

Contents

| | |
|---|-----------|
| <i>Preface</i> | xiii |
| 1 Agenda and Overview | 1 |
| 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 |
| 2 Nanotechnology in Context | 15 |
| 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 |
| 3 | Ethics, Technology, and Risk | 49 |
| 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 |
| 4 | Ethics of Nano(bio)technology: The Program | 89 |
| 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 |
| 5 | Ethics of Nano(bio)technology: An Overview | 107 |
| 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 |
| 6 | Synthetic Nanoparticles | 147 |
| 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 |
| 7 | Toward Creating Artificial Life | 191 |
| 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 |
| 8 | Animal Enhancement | 227 |
| 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 |

| | | |
|-----------|---|------------|
| 9 | Human Enhancement | 251 |
| 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 |
| 10 | Explorative Nanophilosophy: More Than Applied Ethics | 303 |
| 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 |
| 11 | Conclusions and Perspectives | 327 |
| 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 |