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SOCIAL, HEALTH AND ETHICAL IMPLICATIONS OF NANOTECHNOLOGY

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1 Introduction

Nanotechnology will have broad applications across all fields of engineering, so it will be an amplifier of the social effects of other technologies. There is an especially great potential for it to combine with three other powerful trends – biotechnology, information technology, and cognitive science – based on the material unity of nature at the nanoscale and on technology integration from that scale [1]. It will be important to integrate social and ethical studies into nanotechnology developments from their very beginning. Technically competent research on the societal implications of nanotechnology will help give policymakers and the general public a realistic picture free of unreasonable hopes or fears.

Nanotechnology is a booming technology that swiftly has entered society. Amongst the many nano-technological products already available on the market are - besides technological devices in cars, computers and the like – food, health and beauty products. Nanotechnology as a term has not been very prominent in public discourse, although its connotation is rather positive. [2]

In 2002, the US National Nanotechnology Initiative awarded only $280,000 — 0.04% of its budget of $697 million, to study the social and ethical implications of nanotechnology. None of this money was allocated to studying risk perception [3]. However, knowledge worldwide is not yet substantiated enough to permit statements about health-related or environmental impacts of nanotechnological products [2]. We lack reliable data and possible risks and need more in-depth (and in particular long-term) investigations into environmental and health impacts.

A US report named “Nanotechnology in agriculture and food production: anticipated applications”, for the first time analyzes the publicly available data on federally funded research projects in agrifood nanotechnology, supplemented with data from the U.S. Patent and Trademark Office [4]. Written by Jennifer Kuzma and Peter VerHage from the University of Minnesota's Center for Science, Technology, and Public Policy, the report estimates possible areas and timeframes for future nanotechnology-based food and agriculture applications. It takes an early look at potential benefits and risks, and it explores possible areas and needs for environmental, health and safety oversight. Their work also resulted in creation of a searchable, online database with over 160 research projects available at: http://www.nanotechproject.org/50.

2 Social Implications of Nanotechnology

After sociologist Etzkowitz [5] the social sciences can play three different but mutually supportive roles in the development of nanotechnology:

1. Analyzing and contributing to the improvement of the processes of scientific discoveries that increasingly involve organizational issues where the social sciences have a long-term research and knowledge base.

2. Analyzing the effects of nanotechnology, whether positive or negative, expected or unintended, hypothetically and proactively and as they occur in real-time.

3. Evaluation of public and private programs to promote nanoscience and nanotechnology.

In the year 2000, the US National Science and Technology Council sponsored a major workshop at the National Science Foundation, which led to a published report, Societal Implications of Nanoscience and Nanotechnology [6]. About the involvement of social scientists in nanotechnology, it says “It is important to include a wide range of interests, values, and perspectives in the overall decision process that charts the future development of nanotechnology. Involvement of members of the public or their representatives has the added benefit of respecting their interests and enlisting their support. The inclusion of social scientists and humanistic scholars, such as philosophers of ethics, in the social process of setting visions for nanotechnology is an important step for the National Nanotechnology Initiative. As scientists or dedicated scholars in their own right, they can respect the professional integrity of nanoscientists and nanotechnologists, while contributing a fresh perspective. Given appropriate support, they could inform themselves deeply enough about a particular nanotechnology to have a well-grounded evaluation. At the same time, they are professionally trained representatives of the public interest and capable of functioning as communicators between nanotech-nologists and the public or government officials.

Their input may help maximize the societal benefits of the technology while reducing the possibility of debilitating public controversies.

3 Health Implications of Nanotechnology

Roblegg and coworkers from the Nanonet Styria, an Austrian Nanotechnology Network, published a report on health risks of nanotechnology [7]. This report stresses the need for long-term studies on health implications of nanotechnology.

Oberdörster *et al.* showed in animal experiments that there is translocation of inhaled ultrafine particles (smaller than 100nm) along the olfactory nerve into the olfactory bulb in the brain [8]. The significance of this study for humans, however, still needs to be established. The translocation of particles along nerve fibers could provide a portal of entry into the central nervous system for solid ultrafine particles, circumventing the tight blood–brain barrier. Whether this translocation of inhaled ultrafine particles can cause central nervous system effects needs to be determined in future studies.

There are currently no studies on the behaviour of nanoparticles in cosmetics products. Nanoparticles are for example found in sunscreen products and in skin creams. Long term studies are necessary, since currently, the US Food and Drug Administration, the FDA, as well as the Scientific Committee on Cosmetic Products and Non-Food Products intended for Consumers of the European Commission regard nanoparticles in cosmetics as a variation of the bulk material, ignoring possible non-scalable size effects. There is currently to need to perform time consuming and expensive toxicological tests.

There was a similar situation regarding chiral pharmaceuticals. Left- and right-handed isomers (enantionmers) of the same molecule used to be regarded by the FDA as the same component. An impressive (and tragic) example on how different the enantiomers of the same molecule can act in the human body was given by the substance Thalidomide. Thalidomide was sold in some countries under the name Contergan. One enantiomer of Thalidomide is effective against morning sickness (this is why it was administered to pregnant women). The other enantiomer is teratogenic, and causes birth defects (approximately 10 000 “Contergan babies” were born in the 1950s and 1960s). The enantiomers are converted to each other *in vivo* – that is, if a human is given (R)-thalidomide or (S)-thalidomide, both isomers can be found in the serum – therefore, administering only one enantiomer will not prevent the teratogenic effect in humans. At the end of the 1990s a paradigm shift took place in the FDA and today, left- and right-handed isomers of pharmaceuticals are treated as two different substances [9].

4 Ethical Implications of Nanotechnology

Ethical questions related to nanotechnology are not limited to the ways people might use it to harm others intentionally, but also include obligations to avoid potentially harmful unintended consequences [10].

The best way to reassert the truth-oriented professional norms of science would be to rebuild good channels of communication and cooperation, reattaching the researchers to each other and to the scientific community.

In a special issue on “Nanotech Challenges” of the HYLE International Journal for Philosophy of Chemistry, Lewenstein attempts to answer what counts as an ethical issue in nanotechnology. He concludes that the attempts to define ethical issues narrowly is itself an exercise of power that can prevent us from understanding how central ethical issues are to the development of scientific knowledge and its implementation through technology in the modern world [11].

An interesting platform to follow the current discussion on ethics in nanotechnologxy can be found on http://www.ethicsweb.ca/nanotechnology/.

Excellent work on nanotechnology ethics, including technical standards and policies, has been compiled by the Foresight Institute (http://www.foresight.org/). See also the “The Center for Responsible Nanotechnology” (http://crnano.org/), a non-profit organization, formed to advance the safe use of molecular nanotechnology.

Given below are some possible ethical guidelines for nanotechnology, to stimulate discussion in this field:

* Nanotechnology's highest and best use should be to create a world of abundance where no one is lacking for their basic needs. Those needs include adequate food, safe water, a clean environment, housing, medical care, education, public safety, fair labour, unrestricted travel, artistic expression and freedom from fear and oppression.

* High priority must be given to the efficient and economical global distribution of the products and services created by nanotechnology. We recognize the need for reasonable return on investment, but we must also recognize that our planet is small and we all depend upon each other for safety, stability, even survival.

* Military research and applications of nanotechnology must be limited to defense and security systems, and not for political purposes or aggression. And any government-funded research that generates useful non-military technological advances must be made available to the public.

* Scientists developing and experimenting with nanotechnology must have a solid grounding in ecology and public safety, or have someone on their team who does. Scientists and their organizations must also be held accountable for the willful, fraudulent or irresponsible misuse of the science.

* All published research and discussion of nanotechnology should be accurate as possible, adhere to the scientific method, and give due credit to sources. Labeling of products should be clear and accurate, and

promotion of services, including consulting, should disclose any conflicts of interest.

* Published debates over nanotechnology, including chat room discussions, should focus on advancing the merits of the arguments rather than personal attacks, such as questioning the motives of opponents.

* Business models in the field should incorporate long-term, sustainable practices, such as the efficient use of resources, recycling of toxic materials, adequate compensation for workers and other fair labour practices.

* Industry leaders should be collaborative and self-regulating, but also support public education in the sciences and reasonable legislation to deal with legal and social issues associated with nanotechnology.

5 Conclusions and Outlook

Increased spending on pertinent research has resulted in the establishment of broad technological expertise and in a substantial number of important projects in the field of nanotechnology. However, currently there is a lack of capacity with regard to aspects of risk and health-related, environmental and societal implications of nanotechnology. In accordance with the Institute of Technology Assessment of the Austrian Academy of Sciences we propose to earmark a certain part (minimum 5%, as a guideline) of the special funding for nanotechnology for risk research and accompanying measures [2].

Ultimately, the test of the various nanotechnologies will be their benefit for human beings, as measured by economic growth, improved health and longevity, environmental protection, strengthened security, social vitality, and enhanced human capabilities.

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