Book Review

Schmid et al. (Brune, H.; Ernst, H.; Grunwald, A.; Grünwald, W.; Hofmann, H.; Krug, H.; Janich, P.; Mayor, M.; Rathgeber, W.; Schmid, G.; Simon, U.; Vogel, V.; Wyrwa, D.): *Nanotechnology: Assessment and Perspectives*, Berlin, Heidelberg: Springer, 2006, 492 pp., ISBN: 3-540-32819-X, 106.95 €

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Founded in 1996 the Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen (European Academy of Technology Assessment) is devoted to "the scientific study of the consequences of scientific and technological advance for individual and social life and for the natural environment" (www.europaeische-akademie-aw.de). The Academy is located in Bad Neuenahr-Ahrweiler, close to the former federal capital of Germany, Bonn, and financed by the local state government and the Federal Aerospace Center (DLR) with regular project funding coming from the Federal Ministry of Education and Research. Its main approach consists in identifying important TA issues and setting up corresponding interdisciplinary project groups staffed with invited scholars from academia who regularly meet over a period of several years to produce a report. For the present report, a project group on "Nanomaterials, Nanodevices, Nanocomputing: Determination of Present Position and Perspectives" was established in July 2003, chaired by chemist Günter Schmid and consisting of the 13 authors of the volume as members who are said to have met on a monthly basis up to December 2005. The members appear to be all Germans, although some are located at Swiss and Austrian institutions, with disciplinary backgrounds ranging from chemistry, physics, materials science, and electrical engineering to toxicology, philosophy, and business administration. The goal of the project group was not only "to evaluate the state of the art in nanoscience and nanotechnology", but also to consider "– to some extent – philosophical, ethical, toxicological and, last but not least, economic aspects" (p. IX).

The report has a clear and convincing structure: After a kind of executive summary including recommendations, a general introduction that summarizes the subsequent chapters (chap. 1), and a philosophy of science introduction (chap. 2), the bulk or more than half of the volume consists in a systematic and meticulous survey of selected nanotechnological research fields (chap. 3), to be followed by a patent analysis (chap. 4), discussions of risk analysis and management (chap 5) and ethical aspects (chap. 6), and some brief notes on knowledge transfer (chap. 7). With the exception of chapters 3 and 7, most of the content of the chapters appears to be written each by a single author, who are easy to recognize from the (self-)references and previous publications, despite the alleged collective authorship. This, and the unusually long list of book authors, makes the book another interesting publication experiment in between governmental and NGO reports with anonymously written texts that are quickly posted on the Internet, on the one hand, and academic monographs and anthologies with clear indication of authorship that are sold by academic publishers at tremendously increasing prices with year-long delays, on the other. The academic publisher Springer, who provides an outlet for publications by the Academy with the book series *Wissenschaftsethik und Technikfolgenabschätzung* (Ethics of Science and Technology Assessment), of which the present volume is number 27, seems to be trying out new publication forms – as did Kluwer Academic Publisher when they published an official report by the US National Nanotechnology Initiative in 2002, before Kluwer was taken over by Springer.

Chapter 2 provides an informative introduction to Peter Janich's philosophy of science approach called Methodological Constructivism or Culturalism, which is interesting in its own right, because it includes sharp criticism of naive naturalistic attitudes by scientists, when they, for instance, take scanning probe microscopy as an extension of "seeing nature". The most important conclusion, however, concerns the definition of nanotechnology, according to which functions rather than size, i.e. not the nanometer scale, define the scope of nanotechnology. The definition on which the group seems to have largely agreed says, "Nanotechnology comprises the emerging applications of Nanoscience. Nanoscience is dealing with functional systems either based on the use of sub-units with specific size-dependent properties or of individual or combined functionalized subunits." (p. 62) That definition goes back to an earlier, and undeservedly lesser known, 134-page report by the Academy from 2003 entitled *Small Dimensions and Material Properties: A Definition of Nanotechnology* (www.europaeische-akademie-aw.de/pages/publikationen/graue_reihe/35.pdf). The original 2003 idea was to provide a restrictive and meaningful measure against the arbitrary and ridiculous proliferation of "nanotechnologies" since about 2000, when the nano label became a convenient tool to acquire public funding from hype-driven and hype-driving science policy. According to the 2003 definition, "Nanotechnology is dealing with functional systems based on the use of subunits with specific size-dependent properties of the individual sub-units or of a system of those." (p. 24) The emphasis here is on "size-dependent properties" which excludes the mere miniaturization or scaling-down of systems without any new size-dependent phenomena as well as the bulk of molecular chemistry. That definition refers to the nanoscale only indirectly through quantum theory, which suggests that new size-dependent phenomena happen at this scale. However, the new, 2006 definition, I assume under the pressure of the scientists involved, adds a second branch of nanoscience that is about all "functional systems ... of individual or combined functionalized subunits". Yet, without the intentionally avoided reference to the nanoscale, that definition includes watches, cars, and the like, which illustrates how political compromise can produce conceptual flaws. On the other hand, the science authors in their parts of the report always implicitly presuppose the nanoscale and frequently deal with "mere" miniaturization (e.g., much of section 3.2 and all of section 3.4), because that is what scientists nowadays call nanotechnology.

Despite this conceptual shortcoming on the definitional level, the survey of nanotechnological research fields in chapter 3 stands out because of its conceptual clarity and systematics, which in turn is summarized and explained in three fold-out tables (pp. 71-2, 145-6, 199-200). The survey focuses on the selected fields of materials (3.1), digital information storage systems (3.2), biomedical applications, including diagnostics, drug delivery systems, and tissue engineering (3.3), and scaling effects such as the lotus effect and antireflective coatings (3.4). That selection is defended first on the grounds of the report's definition of nanotechnology (with the exceptions mentioned above) and secondly on what the authors consider particularly important. To illustrate the systematics, the section on materials examines size-dependent properties in the magnetic, electric, optical, thermodynamic, etc. regimes each for metals, semiconductors, insulators as well as for molecular and other engineered nanoscale systems; the section on information storage follows a matrix in which electric, magnetic, optical, and mechanic signals each function as stimulus and retrieval signals. However, not every section is written with the same clarity and eloquence, and some sections, particularly on chemical topics, appear to be written for peers rather than for the general audience that the volume aims to address.

The chapter on "commercial perspectives" (chap. 4), which I find the poorest one, is solely based on the analysis of past patents from 1983-2000/2002 and the assumption that patent dynamics reflect funding and therefore commercial interests in specific research areas from which extrapolations to the future ("perspectives") could legitimately be drawn. It would be easier, of course, to skip the patents and directly focus on funding, for which more up-to-

date data is available, as did for instance Lux Capital in their *Nanotech Reports*, who once proudly announced that they would have been "the first to recommend following government funding". Furthermore, the patent analysis struggles with the project group's own definition of nanotechnology, because patent searches with keywords derived from the definition and the survey in chapter 3 "showed that too many patents not related to Nanotechnology were found" (p. 299). As an ad hoc remedy, the authors restricted these patents by adding the search term "nano", of which by now anyone working in bibliometrics knows that it selects linguistic fads rather than specific research fields. Based on their findings the authors conclude that Europe is strongly lagging behind the US and Japan in almost any field of "nanotechnology" of commercial interest, a conclusion that frequently appeared *mutatis mutandi* in earlier US nanotechnology reports. The whole focus on an imagined nanotechnology competition between Europe, US, and Japan, which goes back to the rhetoric of pre-2000 US reports that were written to convince policy-makers of the need of a national nanotechnology initiative, completely ignores leading research countries like China and South Korea. While the chapter is packed with what are obvious self-references, there are neither references nor comparisons to the numerous other published patent analyses.

Chapter 5 starts with introducing a three-component risk analysis model, including risk assessment, risk management, and risk communication, but excluding issues of political and legal implementation. The authors then apply this model to nanotechnology, with specific focus on nanoparticles. Section 5.2 on risk assessment provides a survey of the state of the art (by 2004) of nanoparticle toxicology, largely concluding that we don't know much yet. Based on this conclusion the section on risk management develops a sophisticated analysis of the precautionary principle (PP), arguing that the principle requires a two-step approach that each assesses the available knowledge. The first step decides on whether there is "reasonable concern" (p. 376) about nanotechnology to apply the principle, which the authors think is the case with regard to possible nanoparticle toxicity. The principle then requires, according to the authors, at first further toxicological research to improve the knowledge basis and, secondly, a decision on adequate regulatory measures that must be based on the assessment if there is sufficient "reason for serious concern" (p. 376) in a "case by case and step by step procedure" (p. 378). They conclude that "the existing measures of regulation *need not to be extended* for dealing with possible nanoparticle risks" (p. 378, emphasis in the original) because "treating nanoparticles as new chemicals seem to be the adequate risk management approach" (ibid.).

I am not sure if that conclusion is based on a misunderstanding or linguistic ambiguity. It is clear that sensible chemists in their laboratory research deal (and should deal) with new nanoparticulate forms of known chemical composition in a precautionary way *as if* these materials were new chemicals. However, all our *legal* regulations of chemicals and workplace safety do not. They treat nanoparticles of known chemical composition as old chemicals, because they totally ignore the size, shape, and surface of particulate materials, wrongly assuming that they have no impact on the properties of materials. Thus, scientists take the precautionary measures in their laboratory for the sake of self-protection which our legal regulations exactly omit for the public sphere. That is the well-known regulatory gap – or scandal, if you want – which the present risk analysis blurs rather than clarifies.

Chapter 6, which I find the strongest one, although it ignores more recent publications, discusses ethical aspects of nanotechnology broadly construed. It starts with a general discussion of ethics of technology, arguing that philosophical ethics deals with normative conflicts only if standard procedures of societal decision-making fail. Against this background, the authors ask if there are any genuinely ethical issues that are new and specific to nanotechnology. Based on the analysis of the literature by 2003, they identify six possibly relevant issues, which are (1) chance/risk assessment of nanoparticles, (2) inter- and intragenerational justice regarding the distribution of opportunities and risks, (3) privacy, (4) risk issues in medical applications, (5) crossing the border between technology and life, and (6) human enhance-

ment. They argue that while none of these issues are really new and specific to nanotechnology, nanotechnology makes them more urgent, particularly the issues 5 and 6. From that the authors conclude that there is no need for both a specific "nanoethics" and the fear of ethically motivated public objection to nanotechnology.

Finally, section 6.4 (along with section 5.4 on risk communications) provides an interesting introduction to Armin Grunwald's approach of vision assessment. It distinguishes futuristic visions from both fantastic visions and technological goals and argues that, despite their unlikely feasibility, such visions should be taken seriously because they can have a strong impact on public debates and decision-making in an unforeseen manner. Utopian visions, which serve various needs at the science/society interface, can, because of their inherent ambivalence, quickly turn into distopian visions and cause frustration and mistrust. In analogy to risk analysis, the authors suggest a three-step approach of analyzing, evaluating, and managing visions in order to responsibly deal with futuristic visions in the public.

The volume would have deserved more editorial care by the authors, Academy staff, or publisher (or whoever feels responsible in the production of such kinds of hybrid publication that lacks a volume editor). The quality and style of the English greatly vary from chapter to chapter, cross-references are frequently misleading, perhaps referring to earlier versions of the volume, and sometimes whole paragraphs have been pasted twice into different chapters. A subject index would have been useful to readers as would have been a more detailed introduction that points out more clearly the particularity of the report compared to the numerous other existing reports on nanotechnology and which integrates the various chapters rather than just listing abstracts and copying some "Roco rhetoric". The ten recommendations at the beginning of this volume (support knowledge transfer, patenting, interdisciplinary research, basic research, university research, toxicology research, public information, ELSI "activities", postgraduate multidisciplinary education, and the group's own definition of nanotechnology) are, save the last one, all well known from other reports, although some are, by academic standards, only poorly substantiated by the content of this report. Compared to both academic publications and governmental reports, I find the experimental form of a hybrid publication not very convincing.

The strengths of this volume are clearly its attempt to focus on a more restricted notion of nanotechnology, even if that is not always consistent and successful, and the systematics behind chapters 3, 5, and 6. Thus, readers from different backgrounds will particularly benefit from systematic introductions to core nanotechnologies as well as to risk analysis and ethical issues.