



ARMIN GRUNWALD **RESPONSIBLE**  
**NANOBIOTECHNOLOGY**  
*Philosophy and Ethics*



ARMIN GRUNWALD **RESPONSIBLE  
NANOBIOTECHNOLOGY**

Philosophy and Ethics



PAN STANFORD  PUBLISHING

*Published by*

Pan Stanford Publishing Pte. Ltd.  
Penthouse Level, Suntec Tower 3  
8 Temasek Boulevard  
Singapore 038988

Email: [editorial@panstanford.com](mailto:editorial@panstanford.com)  
Web: [www.panstanford.com](http://www.panstanford.com)

**British Library Cataloguing-in-Publication Data**

A catalogue record for this book is available from the British Library.

**Responsible Nanobiotechnology: Philosophy and Ethics**

Copyright © 2012 Pan Stanford Publishing Pte. Ltd.

*All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the publisher.*

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN 978-981-4316-80-4 (Hardcover)  
ISBN 978-981-4363-33-1 (eBook)

# Contents

<i>Preface</i>	xiii
<b>1 Agenda and Overview</b>	<b>1</b>
1.1 The Motivation	1
1.2 Objectives, Conceptual Framework, and Premises	5
1.3 Quick Guide Through the Book	8
1.3.1 Chapter 2: Nanotechnology in Context	8
1.3.2 Chapter 3: Ethics, Technology, and Risk	9
1.3.3 Chapter 4: Ethics of Nano(bio)technology: The Program	9
1.3.4 Chapter 5: Ethics of Nano(bio)technology: An Overview	10
1.3.5 Chapter 6: Synthetic Nanoparticles	10
1.3.6 Chapter 7: Toward Creating Artificial Life	11
1.3.7 Chapter 8: Animal Enhancement	11
1.3.8 Chapter 9: Human Enhancement	11
1.3.9 Chapter 10: From Applied Ethics to an Explorative Philosophy of Nanotechnology	12
1.3.10 Chapter 11: Conclusions and Perspectives	13
<b>2 Nanotechnology in Context</b>	<b>15</b>
2.1 History of Nanotechnology	15
2.2 The World of Nanotechnology in a Nutshell	18
2.2.1 Nanometer-Scale Analysis and Manipulation	19
2.2.2 Characteristics of Nanomaterials	21
2.2.3 Areas of Activity and Applications	23
2.2.3.1 Synthetic Nanomaterials	23
2.2.3.2 Nanoelectronics	25
2.2.3.3 Nanobiotechnology	26
2.2.3.4 Nanomedicine	26

2.3	Defining Nanotechnology	27
2.4	The Interdisciplinary Nature of the Nanocommunity	33
2.5	Philosophical Interpretations	35
2.5.1	Triumph of Homo Faber	36
2.5.2	Huge Increase on Uncertainty	37
2.5.3	Nanotechnology as a Symbol of the Future	39
2.6	Public Perception	41
2.6.1	The “Grey Goo” Scenario	42
2.6.2	The “Prey” Scenario	42
2.6.3	The “Cyborg” Scenario	43
<b>3</b>	<b>Ethics, Technology, and Risk</b>	<b>49</b>
3.1	Problem-Oriented Ethics	49
3.1.1	Ethics for Resolving Moral Conflicts	50
3.1.2	Standard Situations in a Moral Respect	55
3.1.2.1	Pragmatic Completeness	56
3.1.2.2	Local Consistency	56
3.1.2.3	Sufficient Lack of Ambiguity	56
3.1.2.4	Acceptance	57
3.1.2.5	Compliance	57
3.1.3	Beyond Standard Situations in a Moral Respect	60
3.1.4	Ethical Expertise as Conditionally Normative Advice	63
3.2	Ethics of Technology	67
3.2.1	Normative Uncertainties Emerging from Technological Progress	67
3.2.2	Cross-Cutting Issues	70
3.2.2.1	Human Autonomy vs. Technicalization	71
3.2.2.2	Distributive Justice	71
3.2.2.3	Technology and the Environment	72
3.2.2.4	Technology and Life	73
3.2.2.5	Uncertainty of Our Knowledge of the Consequences	73
3.2.3	Ethics of Technology as Part of Technology Governance	74
3.2.3.1	Political Decisions	75

3.2.3.2	Entrepreneurial Decisions	76
3.2.3.3	Engineering	76
3.2.3.4	Consumer Behavior	77
3.2.3.5	Public Debate	77
3.2.4	Technology, Science, and Responsibility	78
3.3	Ethics and (Unclear) Risk	81
3.3.1	Classical Risk Management and Its Limitations	81
3.3.2	Ethical Issues in Dealing with Unclear Risk	84
3.3.2.1	Acceptability of Unclear Risk	85
3.3.2.2	Weighing Benefits against Unclear Risks	85
3.3.2.3	Normalizing the Situation under Consideration	86
3.3.2.4	Comparisons of Man-Made Situations of Unclear Risk with Natural Situations	87
3.3.2.5	Learning from Historic Cases	87
<b>4</b>	<b>Ethics of Nano(bio)technology: The Program</b>	<b>89</b>
4.1	Motivations of Nanoethics	89
4.1.1	Avoiding to Endanger Innovation	90
4.1.2	Taking Care of Unintended Side Effects as Early as Possible	92
4.1.3	Reacting to Apocalyptic Fears	93
4.2	Nanoethics as a New Field of Applied Ethics?	95
4.3	Problem-Oriented Ethics of Nanotechnology	102
<b>5</b>	<b>Ethics of Nano(bio)technology: An Overview</b>	<b>107</b>
5.1	Literature Overview	108
5.1.1	Interdisciplinary Expert Studies	108
5.1.2	Position Papers from Nongovernmental Organizations	111
5.1.3	Selected Edited Books	114
5.1.4	The Journal Nanoethics	118
5.2	Ethical Questions Related to Nano(bio)technology Applications	119
5.2.1	Nanomedicine: Risks and Benefits	120
5.2.2	Nanoelectronics: Surveillance and Privacy Issues	124

5.2.3	Using Processes of Life for Technological Purposes	126
5.2.4	Human Enhancement	128
5.2.5	Animal Enhancement	129
5.2.6	Military Applications	132
5.3	Cross-Cutting Ethical Issues	134
5.3.1	EHS: Environment, Health, and Safety	134
5.3.2	Distributive Justice: Nanotechnology and Developing Countries	137
5.3.3	Responsibility for Future Generations	140
5.4	Selection of Issues for In-Depth Studies	143
<b>6</b>	<b>Synthetic Nanoparticles</b>	<b>147</b>
6.1	Synthetic Nanoparticles: Fields of Application and Expectations	148
6.1.1	Surface Treatment	149
6.1.2	Food	150
6.1.3	Cosmetics	152
6.2	Possible Risks and Types of Risk	152
6.2.1	Health Risks	154
6.2.2	Environmental Risks	156
6.2.3	Nanoparticle Risks as “Unclear Risks”	157
6.3	Approaches to Dealing with Unclear Risk	159
6.3.1	Philosophical Approaches	159
6.3.1.1	The Consequentialist Approach	159
6.3.1.2	The Imperative of Responsibility	160
6.3.1.3	The Principle of Pragmatic Consistency	162
6.3.1.4	Deontological Advice	163
6.3.1.5	Projected Time	164
6.3.2	Operational Approaches	165
6.3.2.1	The Precautionary Principle	165
6.3.2.2	The Prudent Avoidance Approach	168
6.3.3	Interim Conclusions	170
6.4	Dealing Responsibly with Nanomaterials	171
6.4.1	Conditionally Normative Reflection	171
6.4.2	Informed Consent and Consumer Freedom	174

6.4.3	Regulation, Code of Conduct, and the Common Good	175
6.4.4	Operative Approach: Remarks on the Next Steps	181
6.4.5	Epilogue and Reflection: Risk Ethics and Nanoparticles	187
<b>7</b>	<b>Toward Creating Artificial Life</b>	<b>191</b>
7.1	Nanobiotechnology and Synthetic Biology	191
7.1.1	Nanobiotechnology	192
7.1.2	Synthetic Biology: Engineering Life	193
7.2	Chances and Risks	197
7.2.1	Chances	197
7.2.2	Risks	199
7.3	Ethical Issues	203
7.3.1	Dealing with Risks Responsibly	204
7.3.2	The Moral Status of Created Organisms	207
7.3.3	Quasi-ethical Concerns: Humans “Playing God”?	209
7.4	Hermeneutic Dimensions	213
7.4.1	Technicalization of the Natural or a More Natural Technology	213
7.4.2	The Relationship Between Technology and Life	217
7.5	Responsible Governance of Synthetic Biology	219
<b>8</b>	<b>Animal Enhancement</b>	<b>227</b>
8.1	(Nano)Technology for Intervening in Animals	228
8.2	The Semantics of Animal Enhancement	232
8.2.1	The Semantics of Enhancement	232
8.2.2	Animal Enhancement	234
8.3	Relevant Ethical Challenges and Normative Frameworks	237
8.3.1	Animal Experiments	238
8.3.2	Elimination of Animals’ Capacity for Suffering	240
8.3.3	Transgressing the Boundary Between Humans and Animals	243
8.4	Changing Human–Animal Relationship	244
8.5	Summary and Conclusions	247



<b>9 Human Enhancement</b>	<b>251</b>
9.1 Improving Human Performance of Converging Technologies	251
9.1.1 The Vision of Converging Technologies	252
9.1.2 Improving Human Performance: The Cultural Background	255
9.1.3 Enhancement Utopia 1: Neuroenhancement	258
9.1.4 Enhancement Utopia 2: Antiaging and Immortality	261
9.2 Semantics of Technical Enhancement	263
9.2.1 Enhancement Beyond Healing	263
9.2.2 Healing, Doping, Enhancement, and Alteration	265
9.2.3 Technical Enhancement	269
9.3 Human Enhancement: Ethical Analysis	272
9.3.1 Normative Uncertainties	272
9.3.2 Patterns of Ethical Argumentation	275
9.3.2.1 Ethical Consideration of the Consequences	275
9.3.2.2 The Naturalness of Man	278
9.3.2.3 The Question as to Ought	280
9.3.3 Assessment of the Current Status of the Ethical Debate	281
9.4 Changing Relations Between Humans and Technology	284
9.4.1 Neuroelectric Interfaces	284
9.4.2 Technicalization of Man by Nanotechnology?	290
9.5 Conclusions for Responsible Action	293
9.5.1 Need for Orientation on Human Enhancement	293
9.5.2 Responsible Action	297
9.5.3 Approaching an “Enhancement Society?”	300
<b>10 Explorative Nanophilosophy: More Than Applied Ethics</b>	<b>303</b>
10.1 The Debate on “Speculative Nanoethics”	304
10.1.1 The Main Diagnosis: “Most Nanoethics Is Too Futuristic”	305
10.1.2 How Speculative Is “Speculative Nanoethics”?	306
10.1.3 The Anxiety that Unjustified and Artificial Concerns Might Emerge	308

10.1.4	The Opportunity–Costs Argument	310
10.1.5	Resume	311
10.2	Searching for Orientation by Investigating Futures	312
10.3	Futures as Social Constructs	314
10.4	Explorative Philosophy of Nanotechnology	317
10.4.1	Explorative Philosophy Beyond Applied Nanoethics	318
10.4.2	Elements of an Explorative Philosophy of Nanotechnology	321
10.4.2.1	Nano Epistemology	321
10.4.2.2	Nano Anthropology: The Relationship Between Humans and Technology	322
10.4.2.3	Nanotechnology Hermeneutics: Philosophical Interpretations of Nanotechnology	323
10.4.3	Epistemological Grounding	323
<b>11</b>	<b>Conclusions and Perspectives</b>	<b>327</b>
11.1	Ten Years of Nanoethics: What Has Been Achieved?	327
11.2	Moral Arguments Feeding a Broad Antinano Movement?	331
11.3	The Future of Nanoethics	335
11.3.1	Nanoethics as Concomitant Reflection on Nanotechnologies	335
11.3.2	Nanoethics as Interdisciplinary Research	337
11.3.3	Disentanglement of Nanoethics	339
	<i>Bibliography</i>	343
	<i>Index</i>	369