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Nanoscale

Issues and Perspectives for the Nano Century

Edited by Nigel M. de S. Cameron and M. Ellen Mitchell

NANOSCALE

ISSUES AND PERSPECTIVES FOR THE NANO CENTURY

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"Now nanotechnology had made nearly everything possible, and so the cultural role in deciding what should be done with it had become far more important than imagining what could be done with it."

—Neal Stephenson, *The Diamond Age or a Young Lady's Primer* (1995)

"Each new power won *by* man is a power *over* man as well. Each advance leaves him weaker as well as stronger. In every victory, besides the general who triumphs, he is a prisoner who follows the triumphal car . . . *Human* nature will be the last part of Nature to surrender to Man. The battle will then be won. We shall have "taken the thread out of the hands of Clotho" and be free henceforth to make of our species whatever we wish it to be. The battle will indeed be won. But who, precisely, will have won it?"

—C. S. Lewis, *The Abolition of Man* (1943)

"[T]he discoverer of an art is not the best judge of the good or harm which will accrue to those who practice it."

—Plato, *Phaedrus* (c. 370 BC)

"Science Finds, Industry Applies, Man Conforms"

—Motto of Chicago World's Fair, 1933–34 (Century of Progress Exposition)

PREFACE

Most Americans have not yet heard of nanotechnology, and many of those who have cannot offer a working definition of the term. This low profile is anomalous, disconcerting, and destined, before long, for a correction that could be dramatic in nature. It can, perhaps, be explained by a combination of low public interest in science and science policy in general, the recent dominance of the science space by the stem-cell and cloning debates, the wide variety of applications of nanoscale research, and the fact that there is not—yet—a significant political constituency with an interest in critiquing, or at least monitoring, the very extensive federal funding of work on the nanoscale.

Nevertheless, the broad social implications of this new wave of technology have been recognized in the funding process. When President Bush signed the 21st Century Nanotechnology Research and Development Act (the Act) in December of 2003, a sum of $3.7 billion was designated for nanoscale research over a period of 4 years. This federal largesse, now running in excess of $1 billion a year, is being distributed across more than 20 different agencies, with the National Science Foundation (NSF) as lead. The National Nanotechnology Initiative (NNI) is monitored by congressional reporting requirements and a supervisory committee designated by the President—a role that has been assigned to the President's Council of Advisors on Science and Technology (PCAST) in the White House Office of Science and Technology Policy.

The Act specifies the need to fund nano-related ethical, legal, and societal issues (NELSI) research in addition to work on the technology itself, in a manner that parallels the ELSI (ethical, legal, and societal issues) program established under the human genome project, the last major publicly funded science venture in the United States.

The human genome project was developed with the awareness that issues of science and technology cannot be pursued in isolation from their broader implications for society. The ethical, legal, and social issues raised by new technologies must be addressed in parallel, both to ensure that pitfalls unforeseen by scientists will be addressed in good time, and to help build public confidence in the technologies themselves. Alongside the NELSI issues, questions of environment, health, and safety (EHS) have also been singled out for research, as well as the need to review workforce implications and permeate the educational system with an understanding of this emerging technology and training of tomorrow's scientists.

What, then, are the fundamental questions raised by nanotechnology? At least three distinct areas of concern can be identified.

First, there are concerns about its safety. A recent report by Swiss Re, the world's largest reinsurance company, draws attention to substantial risk issues involved in this new technology that have yet to be assessed.[1]

Second, there are concerns about the impact on the way we lead our lives. For example, one prospect is of miniaturized RFID (radio frequency ID) transponders that would enable the location of each of us to be pinpointed. Technologies that have many beneficial applications can also pose new threats to social values like privacy, and, while not requiring their development, may suggest new directions for the culture. Another aspect of ethical concern is the so-called nano-divide, in that the new capacities that this technology may be expected to provide (e.g., in healthcare and many other fields) will not come without costs that could deepen economic divisions within and between nations.

Third, there are concerns about the capacity of nanotechnology to reshape human nature itself. Early NSF documents have framed development of nanotechnology in the context of the "convergence" of nanotechnology, biotechnology, information technology, and cognitive science (together referred to as NBIC), with a view to the "improvement" of "human performance." While some in the nano community downplay these capacities and others have exaggerated their significance, there is no doubt that a major strand of social concern relates to the potential employment of nanoscale products to effect changes to basic human capacities. The 2003 Act singles out the development of artificial intelligence and the enhancement of human intelligence as key issues of concern.

In 2000, the same year as the NNI was established, Bill Joy, cofounder and for many years chief technologist at Sun Microsystems, emerged as an early cultural critic of nanotechnology in his essay, "Why the Future Doesn't Need Us," published in the premier new technology monthly *Wired*.[2] Joy's argument was that nano, together with genomics and robotics, has the potential to eclipse human nature—either through an accident that destroys the species, or through human choices that lead to the supremacy of a nonhuman form of life. While his remarks may represent far-fetched projections of the future ungrounded in current data, they accurately reflect that nanotechnology can be applied to virtually anything because it refers only to scale and it may have the potential to transform every aspect of life, perhaps even the nature of *Homo sapiens* itself, at some fundamental level. Sifting the truth from the hype is difficult. Mihail C. Roco of the NSF, who has been the most influential voice in U.S. nano policy, has written:

> The vision of the NNI includes a path to discoveries of new properties and phenomena at the nanoscale, working directly at the building blocks of matter with cross-cutting approaches and tools applicable to almost all man-made objects, and development of highly efficient manufacturing. This is completed by the promise of better

[1]Annabelle Hett. 2004. Nanotechnology: Small Matter Many Unknowns. Swiss Re.
[2]Bill Joy. April 2000. Why the Future Doesn't Need Us. Wired Magazine 8.04.

comprehension of nature, increased wealth, better healthcare and long-term sustainable development.[3]

Perhaps the greatest challenges facing our society lie in our assessment of these projections, our management of the expectations they create, and our development of judicious policy approaches to the technology options that may result.

The essays that follow have been selected with the purpose of contributing to what we believe will be one of the greatest of all public debates. A debate that will benefit from full discourse that includes both information and opinion. While there is naturally some overlap between the two, they fall broadly into complementary categories: opinion pieces by visionaries, boosters and critics; and reviews of key areas of ethical, legal, and societal questions. These chapters are rife with strong opinion and new knowledge, and we invite you to use this volume to fuel the conversation.

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[3]Mihail C. Roco. Based on a presentation made at Cornell Nanofabrication Center, September 15, 2000. Available at: http://www.nsf.gov/crssprgm/nano/reports/roco_vision.jsp.

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