Nanotechnology Challenges: Implications for Philosophy, Ethics and Society

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INTRODUCTION

Nanotechnology is a recently emerging and rapidly growing field whose dynamics and prospects pose many great challenges not only to scientists and engineers but also to society at large. Since forecasts of nanotechnology range from the next industrial revolution to severe threats to humanity, nanotechnology has already created enormous social disturbance. While the promises of nanotechnology have been exaggerated toward quasi-religious visions of a posthuman state of Salvation, the perception of risks also have been exaggerated, some to the level of apocalyptic doom-saying. Researchers in nanotechnology increasingly feel embarrassed by both public expectations and public mistrust; increasingly large parts of the public feel uncertain about the uses and abuses of science and technology; and science policy makers and administrators begin to worry if they still have control over the process they once initiated by launching huge nanotechnology programs.

All that poses great challenges to those whose profession is to reflect on science and technology and their place in society. This volume includes the state-of-the-art philosophical, ethical, and sociological reflection on nanotechnology. Rather than being a simple policy guide, it seeks first of all understanding of the philosophical, ethical and societal issues of nanotechnology. It unravels the philosophical underpinnings of nanotechnology, its metaphysical and epistemological foundations, and its conceptual complexity. It explores the ethical issues of nanotechnology, its impact on human, environmental, and social conditions, and the options for reasonable risk management. It examines the public discourse on nanotechnology and its related visions and provides both lessons from the past and outlooks into the future.

Nanotechnology has already impacted society by virtue of its visionary character and will do so more by means of its commercial products. And society has from the very beginning shaped nanotechnology through visionary ideas, science fiction stories, and innovative research and funding programs. Finally, the public relation and public debates have tried to

keep up with these interactions between nanotechnology and society. As with all technologies, the future shape of nanotechnology – or nanotechnologies – will result from these interactions between human beings, with their creative minds and skills, their hopes and fears, and their values, interests, and power relations. The more we understand these interactions, the more we understand current and future nanotechnology, and the more are we able to shape it in a desirable and human way.

Since early 2003 the editors have organized biannual international conferences in the U.S. and Europe that have for the first time brought together scholars from the humanities, social sciences, natural sciences, and engineering to discuss interactions between nanotechnology and society.[1] Although the international community of this field, called nano-Science and Technology Studies (^{n}STS), is a recent arrival, it is now growing almost as fast as nanotechnology itself. In addition, numerous committees, expert groups, and centers have been founded, and the number of reports has grown accordingly. During periods of rapid change, it is important to provide space for well-informed and independent views that might not always be welcome in commissioned reports. To that end, we have published four special issues of the two journals we edit, *Hyle: International Journal for Philosophy of Chemistry*, and *Techne: Research in Philosophy and Technology*. The combined papers of these special issues are reproduced in this volume. They are written by leading scholars from the humanities and social sciences in North America and Europe, covering a wide spectrum of disciplines, including philosophy, ethics, sociology, history of science, literature studies, economics, innovation studies, and science.

The volume is divided into three parts, on (1) philosophical, (2) ethical, and (3) societal issues of nanotechnology. Each part is divided into sections and chapters that we briefly summarize below.

(1) *Philosophical Issues:* The first part, on philosophical issues, focuses on philosophy of science, metaphysics, epistemology, and com-

[1] A selection from the first pair of conferences has been published in Davis Baird, Alfred Nordmann & Joachim Schummer (eds.): *Discovering the Nanoscale,* IOS Press, Amsterdam, 2004.

plexity. It starts with a section on what might be the most provocative challenge for scientists, the Drexler challenge. Two chapters compare chemical approaches to molecular manufacturing with nanotechnology in the sense of its visionary founder, Eric K. Drexler. BERNADETTE BENSAUDE-VINCENT explores the fundamental metaphysical differences between both approaches, particularly in their different notions of molecular machines and living systems. By analyzing the well-known Drexler-Smalley debate, OTÀVIO BUENO points out that these approaches are fundamentally incommensurable because they differ on the conceptual, methodological, and theoretical grounds.

The second section examines metaphysical issues of nanotechnology, particularly its relation to nature. ALFRED NORDMANN argues that, because some areas of nanotechnology resist our capacities of experience and imagination, they provoke a mixture of awe and abhorrence similar to "brute nature". Thus, they undermine the classical idea of controlling nature. GREGOR SCHIEMANN further discusses the distinction between nanotechnology and nature and suggests ways in which artifacts like nanotechnological machines and biological systems can be both distinguished and related to each other. CYRUS MODY critically analyzes the various arguments for technological determinism, according to which nanotechnology would, like a living system, unfold its own logic and completely transform the world beyond human control.

Section three addresses epistemological questions that arise from the imaging techniques that allowed nanotechnology to emerge. Several images of nanoscale structures have even become public icons of the field. In his epistemological analysis of scanning electron microscopy (SEM), JOSEPH PITT argues that, although SEM plots convey exact information, they should not be called images because they are not exact representations of reality. JOCHEN HENNIG documents the history of how data from scanning probe microscopy has been transformed into images of the nanoscale, and thus helps us understand how we – scientists and the broader publics – 'see' and comprehend the nanoscale.

The forth section deals with the complexity of nanotechnology both regarding its interaction with society and the various research fields involved. MARC DE VRIES develops a comprehensive systematics that, rather than taking nanotechnology as a complex whole, distinguishes be-

tween fifteen aspects, including physical, biotic, psychological, social, economic, ethical, and religious aspects, each with their own issues. In order to extrapolate future trends from the current research dynamics, MARTIN MEYER and OSMO KUUSI analyze the various research fields of nanotechnology according to technological paradigms.

(2) *Ethical Issues:* Although most ethical issues are clearly related to societal issues, and many of the chapters in the second and third parts of the book deal with both, not all societal issues are ethical issues. Furthermore, sociological analysis is not the same as an ethical analysis. Thus, the second part of this volume is primarily devoted to ethical issues, whereas the third part focuses on broader societal issues.

Section five provides a comprehensive analysis of what may count as ethical issues of nanotechnology through the complementary perspectives of social ethics and environmental ethics. BRUCE LEWENSTEIN, after surveying the social and ethical issues discussed in pertinent governmental reports on nanotechnology, argues that all these issues refer to principles of social and political ethics, such as fairness, justice, and power. CHRISTOPHER PRESTON analyzes nanotechnology from the different point of view of environmental ethics, and examines how to analyse projects and visions such as the creation of new materials, uncontrollable replicators, human enhancement, and material abundance.

As nanotechnology explores the unknown, we must carefully analyze, assess, and manage its potential opportunities and risks, including the way we perceive and handle them. The three chapters of section six deal with that topic. LOUIS LAURENT and JEAN-CLAUDE PETIT analyze the perception of risks in recent controversies about nanotechnology and argue that, while these concerns are culturally grounded, we need public forums to manage these controversies in an effective and responsible way. JEAN-PIERRE DUPUY and ALEXEI GRINBAUM develop an approach to project nanotechnology and its societal and ethical interactions into the future by the recursive inclusion of predictions of our nanotechnological future. SVEN OVE HANSSON provides a new analysis of how to think about the risks and benefits posed by nanotechnology, where, instead of approaching this issue from standard probabilistic risk assessment, one assesses arguments for the mere possibility of future harms or benefits.

(3) *Societal Issues:* At this point in time, the societal issues of nanotechnology are all tied to futuristic and visionary stories about nanotechnology. These have generated hype as well as public hopes and fears. Section seven takes a closer look at such stories and their authors. In his comparative analysis of Eric Drexler's visionary founding book of nanotechnology – *Engines of Creation* – and a report on nanotechnology by the U.S. National Science Foundation, JOSÉ LOPÉZ demonstrates that both texts employ classical tropes of science fiction to jump from current research to a promising future. ARNE HESSENBRUCH analyzes the emotional content in public material produced by a nanotechnology research group and argues that this plays an important role in the struggle for funding and is a driving factor in the creation of hype.

The final section investigates how the public might react to such nanotechnology visions. CHRIS TOUMEY compares the role of hyperbole in the public understanding of nanotechnology with that of previous technological developments (cold fusion and recombinant DNA). He draws lessons about how nanotechnology might be received in the future. Taking the recent public discourse on "societal and ethical implications of nanotechnology" as another forum for expressing nanotechnology visions, JOACHIM SCHUMMER analyzes the actors and the dynamics of that discourse and warns that it could lead to a major anti-science backlash.

In the late 18th century, the German philosopher and scientist Georg Christoph Lichtenberg wrote his well-known aphorism: "Those who understand nothing but chemistry, don't even understand chemistry". As scientists increasingly move towards engineering practice, the aphorism would nowadays read, "Those who create nothing but nanotechnology, don't even create nanotechnology". Rather than being a creation only by ingenious scientists and engineers, nanotechnology is the result of complex societal interactions. The failure to recognize this could easily lead to creations that, after the preliminary hype-cycle, will move into unintended directions, or end up in oblivion.

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