NANOSCALE

ISSUES AND PERSPECTIVES FOR THE NANO CENTURY

Edited by

Nigel M. de S. Cameron
Center on Nanotechnology and Society
Illinois Institute of Technology
Chicago, Illinois

M. Ellen Mitchell
Institute of Psychology
Illinois Institute of Technology
Chicago, Illinois
NANOSCALE
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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)
CONTENTS

Preface xvii
Acknowledgments xxi
Contributors xxiii

PART 1: POLICY AND PERSPECTIVES 1

1. The View from Congress: A Roundtable on Nanopolicy 3
   U.S. Congressman Mike Honda, U.S. Congressman Brad Sherman,
   U.S. Congressman David Weldon, and Marty Spitzer

   Marty Spitzer 3
   U.S. Congressman David Weldon 6
   U.S. Congressman Brad Sherman 8
   U.S. Congressman Mike Honda 10

2. Nanotechnology and the Two Faces of Risk from a Reinsurance
   Perspective 15
   Annabelle Hett

   The Different Approaches to Risk 16
   A New Kind of Risk 17
   No Future Without Risk 18
   Risk is Knowledge of Possible Losses 18
   Insurance is No Substitute for Safety 19
   Warn Earlier, React Faster 19
   Prophecies of Doom are of Little Use 20
   Risks are a Matter of Definition 21
   Many Causes, Many Perpetrators, No Liability? 21
   What to Believe—or Whom to Believe 22
   Faint Signals? 23
   The Challenge of Risk Assessment 23
Public Perception of Risk 24
Fright Factors 24
Better Safe than Sorry 25
Toward Sustainability 26
Bibliography 26

3. Ethics, Policy, and the Nanotechnology Initiative:
The Transatlantic Debate on “Converging Technologies” 27
Nigel M. de S. Cameron

Roots of Controversy 27
“Converging Technologies” Terminology as a Reflection of Policy 28
European Commission Response 29
Defining Converging Technologies 30
Converging Technologies and the Social Order 32
Risk Management 34
Embedding Converging Technologies Policy 35
Upstream Participation and Agenda Setting 36
Ethics and Social Context 37
International Standards 39
Conclusions 40

4. Scientific Promise: Reflections on Nano-Hype 43
M. Ellen Mitchell

The Role of Expectations in Processes and Outcomes 44
Linear Causal Models 48
Perfection 50
Elusive Truth 52
Scientific Knowledge 53
The Role of Beliefs 56
The Case for Reason, Stability, and Interdisciplinarity 59

5. Beyond Human Nature: The Debate Over Nanotechnological Enhancement 61
James Hughes

Nanotechnology Threatens Humanness? 61
Unhelpful Ontological Concreteness in Human Cognition 62
Human Nature has No Clear Definition 63
Human Nature: No Clear Beginning and No Clear Boundary with Other Species 64
Human Nature has No Clear Ending 64
Human Nature is Not Normative 65
The Inescapable Racism of the Human Nature Concept 66
The Violent Potential of the Human Racists 68
Beyond Human Nature: The Need for a Broad Normative Range for Acceptable Human Enhancement

6. Nanotechnology Jumps the Gun: Nanoparticles in Consumer Products
   Brent Blackwelder
   The Procedures Used to Determine Products Containing Nanoingredients
   Why Size Matters
   Health Risks
   Failure to Conduct or Publicize Health Studies
   Status of Regulations on Nanotechnology
   Research and Funding of Nanotechnology Safety
   Conclusions

7. Nanotechnology: Maximizing Benefits, Minimizing Downsides
   Jacob Heller and Christine Peterson
   Innovation
   Government Financing of Nanotech Research and Development
   Intellectual Property Issues and Nanotech
   Regulation
   Nanoparticle Safety
   Human Enhancement
   Export Controls
   Implications
   Poverty and Disparity
   Surveillance
   Conclusions

8. Reasoning About the Future of Nanotechnology
   Ruthanna Gordon
   Counterfactual Reasoning
   Time Orientation
   Biases in Prediction and Planning
   Conclusions
   Bibliography

   Jerry C. Collins
   Ancient and New Nanotechnology
   Smaller and Smaller
The Faustian Bargain and Stem-Cell Research 117
Learning is a Painful Process 118
Current Issues in Nanotechnology 121
Ethical Arguments for Nanotechnology and Biotechnology 121
Is Rational Public Discussion of Nanotechnology Possible? 123
Teach It to Our Children 125
Nanotechnology in High School: A Case Study 126
Conclusions 127

10. Technological Revolutions: Ethics and Policy in the Dark 129

Nick Bostrom

Ethical, Legal, and Societal Issues Research, and
Public Concerns About Science and Technology 130
Unpredictability 133
Strategic Considerations in S&T Policy 137
Limiting the Scope of Our Deliberations? 141
Expanding the Scope of Our Deliberations? 145
Bibliography 150

PART 2: NANO LAW AND REGULATION 153

11. Regulating Nanotechnology: A Vicious Circle 155

Sonia E. Miller

The Regulatory System 157
The Rhetoric Behind Nanotechnology 158
Nanotechnology: Is It Legal? 160
Nanotechnology: A Market Force? 162
Public Perception: The Vicious Circle—Part I 163
A New Law for Nanotechnology? 165
Congressional Reaction: The Vicious Circle—Part II 166
The Vicious Circle: Part II—Conclusions 171
Regulatory Uncertainties: The Vicious Circle—Part III 172
EPA 172
TSCA 172
FIFRA 173
CERCLA 175
RCRA 176
CWA 176
CAA 177
EPA Conclusion 178
FDA 179
CPSC 182
NRC 183
12. The European Approach to Nanoregulation

Trudy A. Phelps

The Legislative Focus

The New Approach and the Importance of Harmonized Standards

Who Needs What?

Industry

Government Agencies

Insurance Industry

Retail Organizations

Academia

Media

Standardization

The Need for Standards

European Standards Committee: CEN/TC 352 Nanotechnologies

The Role of Research in Standardization

The Royal Society Report and the Government Response

Industrial Applications

Health and Safety in the Workplace

Explosive Hazard

Environment

End of Life and the Waste Stream

Voluntary Reporting Scheme

Consumer Products

Food and Food Packaging

Cosmetics and Sunscreens

Medicinal Products (Medicines) and Medical Devices

Ethical, Legal, and Societal Issues

Public Dialogue

Intellectual Property

Military Uses of Nanotechnology and Other Security Risks

Conclusions

13. The Potential Environmental Hazards of Nanotechnology and the Applicability of Existing Law

George A. Kimbrell

Nanotechnology and Nanomaterials: The Future is Now

On the Loose: Manufactured Nanomaterials in Nature

A New Class of Nonbiodegradable Pollutants

The Potential Environmental Impacts of Nanomaterials
Mobility/Absorption and Transportation of Pollutants 218
Durability/Bioaccumulation of Nanomaterials 219
Detection/Removal 219
The Case of Carbon Fullerenes 220
Applying Existing Environmental Laws to Nanomaterials 221
  Toxic Substances Control Act 222
  TSCA’s Section 5: New Chemicals versus Existing Chemicals 224
  EPA’s TSCA Voluntary Pilot Program 225
  Clean Air Act 226
  Clean Water Act 227
  Resource Conservation and Recovery Act 228
  Comprehensive Environmental Response, Compensation, and Liability Act 229
  Federal Insecticide, Fungicide, and Rodenticide Act 230
  National Environmental Policy Act 232
  The Federal Food, Drug, and Cosmetic Act 233
  The Occupational Safety and Health Act 235
Conclusions 235


Patent Law and Nanoinvention 241
  The Constitutional and Statutory Foundation of the U.S. Patent System 243
  Patents May Only Be Granted on Eligible Subject Matter 245
  Novelty and Nonobviousness 246
The USPTO’s Response to Nanotechnology 248
  Practical Review Issues Faced by the USPTO 251
  Patent Infringement and the Strict Liability Standard 253
Conclusions 257

15. Patenting Trends in Nanotechnology 259
Jessica K. Fender

Results 260
  Nanotechnology Patents on the Rise 260
  Beyond the Numbers: Emerging Trends in Nanotechnology Patenting 266
Conclusions 277
PART 3: NANOMEDICINE, ETHICS, AND THE HUMAN CONDITION 279

16. Toward Nanoethics?  
Nigel M. de S. Cameron  
Ethics, Policy, and New Technologies 281  
The Emerging Ethical Agenda 284  
The Context of Bioethics 285  
An Ethical Agenda for Nanotechnology 288  
The Prospect of “Enhancement” 291  
The Question of “Nanoethics” 293

17. Anticipating the Impact of Nanoscience and Nanotechnology in Healthcare  
Debra Bennett-Woods  
A Strategic Mandate 296  
Scope and Background 297  
Frame Analysis 299  
The Structural Frame 300  
Human Resource Frame 304  
Political Frame 305  
Symbolic Frame 307  
Conclusions 311  
Bibliography 312

18. Doing Small Things Well: Translating Nanotechnology into Nanomedicine  
William P. Cheshire, Jr.  
The Discovery of Cells and Germs 316  
Penetrating the Subcellular Matrix 318  
The Nanorealm 318  
The Tools of Nanomedicine 319  
Heir of Micromedicine 321  
Unlike Previous Medicine 322  
Visions of Medical Nanoutopia 327  
Visions of Medical Nanodystopia 330  
Medical Nanorealism 334

19. Nanotechnology and the Future of Medicine  
C. Christopher Hook  
Nanomedicine and Human Re-engineering 342  
Freitas’ Normative Volitional Model 344
PART 4: NANO AND SOCIETY: THE NELSI IMPERATIVE

20. The NELSI Landscape

Michele Mekel and Nigel M. de S. Cameron

NELSI and the Nanosphere: Setting the Stage

When Congress Talks: The NELSI Mandate

Do People Listen?: The NNI’s Performance on the NELSI Front

An Overview of U.S. NELSI Initiatives

Academic-Based NELSI Initiatives

NGOs and Other Entities with a NELSI Focus

Governance in a Nanoworld

Big Issues from Small Science: Formulating a NELSI Framework

Nanoethics

Nanogovernance and Nanopolicy

Risk Management, Socially Responsible Development, and Sustainability

Public Engagement

Lessons in NELSI from The Diamond Age

21. The Center for Nanotechnology in Society at Arizona State University and the Prospects for Anticipatory Governance

David H. Guston

Studying Nanotechnology in Society

CNS–ASU and Anticipatory Governance

CNS–ASU and RTTA

Education and Outreach

CNS–ASU and the Prospects for Anticipatory Governance

Bibliography

22. The International Council on Nanotechnology: A New Model of Engagement

Kristen M. Kulinowski

The NNI and the Genesis of CBEN

Societal Debate Heats Up

Genesis of ICON

EHS Database
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.</td>
<td>From the Lab to the Marketplace: Managing Nanotechnology Responsibly</td>
<td>413</td>
</tr>
<tr>
<td></td>
<td><strong>Vivian Weil</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>On-the-Ground Nanodevelopments</td>
<td>414</td>
</tr>
<tr>
<td></td>
<td>Rationale for Concentrating on Responsible Management: Public Trust</td>
<td>415</td>
</tr>
<tr>
<td></td>
<td>Responsibility in Research</td>
<td>417</td>
</tr>
<tr>
<td></td>
<td>Translation to the Marketplace</td>
<td>421</td>
</tr>
<tr>
<td></td>
<td>Experiments in Public Engagement</td>
<td>423</td>
</tr>
<tr>
<td></td>
<td>Conclusions</td>
<td>424</td>
</tr>
<tr>
<td></td>
<td>Policymakers</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Nigel M. de S. Cameron</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Science Policy and Nanotechnology</td>
<td>425</td>
</tr>
<tr>
<td></td>
<td>Points to Consider</td>
<td>429</td>
</tr>
<tr>
<td></td>
<td>The Administration of the National Nanotechnology Initiative</td>
<td>429</td>
</tr>
<tr>
<td></td>
<td>The Development of Nanotechnology Policy</td>
<td>432</td>
</tr>
<tr>
<td></td>
<td>The Lewis Paradox: The Abolition of Man?</td>
<td>436</td>
</tr>
<tr>
<td></td>
<td>The Challenge to the Policy Community</td>
<td>437</td>
</tr>
<tr>
<td></td>
<td><strong>Bibliography</strong></td>
<td>439</td>
</tr>
<tr>
<td></td>
<td>1. Key Documents Related to NELSI</td>
<td>439</td>
</tr>
<tr>
<td></td>
<td>2. Online Resources Addressing NELSI</td>
<td>441</td>
</tr>
<tr>
<td></td>
<td><strong>INDEX</strong></td>
<td>445</td>
</tr>
</tbody>
</table>
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

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 complemen-
tary 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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This section opens with perspectives from members of the U.S. Congress, and includes some of those who wrote the 2003 21st Century Nanotechnology Research and Development Act that established the National Nanotechnology Initiative. It is the product of a roundtable at the Center on Nanotechnology and Society’s first annual conference on nanopolicy (in 2006). Keynotes had been delivered by Mihail C. Roco, nanotechnology advisor at the National Science Foundation and the most influential figure in U.S. nanotechnology, and Sean Murdoch, who directs the trade group the NanoBusiness Alliance.

Central to the concerns of policymakers, technologists, and business leaders is the question of risk. This is discussed by Annabelle Hett, head of emerging technology risk at Swiss Re, now the world’s largest reinsurance company and publisher of the influential report she authored on risk and nanotechnology. Risk covers many issues; one plainly lies in environmental hazards and toxicology concerns. Brent Blackwelder, U.S. President of the international environmentalist group Friends of the Earth, offers a somewhat different perspective, focused on issues of consumer safety. Looking more broadly at the need to maximize benefits and minimize risks, Jacob Heller and Christine Peterson write from the Foresight Nanotech Institute (of which Peterson was co-founder with K. Eric Drexler), the nano think tank that has long promoted the nano vision, including a special focus on “molecular” nanotechnology.

But the implications of a new technology range more broadly than quantifiable issues of safety and broader risk. Two psychologists, M. Ellen Mitchell and Ruthanna Gordon, tackle wider questions with one eye on the human dimension and another on the claims made for technological promise.

What of the purpose for which nanotechnology is being developed, and the wider policy context? Nick Bostrom from Oxford and James Hughes from Trinity College, Hartford, Connecticut, both leaders of the World Transhumanist Association, make their respective cases for a vision of the future in which “human nature” may have become a thing of the past, and yet in which technology enables persons to thrive in conditions that stretch our imagination. On the same theme, Nigel Cameron reviews
the European response to the National Science Foundation’s first report on *Converging Technologies for Improving Human Performance*, which was seen as favoring the transhumanist vision (by enthusiasts and critics alike), and misunderstood by many as a statement of U.S. policy.

Taken together, these chapters set the scene for the cultural politics of the twenty-first century, setting out the promises and the perils of nanotechnology and sampling arguments that will be heard for many years to come.