled in the course of time. It requires an additional assumption that this future will historically transform the subjects who are embarked on this journey. Andreas Lösch (see note 30 above) has shown how nanotechnological visions conceive the future ahistorically as a space that opens up to “us” (as subjects whose identity remains untouched). Another analysis was recommended by Kate Marshall (2004). According to her, the spaces claimed by nanotechnology are endangered from the future. They are “risky spaces” since, in the risk society, everything present is a product of an imagined, possibly scary future. Again, this notion of a present as product of the future posits an entirely ahistorical future, one that is relevant only to the extent that it affirms and confirms our present existence. It may well be the case that citizens of today’s societies can only countenance the ahistoric “futures” described by Lösch and Marshall. Indeed, with reference to Niklas Luhmann’s “Beschreibung der Zukunft,” Sabine Maasen made a compelling case how this holds for visual anticipations and verbal descriptions of the nanotechnical future. I take this diagnosis not as a final verdict, however, but as an argument for purposes of policy and deliberation – that is in immediate relation to my considerations on the “If and Then” (see note 4 above) and to the notion of “entanglement” (see my “Knots and Strands: An Argument for Productive Disillusionment” (2007a)).

<sup>35</sup>Blumenberg (1963). I owe this reference to Christoph Hubig.

<sup>36</sup>Reinhart Koselleck construes this as a characteristic difference between sphere of experience (*Erfahrungsraum*) and horizon of expectation (*Erwartungshorizont*), thus of a spatial discontinuity within the modern conception of historical progress, see his *Vergangene Zukunft* (1989, pp. 349–375).

If they did so, they would abandon the possibility of politics and the necessary illusion that they can express their values or shape their societies. This matter of principle motivates the proposal to imagine the advance of nanotechnologies not as a progression into the future but as a conquest of space, and thus as a journey that, empirically speaking, takes time but throughout which our moral point of view remains intact.<sup>37</sup>

The proposal to stop relating ourselves to the future appears outrageous and unheard-of in its own right: How could this even be achieved? It is worth recalling, however, that Science Studies, the Philosophy of Science, and the technosciences themselves have achieved this already. Science and Technology Studies has shown that technoscience differs from classical science precisely in that it is oriented not to the future but to space. For hypothesis-testing science and traditional philosophy of science, the truth was thought to lie in a remote future. According to Max Weber, Charles Sanders Peirce, or Karl Popper science approaches but never reaches this truth as it keeps postulating and testing hypotheses. If it advances further and understands more, this is because it builds upon the work of its predecessors and thus stands on the shoulders of giants. And for that very reason scientists must hope that their findings do not last but will be superseded in the course of progress.

Aside from the idea of progress, that of objectivity is also conceived by traditional science in historical terms. The main threat to objectivity is seen in historical or cultural contingency. The truth will have to be eternal and must therefore be cleansed of idiosyncrasies of personality, context of discovery, or cultural background. In the words of Paul Feyerabend, objective knowledge depends on the “separability assumption” and thus on the separability of a scientific claim from the historical conditions under which it was produced.<sup>38</sup>

None of this holds for technoscience.<sup>39</sup> The difference is apparent already in its conception of objectivity. Instead of looking to dehistoricize claims, technoscience is said to delocalize phenomena. The object of technoscience is not to gradually approximate eternal truth. Instead, it concerns the acquisition and spread of

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<sup>37</sup> Especially Dupuy’s analysis could be reformulated accordingly. Instead of positing the future as it is presently given with the *logos* of nanotechnology, he could argue more simply and without invoking the future: Nanotechnology aims to create a paradise on earth, I show you this paradise, see for yourself whether you really find it so enticing. This would make explicit an implicit assumption of Dupuy’s (one that is not shared by Grunwald and Khushf), namely, that he is judging nanotechnological visions from the point of view of today’s human being who acknowledges his mortality, his lack of technical perfection. At this point one should also consider the approach of the chemist George Whitesides. Refraining from predictions of the future, he identifies some core assumptions that underwrite our contemporary culture and form of life (following Wittgenstein, Andreas Kaminski and Barbara Orland refer to these assumptions as the “hinge propositions” since all other propositions and our form of life hinges upon them; they include propositions like “humans are mortal”). Whitesides goes on to show how these assumptions have become questionable, for example by way of nanotechnological visions. See his “Assumptions: Taking Chemistry in New Directions” (2004).

<sup>38</sup> Compare, for example, Weber (1946), Merton (1965) and Feyerabend (1999)

<sup>39</sup> See, for example, Nordmann (2004c).

capabilities.<sup>40</sup> Its goal is, first of all, to produce a phenomenon in the laboratory. One then needs to establish that the phenomenon does not exist under the special local conditions of the laboratory alone, but that it is stable enough to be transported to other laboratories and, finally, into society at large. This delocalization requires on the one hand that the phenomena become routinized, isolated, scaled to production, etc. It requires on the other hand that the external world is assimilated to laboratory conditions, that it becomes homogenized, standardized, sanitized. Technical or scientific advance therefore does not pursue an ideal of perfectibility towards the future, it marks no transcendence of past limitations. Instead, it is an advance quite concretely outward into the world. It expands territorially. First it may conquer inner space at the nanoscale, then it structures our daily actions in a pervasively technologized environment, and finally it pervades technically less developed cultures.

## Space Travels

The term delocalization appears in a paper by Peter Galison that shows his proximity to as well as his distance from Bruno Latour.<sup>41</sup> This final section will compare three conceptions of technology. All three view technology as permeating or conquering space. Despite the differences among them, Galison and Latour represent the first of these, Gerhard Gamm the second, and my own third proposal will be sketched very briefly only.

Galison's and Latour's Science Studies notion of delocalization makes the beginning. According to Latour, the laboratory is no longer a locally bounded space for experimentation. The presumed difference between its inner life and a societal environment has evaporated.<sup>42</sup> It has evaporated because society at large is implicated in various ways in the biopolitical experiments of genetic and agricultural engineering, nano- and biotechnology. First of all, these experiments are undertaken by an alliance of stakeholders and not a specialized scientific community. Inversely, the experiments are performed on all of society and not on a more or less self-selected sample population. The social benefits as well as environmental or health risks of new technologies are determined not in advance but only in the course of such large-scale experiments, namely by observing their diffusion and appropriation. The divide between the inner workings of science and the outer social order has evaporated also because technologically significant facts need to be sustained through the co-production of innumerable human and non-human actors,

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<sup>40</sup>This is reflected also in recent philosophy of science with its emphasis on modelling practices (local models, fitting models to phenomena and *vice versa*) and the specification of mechanisms.

<sup>41</sup>Galison (1997).

<sup>42</sup>Compare, for example, Bruno Latour's notion of collective experimentation in his *Politics of Nature: How to Bring the Sciences into Democracy* (2004, pp. 196–200).

and through a distributed effort that involves a continuous societal effort.<sup>43</sup> Finally, the boundary has vanished because technical interventions are negotiated and appropriated in social settings that include advocates of the economy and the environment, professional and lay cultures.<sup>44</sup>

When Peter Galison speaks of delocalization, he places the emphasis somewhat differently. Against Latour's image of a global network that is everywhere local and that, as a whole, sustains the facts, Galison asks how things move between local cultures and thus how phenomena travel from one laboratory to another, from there to industrial production and from there into our households. Delocalized objectivity owes to the objects. Highly idiosyncratic local cultures build conceptual bridges and stable practices as they develop the instruments for the representation and manipulation of objects.<sup>45</sup> Just like the tools and instruments, the results of this engagement with the object are not transported merely in the form of writing. They do not simply travel as it were on the rails provided by a shared theory or conception of reality. Instead, they must be carried from place to place by persons. In a sense, objectivity is spread by adventurers, explorers, missionaries, and developers – the kind of people who are celebrated in books about the great seafaring “discoverers.” While Latour tends to equate product and process (the global network coordinates local practices and results from their coordination), Galison emphasizes the effort involved in overcoming divisions and local contingencies: Initially, the worlds of the laboratory and of the environment at large are still divided and it requires work to universalize the laboratory phenomenon. Only if that work is successful, a new process or artefact will serve to coordinate practice in a global network of knowledge and industry.<sup>46</sup>

This difference between Galison and Latour can be related to current nanotechnological developments. Carbon nanotubes are presently manufactured in more or less cumbersome ways, in greater and smaller quantities with considerable variance among their properties. Standards of production and characterization are emerging only slowly, and everyone is still awaiting whether they will live up to their promise as universal building blocks for global solutions (chip architectures, display technologies, etc.). The global network of artefacts and practices based on nano carbon-tubes remains programmatic. All the while, researchers are working to bridge

<sup>43</sup>One of Latour's prime example is the *Pasteurization of France* (1988).

<sup>44</sup>Here, one of the most compelling case studies is Steve Epstein's *Impure Science: AIDS, Activism, and the Politics of Knowledge* (1996).

<sup>45</sup>Galison quotes Latour's conception that instruments as simple as a clock can “travel very far without leaving home.” He contrasts this with his own view that “meanings, values and symbols often stay home or switch identities when scientific theories and instruments travel,” compare Galison (1997, pp. 677, 679) (note 42 above). Latour speaks of global networks that are everywhere local in *We have never been modern* (1993).

<sup>46</sup>As opposed to Latour, Galison exercises rather more restraint when it comes to telling global stories about the social fabric. The previous reconstruction extrapolated from his analyses of the scientific interactions within and among large physics laboratories, especially *Image and Logic: A Material Culture of Microphysics* (1998).

different laboratory cultures so that these artefacts might travel more smoothly among and between them. The program that motivates this work – Dupuy would call it the metaphysical program of nanoscale research – cannot be represented by Latour’s networks that are already all-encompassing. These networks are a spatial equivalent to Grunwald’s evolutionary view of the future: They cannot be governed, they are neither determined nor subject to shaping. In contrast, Galison paints a picture of piece-meal constructions that might be open to shaping but that offer no Archimedean point for a social intervention that could globally orient technological development.

Aside from the image of nanoscale research as (inner) space travel and aside from a research process that moves from local tinkering to global solutions, there are numerous further indications that nanotechnologies are engaged in a conquest of space.<sup>47</sup> The first of these is the very label “nanotechnology” that refers to a region of space and the intermediary realm between classical and quantum physics. For the surprises that it holds, this highly complex world has been called an “exotic territory.”<sup>48</sup> The first goal of nanoscale research was and is to find one’s bearing or orientation and to act in this space. After learning to see and to move single atoms, one writes the name of one’s lab in molecular script, acquires the capability to build a wire, to produce some effect, etc. The second goal of nanotechnology is to create great effects from small things. Here, miniaturisation gives way to the project of advancing from the nanoscale to larger scales. Thus, nanotechnologies advance in space by taking nanoscale processes and nanostructured materials to construct larger technical artefacts and systems. As opposed to traditional (outer) space travel or colonial conquests of discovery, however, nanotechnologies do not aim to inhabit this or that particular corner of the world. The nanocosm is presumed to extend everywhere where things consist of molecules. When nanoscale research seeks to control the molecular domain, it literally claims the space of everything. Silicon chips and nerve cells, proteins and pharmaceuticals used to belong to ontologically separate realms of organic and inorganic nature and technology. Now, nanotechnology considers all of these as aggregates of molecules that might be recombinable at will. With the unification of previously separate realms, nanoscale research extends its reach to biotechnology, information and communication technology, and other disciplines.<sup>49</sup> In the language of atoms and molecules, everything becomes nanotechnologically malleable.

Nanotechnology may thus appear to be a paradigm case of what Gerhard Gamm calls technology as medium: “Technology is like language or money a circulatory

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<sup>47</sup>For a more comprehensive account see my “Design Choices in the Nanoworld: A Space Odyssey” (2007c); for rather more detailed accounts see my “Molecular Disjunctions” (2004b), and “Nanotechnology’s Worldview: New Space for Old Cosmologies” (2004d)

<sup>48</sup>See Roukes (2001).

<sup>49</sup>This aspect of nanotechnology’s expansiveness underwrites the so-called NBIC-convergence, that is, the convergence of “nano, bio, info, cogno.” In a soberingly deflationary manner, the etc-Group speaks of the “little BANG” that combines bits, atoms, neurons, and genes.

system in modern society.”<sup>50</sup> Considered not as means to an end but as an indeterminate site for mediation, Gamm’s medium permeates space and lies “at the limits of time.” When Gamm distinguishes between transcendental and immanent indeterminacy of technology, this distinction can be applied to nanotechnology.

Transcendental indeterminacy aims for a fundamental transformation of the modern age. This is to occur as technical agency inscribes itself [...] into the emptiness of a non-stereotyped productivity. For this, there is in principle neither an inner nor an outer limit.<sup>51</sup>

This “emptiness of non-stereotyped productivity” has been characteristic for the visions of nanotechnology ever since the “crazy” engineer Eric Drexler imaginatively claimed Richard Feynman’s room at the bottom.<sup>52</sup> Immanent indeterminacy, in contrast, is based on the gap between technical function and use and thus on the seemingly unlimited adaptability of technical functions to different contexts of use. An example of this was offered above – the case of carbon nanotubes that may produce the next generation of computer chips, new textiles, displays, medical and environmental sensors, etc.

Obviously then, nanotechnology can be conceived as a medium that fills space and within which wholly original functions and uses can be imagined productively. However, one might reject this conception of technology as a medium for the same reasons that one might prefer Galison’s over Latour’s concept of delocalization. When Gamm’s medium is compared to language, money, the circulation of blood, and the matrix of being, it proves to be too thin-bodied, immaterial, and rare. This subtle medium has already spread everywhere. Its spatial expansion can no longer be felt as a material claim, conquest, colonization or annexation. According to Gamm, this medium becomes apparent only when it becomes a form of reflection:

By harbouring within it the *logos*, technology is essentially a medium for the *disclosure of self and world*. [...] [It] refers to the horizon from within which we invent the world and from within which with increasing insistence we technically reinscribe the image of our selves [...] It is the medium in which human beings become transparent in their artefactual character.<sup>53</sup>

This notion of technology as a medium therefore serves well to describe how we find ourselves in regard to technology that is routinized and normalized through use. It characterizes a way of thinking that conceives of every problem first and foremost as a technical problem. The notion of technology as a medium finally captures the spirit of specific technological visions like “ambient intelligence” or “ubiquitous computing” – visions that aim for a deeply pervasive technological environment as a kind of second nature. However, like Latour’s networks, the notion of technology as a medium does not capture how such visions need to be asserted and materially implemented.

<sup>50</sup>This and the following quotations are from Gerhard Gamm, “Technik als Medium: Grundlinien einer Philosophie der Technik” (2000, Suhrkamp, pp. 275–287)

<sup>51</sup>Ibid., p. 279.

<sup>52</sup>See Feynman (1960).

<sup>53</sup>Gamm (2000, p. 285).



Moreover, in light of Marcuse's one-dimensional technological culture or Heidegger's "*Gestell*," Gamm's conception asserts all too optimistically an emancipatory dynamics. It advances all too quickly and with the semblance of necessity from thought in the medium of technology to a technological indeterminacy as a form of reflection that discloses self and world. Technology as a medium is supposed to lead us not only to reflect our artefactual character but at the same time to reveal indeterminacy as a norm that establishes a critical relation to technology. According to Gerhard Gamm, the indeterminacy of technology leads us to perceive

another aspect of openness that is qualified and not arbitrary and almost always overlooked. It includes a normative significance that can be summarized in the form of a maxim: to probe actions, projects, decisions, plans for the future as to whether openness will be preserved also after the realization of the projects. In regard to the implementation of risky technologies this amounts to the question whether the decision for or against it includes the possibility of a reversal, whether technologies open spaces for action in which errors and mistakes do not lead to irreparable, that is, catastrophic consequences.<sup>54</sup>

In contrast to Latour and Galison, Gamm has thus achieved a normative point of view that permits an assessment of technological programs. This is an important achievement, but it comes at a high price: Delocalization comes at the expense of dematerialization with the added assumption that we necessarily advance on a conceptual path that will lead us to reflect and evaluate the pervasive, yet indeterminate presence of technology.

In contrast, I would like to finally suggest that delocalization is quite literally the program of technoscience. On this account it is nothing but territorial expansion pure and simple – and it is human beings and societies who are the ultimate object of appropriation, that is, human bodies and everything that structures human decisions and actions. By way of the technosciences, in general, and nanotechnologies, in particular, we engage in a project of self-colonization.<sup>55</sup> This process of self-colonization takes place at a variety of levels. It begins with the break-down of the boundary between laboratory and society, and continues with the ways in which promoters and critics alike are drawn into the affirmative project of "responsible development of nanotechnology." The project of self-colonization also involves the creation of systems of total information and control that would allow us to use our material resources far more efficiently. Such systems of control are pursued for environmental monitoring, medical imaging, or manufacturing, and they forge new constellations between material processes and human agency as one cultivates on the one hand an attitude of surprise toward the bottom-up emergence of novel

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<sup>54</sup>Ibid., p. 226.

<sup>55</sup>Here emerges another point of contact with Dupuy's work on the self-mechanization of the mind in AI-research. He shows that self-mechanization or self-colonization are perfectly coherent technological projects that involve us in a paradoxical relation to ourselves as developers of these technologies; see his *The Mechanization of the Mind* (2000).

properties, and on the other hand the exercise of precision control that reaches beyond human powers of imagination and understanding.<sup>56</sup>

In the age of technoscience we pursue projects of delocalization and self-colonization to develop solutions to currently identified problems. This “we” is not challenged by or obliged to a historical process but views the future merely as the place where technical possibilities will be realized. At the same time, this “we” is historical in that it is contingently given with its world, its values and traditions. Without arrogating to itself an entirely fictitious view from eternity, this “we” can only claim to be a citizen of its presently given world and it decidedly does not represent a persistent human nature against which the future can be measured. This historically contingent subject of its own world is aware of its contingency and therefore at odds with an ethics of responsibility for the future as postulated, for example, by Hans Jonas.<sup>57</sup> Our world is indeed, as George Khushf put it, only a particular equilibrium of nature, technology, society, and individual. We do not know whether we have any right to pass judgment or to act on behalf of future generations whose values or sense of self may be quite from ours. At the same time, however, we are obligated to act in accordance with our values, to assert our cultural sense of body and self. On the one hand, therefore, we have no right to paternalistically judge in the name of future generations the cyborg, for example, as deficient, perverse, or alienated. For, if cyborgs were to have a self, they would be no more or less alienated from themselves as we are (and if cyborgs have no selves, the problem takes care of itself). As hybrids of humans and machines, cyborgs will also find themselves in an equilibrium of values and physical facts – there will be no need for them to relate the conception of machine to that of a human being, since to them the machine represents no alien otherness. On the other hand and at the same time, we cannot do otherwise but to experience the technological transformations of the human body in the terms of invasion and heightening of self, as a precondition or alienation of physical being. When artists like Stelarc place their bodies in experimental situations of extreme technological control, the significance of their work consists in the fact that they apply a discourse about the future of the human being to the body of the present human being. They draw technological visions into the horizon, values, and evaluations of the present. The troubling immediacy of transition, from the time when critical questions can “not yet” be asked to the time when they can “no longer” be raised, is addressed by artists like Stelarc: They ask “already now” what is effected by the technical penetration of his body.<sup>58</sup>

<sup>56</sup>These themes cannot be developed here in any detail. They constitute a major strand of ongoing inquiries (in close collaboration with Astrid Schwarz) on naturalized technology, the limits of knowledge and understanding in nanotechnologies, the enhancement of material nature, the nano- and ecotechnological discovery of unlimited possibility beyond the limits of growth, and the seductive power of technoscience. To be sure, the currently popular discussions of human enhancement should also be placed in the context of technoscientific projects of self-colonization (they constitute the tip of the iceberg, so to speak).

<sup>57</sup>Jonas (1984).

<sup>58</sup>Stelarc thus experimentally forges together again what Koselleck diagnosed as the modern separation of the sphere of experience (*Erfahrungsraum*) and horizon of expectation (*Erwartungshorizont*), see notes 33 and 34 above. See also Hanson (2005) quoted above.

Paradoxically perhaps, it is therefore the descriptive enterprise of Science and Technology Studies with its emphasis on the spatial orientation of the technosciences that enables normative critiques of technology. Its analyses link up with political and ethical discourses of the present precisely in that they surrender the concern for future generations in favour of critiques of colonialism and globalization. This linkage has only begun to be developed and explored within the context of Science and Technology Studies – and must therefore remain programmatic here.<sup>59</sup>

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<sup>59</sup>See note 57 above. A different kind of beginning was offered by Meaney (2006); see also Marshall (2004). (note 35 above).

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