

# Nanotechnologien im Kontext

Philosophische, ethische und  
gesellschaftliche Perspektiven

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# Wissenschaftstheorie der Nanotechnologie

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**Abstract.** The clarification of the nanotechnological research enterprise calls for a contribution of philosophy of science within the disciplinary division of labor. This applies, in particular, to the definition of the nanometer size range that presupposes measurement and measurement apparatus, and thus a particular way of acting. Action is guided by purposes. An account is provided of how the purpose of gaining knowledge is reoriented towards purposes of application. This helps clear up the relation of discovery and invention in nanoscience and nanotechnology. By focusing on the production of knowledge through a definite sequence of actions, certain self-misunderstandings of nanoscale research can be exposed. These concern the relation of physics and chemistry or that of microscopes to the images they produce. Finally, since substances are procedurally defined by ascertaining certain material properties, the question is raised whether nanoscale substances require an entirely new phenomenology: Can we even speak of some given substance having new properties or do we need to assume that uniquely different substances emerge from the nanotechnological procedures that ascertain the new properties?

## Eine Definition von Nanotechnologie: Erster Schritt für ein interdisziplinäres Nanotechnology Assessment

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**Abstract.** Technology Assessment as problem oriented research aims at contributing to the formation of political and public opinion on societal aspects of science and technology. These socio-political problems transcend academic disciplinary borders and are rooted outside the scientific area. Therefore it needs inter- and often transdisciplinary research to contribute effectively to the formative process. Crossing disciplinary borders requires a common vocabulary as disciplinary definitions are too limited in an interdisciplinary context. To ensure that the term 'nanotechnology' means the same to all parties involved, its definition is therefore a crucial first step of interdisciplinary research, and has strong normative implications.

## Nanotechnologie als Chiffre der Zukunft

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**Abstract.** Nanotechnology and the idea of Converging Technologies both have considerably influenced the scientific and societal thinking about future. Debates on the future of the nature of humans and on the enhancement of human performance, on the future of technologies and their relations to humans, as well as debates on the future of the sciences are most prominent examples. Such debates are dominated by futuristic, far-ranging visions about technological developments but also about the predicted change of human, individual and collective, conditions and ways of life. Visions of this type are used by all groups involved in the debate, by scientists and engineers, by managers and politicians, by the media and civil society actors, by philosophers and writers – in, however, not always the same meaning and intention. In this way, a new round in the debate about the future of humankind can currently be observed. In this paper the debate on nanotechnology and converging technologies is considered in how the term „future“ is used in these debates: What is claimed to become reality in the future, which arguments are given to support the predictive statements, and where are the limits and shortcomings of these arguments. The paper focuses on epistemological questions behind future expectations, fears and visions emerging in the nanotechnology and converging technologies debate. The main thesis is that future developments are not accessible *as future ones*, but only as our present images of them.

## Unsichtbare Ursprünge: Herbert Gleiter und der Beitrag der Materialwissenschaft

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**Abstract.** Herbert Gleiter promoted the development of nanostructured materials on a variety of levels. In 1981 already, he formulated research visions and produced experimental as well as theoretical results. Still he is known only to a small community of materials scientists. That this is so is itself a telling feature of the imagined community of nanoscale research. After establishing the plausibility of the claim that Herbert Gleiter provided a major impetus, a second step will show just how deeply Gleiter shaped (and ceased to influence) the vision of the US Nanotechnology Initiative. Finally, then, the apparent invisibility of Gleiter's importance needs to be understood. This leads to the main question of this investigation. Though materials science research meets even the more stringent definition of nanotechnology, there remains a systematic tension between materials science and the device-centered visions of nanotechnology.

## Atome Sehen, Atome Hören

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**Abstract.** We know from research into legends that information that is removed from its original source and passed on further tends to get changed in the process. The same thing happens to scientific images and particularly to the 'images' of atoms that have become common through STM and ATF microscopy. The original information is altered during the journey from the atomic force microscope to the laboratory PC, to the academic journals and finally to the newspaper reader. On the one hand, the complexity of the information is immensely reduced. On the other hand, the messages are also enriched by the addition of certain elements. To prove this claim I am draw not only on optical images but also on acoustic images. Interestingly, certain sounds play a central role in scientific measurement of atoms. It is easy to demonstrate that such noises represent the atomic measuring process much more precisely than two-dimensional images. To speak of 'hearing atoms' would make much more sense than to claim that we can see them. Nevertheless acoustic representations have not been publicized. On the contrary they are downright suppressed. To look for reasons for this situation turns out to be very instructive. The starting point of my investigation is the Print 'Erster Blick' (First View) by the Artist Gerhard Richter, which poses the question of this article in a very subtle and multi-faceted way.

## Kein Weg vorbei an der Natur: Natur als Gegenpart und Voraussetzung der Nanotechnologie

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**Abstract.** Two criteria are proposed for characterizing the diverse and not yet perspicuous relations between nanotechnology and nature. They assume a concept of nature as that which is not made by human action. One of the criteria endorses a distinction between natural and artificial objects in nanotechnology; the other allows for a discussion of the potential nanotechnological modification of nature. Insofar as current trends may be taken as indicative of future development, nanotechnology might increasingly use the model of nature as a point of orientation, while many of its products will continue to be clearly distinguished from nature.

## Maßgeschneiderte nanoskalige Systeme: Methodologische und ontologische Überlegungen

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**Abstract.** Focussing on ethical and social questions the recent philosophical debate on nanotechnology ignores the wide dimension of methodological and ontological questions. To complete the philosophical analysis in this sense nanotechnology here is observed with regard to the fact that all science is intervention. Two aspects of nanosystems were pointed out: First the double function of nanosystems as objects *and* instruments or tools of investigation, second the hybrid state of nanosystems as artefacts *and* as natural products. In both directions – from a methodological and from an ontological point of view – nanotechnology can be understood as a continuation of the modern sciences research programme. For that reason it is confronted with the basic dialectics in the relation between intervening science and nature too.

## Mit dem Unerwarteten rechnen? Computersimulation und Nanowissenschaft

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**Abstract.** Nanotechnology uses computer simulation to control phenomena in complex situations where traditional theoretical approaches fail. It is claimed is introducing a methodologically new conception of modeling that is based on an adaptive feedback loop between experimentation and visualization of the results. Thus a type of knowledge is produced that fits particularly to the demands of technology for manipulation and control, but not to the more theoretical goal to reflect on the limitations of the knowledge.

## Visualisierungstechniken: Die medial vermittelte Sicht auf die Welt in Kunst und Wissenschaft

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**Abstract.** There are many examples of the employment of technical devices that extend human perception far beyond its natural limits. The technologies to be examined enlarge the power of human vision and the grasp of the hand. It is mainly the practice of fragmentation and the alignment of vision that have led to images of the formerly invisible. Visualization technologies at the nano-scale change the whole order in the engineering of vision. It is no longer an extension of the human vision, but an instrumental vision, a substitute for seeing. In apparatus-driven perception the elimination of the context and the enlargement of one aspect culminate in the loss of verifiable references. Instead we have to deal with data produced by measurement instruments. The visualisations of data trigger interpretations that are influenced not only by visual conventions and aesthetic expectations.

## Konvergenztechnologische Zukunftsvisionen und der klassische Utopiediskurs

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**Abstract.** The key question of this paper is the relationship between the American report 'Converging Technologies for Improving Human Performance', published in 2002, and the classical tradition of Utopian thinking. To perform such a comparison the author focusses on three overlapping issues. On this basis he analyzes five differences which reveal the principal divergence of these approaches. Having done this he opposes the American report with the European blueprint 'Converging Technologies – Shaping the Future of European Societies' of 2002. He concludes that the later one is indeed an alternative to the American design. The reason is clear. On the one hand the European report recognizes the opportunities of the leading technologies at the beginning of the 21st century. On the other hand it reflects the dangers of this development. Due to the European scenario the solution could be a social contract that considers the technological advance not as the myth of an inescapable fate, but as a result of a democratic agreement of the European civil societies themselves.

## Der posthumanistische Technofuturismus in den Debatten über Nanotechnologie und Converging Technologies

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**Abstract.** The debates on nanoscience and technology and their convergence with other fields of research are heavily influenced by technofuturistic visions that have a long-standing tradition in Western thought. In the controversies about technofuturism the debate on converging technologies is framed as a political and cultural conflict. Posthumanist technofuturism, as both a particular set of ideas and a sociocultural movement, plays a significant role in this context. What follows is an analysis of posthumanism's role in the debates, with particular references to its crypto-religious and utopian aspects.

## Antizipationen nanotechnischer Zukünfte: Visionäre Bilder als Kommunikationsmedien

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**Abstract.** On the basis of a case study on visionary images of medical nanorobots and micro-submarines in media debates, this contribution demonstrates that these images serve as a means of communication between the discourses of science, economy, and the mass media. Through a systems-theoretically and discourse-analytically oriented examination of the pictorial dimension of expectations, this contribution shows that 'communicative spaces' suggested by the images enable productions of meaning for the current potential of nanotechnological innovations between various discourses. The dynamics of expectations within the communication processes can be reconstructed according to the variations of discourse-specific evaluations of the depicted visions.

## Richard Feynmans Vision theologischer Prägung: Etappen einer Geschichte der Mikromanipulation

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**Abstract.** This article detects the sources of Richard Feynman's famous Caltech talk of 1959 referring to the possibilities of writing the Lord's Prayer on the head of a pin and his plea for the improvement of the ability of writing on a small scale. Both of his topics, the finest writing as well as the pin are confronted with their role in the history of microscopy. The analysis reveals the connotations of their use and shows that Feynman's way of visionary thinking had been highly influenced by a historical background of interpreting the microcosm in a religious way.

## Nano-Erlösung oder Nano-Armageddon? Technikethik im christlichen Fundamentalismus

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**Abstract.** This paper argues that the extraordinary excitement about nanotechnology, including exaggerated hopes and fears, first emerged in the US, because it is deeply rooted in the specific religious tradition of that country. Virtually absent in Europe, mainstream Christian fundamentalism in the US has always had a particular relationship both to the future and to technologies, due to its apocalyptic orientation. The recent excitement about nanotechnology is only the latest offspring that comes in the bizarre form of apocalyptic ethics, propagated particularly by influential transhumanists. Attempts at copying the American excitement in Europe, at the expense of philosophical engineering ethics, are likely to be less successful because of the different religious and cultural traditions.

## Die Notwendigkeit einer offenen Nanotechnik

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**Abstract.** Nanotechnology is likely to strongly affect economies and societies worldwide. As a strategy to minimize adverse consequences as well as to enable a broad productive adaptation of nanotechnology and to prevent a global 'nano-divide' I propose a concept of 'open nanotechnology'. This is based on four arguments that I draw from a systems theoretical approach to technology as introduced by Günter Ropohl and from experiences with open source software and open hardware design for a secure diffusion of technology.

## Je breiter die Anwendung, um so gravierender die Konflikte – der Fall des Verteilten Rechnens

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**Abstract.** This contribution deals with the technology of 'ubiquitous computing' to discuss a very general problem of ethics in technology. As much as the extension of possibilities of an application of a given technology grows, as much will the potential for conflicts, i.e. for normative or moral conflicts, grow, too. Particularly this is the case for organizational issues and the concatenation of realms and living contexts that have not been brought together before.

## Nanoethik – eine Neufassung der Debatte

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**Abstract.** Nanotechnology is developing very rapidly and is believed to have the potential of huge upsides and extreme downsides. In the public debate there has been a strong tendency to exclusively focus on the first or the latter. Accordingly ethical assessments of nanotechnology tend to drastically diverge. These fundamentally opposing assessments hold the risk of undesirable clashes and backlashes. In addition, many of these far-reaching views are based on cut down and obsolete visions of nanotechnology being dominated by self-replicating assemblers and nanomachines. For this reason, the present state of the ethical debate on nanotechnology calls for the development of more balanced and better-informed assessments. As a first step in this direction this contribution develops a new method of framing the ethical debate on nanotechnology.

## Nanotechnologie in der Medizin als Gegenstand ethischer Reflexion: Problemfelder, Herausforderungen, Implikationen

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**Abstract.** The article provides an overview of the most important ethical issues of nanotechnological developments in medicine. Whether or not there are ethical issues that are specific to nanotechnology is cautiously answered in the negative; most of the questions that are considered ethically relevant in the context of nanotechnology have already been discussed in several fields of applied ethics. Some of these ethical issues seem to be specifically accentuated by nanotechnology, however. The article includes some considerations concerning basic requirements for a comprehensive ethical investigation of nanotechnology and argues for an inclusion of visionary projects in the analysis of ethical aspects of nanotechnology.

## Minimal-invasive und nanoskalige Therapien von Gehirnerkrankungen: eine medizinethische Diskussion

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**Abstract.** Modern medical technologies open new opportunities for the effective treatment of brain diseases and injuries. But since each intervention into the brain bears the risk of changing the personality of the patient, there are some ethical problems. In this article, the new technologies (surgical, radiosurgical, pharmaceutical, and nanoscaled interventions into the brain) are briefly described. Then two examples of modern brain therapy are discussed regarding medical and ethical issues: the deep brain stimulation for the treatment of Parkinson disease and the Magnetic Fluid Hyperthermia with ferrofluid nanoparticles for the therapy of malignant brain tumors.

## Integrierte Innovation in der Entwicklung der Nano- technologie: Von der Regulierung durch Definitionen zur Orientierung an Dritten Größen

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**Abstract.** The varying definitions of 'nanotechnology' constitute a shaky basis for the dialogue between scientific communities and society. The attempt of the European Academy to define this term introduces a new, constructive approach. By evaluating the more or less certain candidates for 'nanotechnology', this approach inductively develops a limiting criterion: discontinuity on the nanoscale. Critical acknowledgment of this approach, however, necessitates orientation on third terms rather than on definitions. Inside and outside of nanotechnology these third terms provide a sound basis for communication across system boundaries. Developments within nanotechnology can thus, in both inter- and intradisciplinary dialogue, become productive for dealing practically with innovations.

## Disziplinäre Identitätsbildung neu gedacht: Toxikologie als Nanowissenschaft?

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**Abstract.** Focusing on toxicology as a leading discipline that analyzes health implications of nanosciences and nanotechnologies, we study the formation of disciplinary identities. By expanding its disciplinary boundaries, participating within the new research fields, continuing with its previous research and only vaguely shaping its topics, toxicology is searching its way into the new fields without giving up its present self-conception. However, the toxicological research community is also discussing a new positioning that could move toxicology from an auxiliary to a constitutive position to take over a basic role in the field of nanosciences, regarding its cognitive, institutional, and social framing.



# Militärische Nutzung der Nanotechnik: Begrenzung ist nötig

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**Abstract.** New technologies may bring decisive advantages in case of war. It is for this reason that research and development (R & D) is pushed systematically by the armed forces, preparing many new destructive technologies. On the other hand civil society will try to prevent such dangerous applications of technology. The USA spends 4 to 10 times as much as all other countries together for military R & D of nanotechnology. Nanotechnology could be used in all areas of combat and its preparation. In a first purview of potential military applications, some of them have turned out to be particularly problematic in terms of preventive arms control. Limitation is recommended in areas ranging from small sensors via body manipulation to autonomous systems.