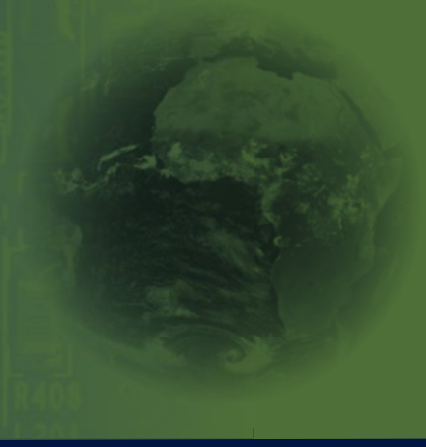
The International Library of Ethics, Law and Technology 13



Simone Arnaldi
Arianna Ferrari
Paolo Magaudda
Francesca Marin *Editors*

Responsibility in Nanotechnology Development

Springer

Responsibility in Nanotechnology Development

The International Library of Ethics, Law and Technology

VOLUME 13

For further volumes:
http://www.springer.com/series/7761

Simone Arnaldi • Arianna Ferrari
Paolo Magaudda • Francesca Marin
Editors

Responsibility in Nanotechnology Development

Springer

Editors
Simone Arnaldi
Centre for Environmental, Ethical, Legal and Social Decisions on Emerging Technologies (CIGA)
University of Padova
Rovigo, Italy

Istituto Jacques Maritain
Trieste, Italy

Arianna Ferrari
Institute for Technology Assessment and Systems Analysis (ITAS)/Karlsruhe Institute of Technology (KIT)
Karlsruhe, Germany

Paolo Magaudda
Francesca Marin
Department of Philosophy, Sociology Education and Applied Psychology
University of Padova
Padova, Italy

ISSN 1875-0044 ISSN 1875-0036 (electronic)
ISBN 978-94-017-9102-1 ISBN 978-94-017-9103-8 (eBook)
DOI 10.1007/978-94-017-9103-8
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2014941876

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

Contributors

Simone Arnaldi is Research Fellow of the Centre for Environmental, Ethical, Legal and Social Decisions on Emerging Technologies (CIGA) and of the Department of Political Science, Law, and International Studies at the University of Padova (Italy). He teaches sociology and foresight at the University of Trieste (Italy). He is the Director of the Istituto Jacques Maritain (Italy). His research interests focus on social and media representations of emerging technologies and public engagement in technological decision-making.

Colette Bos is a Ph.D. candidate at the University of Utrecht. She studied Science and Innovation Management at the University of Utrecht and graduated in August 2011. She continued as a Ph.D. in the Innovation Studies group with research within the NanoNextNL program. Her research is conducted under the supervision of Prof. Dr. Ir. Harro van Lente and Dr. Ir. Alexander Peine.

Ilaria Anna Colussi is an Italian attorney and earned a Ph.D. (Doctor Europaeus) in Comparative and European Legal Studies (field: Public Law) from the University of Trento (Italy). Her research interests focus on law, genetics, synthetic biology and new technologies, dealing with the governance of risks and the protection of fundamental rights, from the perspectives of comparative constitutional law and human rights law. She was a member of the Biolaw Project within the Department of Legal Science of the University of Trento, and she has collaborated with the European Centre for Law, Science and New Technologies in Pavia, Italy, since 2009. She was a visiting scholar at the Uehiro Centre for Practical Ethics in Oxford, UK, and at the Interuniversity Chair of Law and the Human Genome in Bilbao, Spain.

Viviana Daloiso graduated in Political Science and earned a Ph.D. in Bioethics, at the "A. Gemelli" School of Medicine (Università Cattolica del Sacro Cuore) in Rome. She is a ranking member of clinical bioethics committees in Rome. Her fields of interest are nanoethics, neuroethics, ethical review of experimental protocols, and forensic bioethics.

Sarah R. Davies is a Marie Curie Research Fellow at the University of Copenhagen. Her Ph.D. (2007) was carried out in Imperial College London's Science Communication

Group; since then, she has worked at Durham University, UK and at Arizona State University's Center for Nanotechnology in Society. Davies has published in journals such as *Science Communication*, *Science as Culture*, and *Public Understanding of Science*, and has co-edited three volumes (*Science and Its Publics*, 2008; *Understanding Public Debate on Nanotechnologies: Options for Framing Public Policies*, 2010; and *Understanding Nanoscience and Emerging Technologies*, 2010). Her current work explores a number of themes, including materiality and affect in deliberative processes, the governance of emerging technologies, and science communication in museums and science centres.

Arianna Ferrari philosopher, is a researcher at the KIT's Institute for Technology Assessment and Systems Analysis (ITAS) since November 2010. She studied Philosophy at the University of Milan (Italy) and at the University of Tübingen (Germany) and in 2006 completed a Ph.D. in Philosophy (carried out jointly at Tübingen, Germany and Torino, Italy) on ethical and epistemic questions of genetic engineering of animals in biomedical research. Arianna has published widely and lectured on ethical, political and social aspects of emerging technologies, particularly nanotechnologies and genetic engineering. She also teaches and researches on animal philosophy, on the interface between ethics and epistemology as well as ethics and politics in life sciences.

Torsten Fleischer is deputy head of the research area 'Innovation processes and impacts of technology' at the Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe Institute of Technology (KIT), and project coordinator for 'Technology Assessment for Nanotechnologies' at ITAS. After graduating in physics, he joined ITAS' predecessor AFAS in 1991. He served as Project Manager for several TA studies for ITAS and the Office of Technology Assessment at the German Parliament (TAB). His working fields are nanotechnology and its implications, new materials and their applications in the energy and transportation sectors, methodological questions of technology assessment as well as the governance of innovation processes and participation therein.

Cecilie Glerup is a Ph.D. student at the Department of Organization, Copenhagen Business School. Her thesis focuses on how political demands for 'responsible innovation' affect both the organization of scientific work in public laboratories and scientists' professional identities. She is furthermore interested in how science and the public interact, and has been involved in the organization of several public engagement events.

Armin Grunwald carried out a Ph.D. in the University of Cologne (Germany) in the field of Theoretical Solid State Physics. After occupations in industry and in the German Aerospace Center, he moved to philosophy and absolved the habilitation at Marburg University. Armin Grunwald holds the Chair of Philosophy and Ethics of Technology at Karlsruhe Institute of Technology (KIT) since 2007. He has been Director of the Institute for Technology Assessment and Systems Analysis (ITAS) at KIT since 1999, and he also has been Director of the Office of Technology

Assessment at the German *Bundestag* since 2002. His main research interests are the ethical aspects of new and emerging sciences and technologies (nanotechnology, synthetic biology, and enhancement technologies), theory and methodology of technology assessment as well as theory and conceptualization of the *Leitbild* of Sustainable Development.

Maja Horst is Head of Department of Media, Cognition and Communication at University of Copenhagen. She holds a masters' degree in communication and a Ph.D. in Science and Technology Studies. Among other projects, she has directed 'Research Management and Risk' (2007–2011) and 'Scientific Social Responsibility' (2009–2014) funded by the Danish Research Council for Social Science. She has published on governance of science and technology, public engagement, science communication and public understanding of science. She has also been experimenting with her own research communication through interactive installations.

Jutta Jahnel food chemist, is a researcher at the KIT's Institute for Technology Assessment and Systems Analysis (ITAS) since July 2010. She studied Food Chemistry and completed her Ph.D. thesis in Chemical Engineering at KIT in Karlsruhe (Germany) on the development of analytical methods in water chemistry. Jutta worked at the DVGW water laboratory and at the Food Control and Animal Health Laboratory in Karlsruhe. At ITAS, she is currently working on environmental, health and safety aspects of nanomaterials with a focus on risk assessment and risk governance frameworks.

Paolo Magaudda is Research Fellow in Sociology at the Department of Philosophy, Sociology, Education and Applied Psychology (FISPPA), University of Padova. In 2011–2012, he was Research Fellow at the Interdepartmental Research Centre for Environmental Law Decisions and Corporate Ethical Certification (CIGA) in the same university. His main research interests are in the fields of science and technology, consumption processes, cultural studies, digital media and popular culture. Among his recent publications are an edited volume (with F. Neresini) on the representations of science and technology on the Italian TV, *La Scienza in TV* (Il Mulino 2011), an ethnographic research on the consumption of musical technologies, *Non solo Oggetti* (Il Mulino 2012) and a book on the representation of science and technology in popular culture, *Innovazione Pop* (Il Mulino 2012).

Francesca Marin philosopher, is Research Fellow at the Department of Philosophy, Sociology, Education and Applied Psychology (FISPPA), University of Padova since February 2013. In April 2011 she completed a Ph.D. in Philosophy at the University of Padova. In 2011 and 2012 she joined the EPOCH project (*Ethics in Public Policy Making: The Case of Human Enhancement*) within the Interdepartmental Research Centre for Environmental Law Decisions and Corporate Ethical Certification (CIGA), University of Padova. Her main research interests include end of life issues, pain management, ethical aspects of emerging technologies and human enhancement. She teaches moral philosophy at the Superior Institute of Religious Sciences (ISSR) in Padova (Italy).

Giuseppe Pellegrini Ph.D. Sociology, teaches methodology of social research at the University of Padova, Italy. His current research focuses on sociology of science, evaluation, citizenship and public participation. He is the coordinator of the research area "Science and Citizens" at the centre Observa Science in Society. His last publications are: *Women and Science: Italy in the International Context* (edited with Barbara Saracino), 2013; *Tecnoscienza, democrazia deliberativa e relazionalità*, Sophia, 1, 105–11, 2013.

Stefanie B. Seitz biologist, has worked for KIT's Institute for Technology Assessment and Systems Analysis (ITAS) since August 2010. She studied Biology at the Friedrich Schiller University of Jena (Germany) and in 2010 completed a Ph.D. in Biology on molecular biologic mechanisms of the circadian clock of the green alga *Chlamydomonas reinhardtii*. Stefanie is currently working on environmental, health and safety aspects of manufactured nanoparticles. Her research interests focus on governance of emerging technologies like nanotechnology or biotechnology including synthetic biology and epigenetics.

Antonio G. Spagnolo graduated in medicine and specialized in Cardiology and in Forensic medicine. He is Full Professor of Bioethics at the "A. Gemelli" Faculty of Medicine (Università Cattolica del Sacro Cuore), Rome, and the Director of the Institute of Bioethics. He is ranking member of several bioethics committees. He is corresponding member of the Pontifical Academy for Life and consultant of the Pontifical Council for Health Care Workers. He is member of the American Nano Society and Member of the Editorial Board of the International Journal of clinical research and bioethics. His fields of interest are: clinical ethics consultation, nanoethics, ethical reviews of experimental protocols, and healthcare ethics committees.

Harro van Lente is Socrates Professor of Philosophy of Sustainable Development at Maastricht University and Associate Professor of Innovation Studies at Utrecht University. He has studied physics and philosophy and has widely published on the dynamics of expectations in science and technology. His research interests concern how emerging technologies – such as nanotechnology, hydrogen and medical technologies – produce novelty and needs. This involves studies of technology assessment, foresight, intermediary organizations, politics of knowledge production and philosophy of technology. Currently, he is Program Director of Technology Assessment of the NanoNextNL, the leading Dutch research consortium in nanotechnology.

Silvia Zullo graduated in Philosophy and earned a Ph.D. in Bioethics at the University of Bologna in 2005, where she is a senior postdoctoral research fellow in bioethics at CIRSFID, Bologna University School of Law. Under several projects supported by the Italian Ministry of Scientific and Technological Research focused on medical genetics, she conducts research on technology, bioethics, and law. Her research takes a legal-philosophical angle, with a specific focus on moral theory and practice in bioethics and law, working on issues relating to the end of life, genetic technologies, and social justice, such as equity, the distribution of risk, and the precautionary principle.

Chapter 1
Introduction: Nanotechnologies and the Quest for Responsibility

Simone Arnaldi, Arianna Ferrari, Paolo Magaudda, and Francesca Marin

1.1 Why Nanotechnology and Responsibility

In the last decade, the field of nanotechnology has changed very quickly from an uncertain promise of benefits and innovations to the ground level of concrete and effective applications. Although still far from science-fiction visions proposed in *Engines of Creation* by Eric Drexler (1986), today nanotechnology has become an actual generator of concrete products and processes, gaining prominence in policy and funding, as well as salience in the public debate and in popular culture over the past few years. Nanotechnology has therefore become an area in which the distance between possibilities and hopes on the one hand, and practical applications on people's lives on the other have been substantial and the connections between these actual presents and possible futures are particularly vague and uncertain, therefore leaving substantial scope to reflect on hypothetical future consequences, even unexpected ones (Selin 2007).

Since the concerns related to nanotechnology's actual and conjectured impacts refer to societal aspects that are very relevant and sensitive, such as the possible consequences on the environment and human health, the quest for a responsible

S. Arnaldi (✉)
Centre for Environmental, Ethical, Legal and Social Decisions on Emerging Technologies (CIGA), University of Padova, Viale Porta Adige 45, Rovigo, Italy

Istituto Jacques Maritain, Trieste, Italy
e-mail: simone.arnaldi@unipd.it

A. Ferrari
Institute for Technology Assessment and Systems Analysis (ITAS)/Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
e-mail: arianna.ferrari@kit.edu

P. Magaudda • F. Marin
Department of Philosophy, Sociology, Education and Applied Psychology, University of Padova, Padova, Italy

S. Arnaldi et al. (eds.), *Responsibility in Nanotechnology Development*, The International Library of Ethics, Law and Technology 13, DOI 10.1007/978-94-017-9103-8_1,

development of nanotechnologies has progressively gained momentum in research and policy (cf. Roco 2005; Robinson 2009; McCarthy and Kelty 2010).

A prominent policy example is the launch of the Code of Conduct for Responsible Nanosciences and Nanotechnologies by the European Commission in 2008 (European Commission 2008). The Code aims at enabling safe and beneficial innovation through nanotechnologies and to foster the organization of collective responsibility for the field (von Schomberg 2007). The notion of 'responsible development' works as an overarching ethical framework for innovation, a general foundation of different principles, which should inspire actions (such as sustainability, inclusiveness, excellence, innovation and accountability). The Code was designed to steer responsible research and technology development, so that they should be capable of granting benefits for the society as a whole. In so doing, the Code functions as a instrument for fostering responsibilisation (Dorbeck-Jung and Shelley-Egan 2013), assigning responsibilities to actors and promoting their active involvement, so that cooperation and coordination is strengthened and ensured on a voluntary basis. This assumption of responsibility is described as fundamental for realizing societal goals: the prerequisite here is that the different actors understand and willingly take on the different responsibilities that are connected to the multiple roles in the research and development process they become aware of. In other words, the idea of responsibility in the innovation process in the form of the Code cannot be other than a collective responsibility.

Though prominent, the Commission's Code of Conduct is by no means a unique example and several other instruments attempted to address the junction between responsibility and nanotechnology development, fostering the active commitment of the various actors involved in the field. For example, the voluntary engagement of the relevant social actors was sought through national instruments like the 'Voluntary Reporting Scheme for Engineered Nanoscale Materials', which was promoted by the Department of Environment, Food and Rural Affairs of the UK government in 2006–2008 and was aimed at stimulating an interest by importers and manufacturers of engineered nanomaterials to provide the Department with comprehensive information on material characteristics, as well as with data on toxicity and ecotoxicity (DEFRA 2008a, b). Similarly, the US Environmental Protection Agency (EPA) formally implemented its own voluntary 'stewardship program' for nanoscale materials under the Toxic Substances Control Act (TSCA) in years 2008–2009. Through this voluntary information collection, EPA intended to collaboratively assemble existing data and information from manufacturers, importers, and processors of nanoscale materials in an effort to generate more detailed information of certain specific nanoscale materials. This collaboration between EPA and industry was expected to generate data and analyses for a more complete characterization of materials, and to increase understanding of the environmental health and safety implications of manufactured nanoscale materials for guaranteeing their safe manufacture, processing, distribution, use, storage and disposal (EPA n.d.). At the international level, the OECD Working Party on Nanotechnology (WPN) was established in March 2007 to advise upon emerging policy issues of science, technology and innovation related to the development of nanotechnology and to foster international cooperation that facilitates, among other

related issues, the responsible commercialisation of nanotechnology in member countries and certain non-member states (OECD n.d.). In the broader context of the governance of science and technology, the UNESCO Declaration on Bioethics and Human Rights (UNESCO 2005) has affirmed "the desirability of developing new approaches to social responsibility to ensure that progress in science and technology contributes to justice, equity and to the interest of humanity". In general, although it is not nano-specific, the Declaration introduces a "social responsibility principle" (Faunce 2012b), which sets a core group of goals science and technology should be steered to and which is therefore relevant for nanotechnology too. In particular, article 14 of the Declaration lists five "putative public goods" (Faunce 2012b) which the private and public actors involved in science and technology are required to respect: access to quality healthcare and medicines, as well as to nutrition and water; improving of living conditions and environment; elimination of marginalization and exclusion; reduction of poverty and illiteracy. Academic research has proposed the UNESCO Declaration as a "point of departure" for shaping the ethical and human rights principles governing a global project of "artificial photosynthesis", i.e. the replication of photosynthesis, by means of nanoengineering, for localised production of carbon-neutral hydrogen based-fuel and carbohydrate-based food and fertilizer, as forms of planetary therapeutics (Faunce 2012a).

While these examples share the fact that they are initiated by public authorities, private organizations as well launched initiatives for seeking to outline and foster a 'responsible way' to develop nanotechnology. A prominent example is the Responsible Nanocode, which "aims to provide clear guidance about the expected behaviour of companies in relation to their nanotechnology activities" (NIA n.d.) through the implementation of a set of "principles" ranging from "board accountability" (Principle 1) and "worker health and safety" (Principle 3) to "wider social, environmental, health and ethical implications and impacts" (Principle 5). Individual companies like DuPont and BASF developed internal policies, codes of conduct and assessment frameworks for the responsible development of nanotechnologies, ensuring safe production, use and disposal of nanoscale materials and identifying, managing and reducing potential health, safety and environmental risks (DuPont 2012; BASF n.d.). Finally, although not "nano-specific", initiatives like ResponsibleCare© for the chemical industry are equally relevant (Heinemann and Schäfer 2009). ResponsibleCare© is aimed to going beyond legislative and regulatory compliance, and by adopting cooperative and voluntary initiatives with government and other stakeholders (ICCA 2006) and commits the "[t]he global chemical industry [to] extend existing local, national and global dialogue processes to enable the industry to address the concerns and expectations of external stakeholders to aid in the continuing development of Responsible Care" (ICCA 2006, 4).

In sum, nanotechnology and responsibility have become a tightly connected pair and policy formulation, academic research, business strategies, and civil society campaigns agree that nanotechnology development should be responsible. Responsibility is not only considered as a value which frames regulation, but as the fundamental condition for enabling good, legitimated and desired technological developments. The transformative power that is attributed to nanotechnology makes this emerging field a perfect candidate to exemplify the consequences of the

far-reaching, collective, and uncertain technological endeavour on the notions and practices of responsibility. It is not by chance (cf. Grunwald (Chap. 12) in this book) that this emphasis on the responsible development of nanotechnology has accompanied and sustained over the years the parallel establishment of responsibility as a general feature of technology policy and development. In Europe, such a gradual process has resulted, for instance, in the assumption of the notion of Responsible Research and Innovation (RRI) as a cross-cutting issue under the EU Framework Programme for Research and Innovation "Horizon 2020" (European Commission n.d.; von Schomberg 2013), representing a core value in the new research agenda of the European Union.[1] Similarly, the 'sister concept' of 'responsible innovation' (Owen et al. 2012, 2013) has made its way in the academic debate. Here the idea is that innovation (the new products, services and technologies developed) should not only be simply new, but they should be made and act in the society in a responsible way. These concepts still being in their infancy and despite some differences, they present three shared, distinct features. The first one emphasises the democratic governance of the purposes of research and innovation and their orientation towards the 'right impacts'. The second one values responsiveness, emphasising the integration and institutionalisation of established approaches of anticipation, reflection and deliberation in decision-making processes about research and innovation. The third feature concerns "the framing of responsibility itself in the context of research and innovation as collective activities with uncertain and unpredictable consequences" (Owen et al. 2012). These features are translated in a vision according to which science and society are mutually responsive to each other with a view to the acceptability, sustainability, and societal desirability (von Schomberg 2011).

Responsible innovation is therefore considered an answer to the policy and regulatory dilemmas that are set by techno-scientific fields whose impacts are poorly characterized or highly uncertain. While risk-based governance and the regulatory science that supports it are challenged by the complex and uncertain nature of these phenomena, responsible innovation argues "that stewardship of science and innovation must not only include broad reflection and deliberation on their products, […] but also (and critically) the very *purposes* of science or innovation" (Owen et al. 2013). A discussion on responsibility in nanotechnology development cannot forget this broader context.

1.2 Charting Responsibility: The Structure of the Book

The idea of this book has developed from the acknowledgement that the notion of responsibility is anything but unequivocal and the meanings associated to this notion are extremely diversified in the public discourse of nanoscale technologies.

[1] For the parallel development of a distinct notion of 'broader impacts' of research in the US context, cf. Davis and Laas (2013).

Furthermore, these different meanings suggest to commentators and operators different *foci* of attention, ranging from radical appeals to precaution, to the experimentation of new procedures for rule-making, to the implementation of public understanding and/or public engagement activities, and to the development of tests, standards, and measures of exposition for humans and the environment. On the one hand, the formulation and implementation of these policies are affected mostly by our capacity to conjugate what 'responsible development' means for us in the future tense, i.e. with regard to the consequences of our actions on future generations, but also with regard to the assumptions about future situations that influence our way of acting. On the other, assumptions about individuals and their ties to broader social communities affect the solutions for developing nanotechnology responsibly: balancing safety and the legitimate pursuit of knowledge or economic opportunities, individual freedoms and collective interests (in a stronger fashion, the 'common good'), distributing tasks, costs and rewards.

The search for a comprehensive overview of the differentiated concept of responsibility is far beyond the scope of this book, which has the more instrumental goal to chart a landscape of issues, areas and perspectives to examine the current and future configurations of the relationship between nanotechnology and responsibility. Three distinct sections reflecting the multiple levels of the relationship between nanotechnology and responsibility guide the reader in the exploration of these changing notions and practices.

The first section, entitled *Scrutinizing responsibility: theoretical explorations into an entangled concept*, addresses the implications of technological visions for responsibility and examines the criteria and principles that can orient the responsible development of nanotechnology. Focusing on technological visions, Arianna Ferrari and Francesca Marin argue that a different framework is required because the current normative debate on responsibility in new and emerging technologies lacks both explicit acknowledgment of visionary communication about possible technological developments, and awareness of the normative influence of these visions in the present. After offering insights into the etymology of the word 'responsibility' and discussing some examples provided in the literature and regarding the current debate on human enhancement, they show how technological visions shape discourses on emerging technologies and drive research programs as well as our actions and activities. For Ferrari and Marin, thinking about responsibility in relation to technological visions and addressing their normative implications means opening a more fruitful and responsible debate on technological development. Silvia Zullo discusses the contribution of the principle of responsibility and of the precautionary principle to an ethics of responsibility for future generations when faced by policy challenges regarding emerging technologies and their regulation. Zullo stresses the limits of these principles and she argues for the need to integrate utilitarian principles in the equation. From her point of view, the adoption of the principle which demands the maximization of total utility and the principle of maximin in cases where irreversible effects may occur, encourages a concrete intergenerational responsibility, and nurtures a dynamic ethical perspective, both of which are needed to deal with the development of emerging technologies. Moving from a comparison of nanotechnology

and synthetic biology, Ilaria Anna Colussi proposes a view of responsibility as a "shared moral obligation" of social actors. Indeed, after presenting similarities and differences between nanotechnology and synthetic biology, Colussi discusses the main principles adopted in the risk analysis model, i.e. the precautionary principle and the proactionary principle, as well as their limits, and finally suggests the notion of 'responsible stewardship'. Being aware of the uncertainty surrounding both risks and benefits of emerging technologies, the proposed model considers alternative actions, immediate and follow-on effects, and interests at stake, letting the technological development go ahead while remaining alert.

The second section on *Responsibility in technology assessment and public engagement* examines the links between the responsible governance of nanotechnology and the practice and mechanisms of technology assessment and public engagement. First, the need to broaden the assessment framework beyond toxicology and beyond scientific experts is discussed. Secondly, the role of Ethics Research Committees in assessing nanotechnology clinical trials protocols is examined. Thirdly, public participation as an instrument for nanotechnology policy is explored. Torsten Fleischer, Jutta Jahnel and Stefanie Seitz point out that the current concept of toxicological risk assessment in the field of nanotechnology (in particular in that referred to manufactured particulate nanomaterials or MPN), which is based on conventional expert-based chemical risk assessment procedures, is too narrow. They start by analysing diverse proposals, such as the one by the International Risk Governance Council based on the considerations of societal impacts and needs, and one for including concerns assessment in the process (concerns of the general public and the stakeholders), which is however still in the early stages. Then, after having discussed the methodological challenges of a broadening of the concept of risk assessment, they discuss the results from a Eurobarometer 2010 as well as from public engagement exercises and focus groups. In the paper the authors call for a wider concept, further developing the idea of concern assessment: this approach should allow for a plurality of actors and different kinds of knowledge which adequately consider societal impacts for understanding risk in a broader sense than in expert-based assessments. Viviana Daloiso and Antonio G. Spagnolo discuss the issue of responsible nanotechnology research in a specific institutional setting: clinical trials and clinical research. According to the Authors, the uncertainty and complexity surrounding the applications of nanotechnologies that are tested in clinical trials assign to Ethics Research Committees (ERCs) for human experimentation the key, if not the decisive, role as public guarantor of the rights and the welfare of trial subjects, while contributing to the increase of available knowledge about human health. In particular, the ERCs must verify that the chosen methodologies are the best suited to the aims of the protocol, that the risk is assessed in terms of probability, magnitude and duration, that the protocol identifies all those elements that may influence that risk. The Authors argue that ERCs' role is even more important in nanomedicine as risks and toxicity change at the nanoscale and that information about them is still not comprehensive. Giuseppe Pellegrini connects responsibility and the public engagement of citizens in decision-making about technologies. Nanotechnology offers a privileged perspective from which to consider the relationship between the development of innovation, ethics and governance, given that the developmental

stage of this technology does not allow for a definite characterisation of the main environmental and social issues that are connected to them. The design, production and deployment of nanotechnological innovations can therefore be studied in order to immediately activate pathways of public involvement, even on the basis of similar recent experiences, as in the case of biotechnology.

The third section of the volume on *Representations and configurations of responsibility* deals with some of the ways in which the issue of responsibility in nanotechnology enters the actual processes of innovation and the social discourses about nanotechnology. Colette Bos and Harro van Lente open this section offering a contribution to the current literature regarding corporate social responsibility (CSR) and value chain responsibility (VCR). Given that this literature is particularly focused on existing technologies and value chains, and consequently underestimates firms' views on social responsibility in the light of emerging technologies and new value chains, Bos and van Lente explore these new areas of investigation by presenting three case studies concerning both large and small companies active in the nanotechnology sector. Their empirical results show that changes in the companies' view on social responsibility occur when they deal with new technologies and new value chains. Nevertheless, if the company deals with new technologies but the value chain is stable, then a change in social responsibility is not deemed necessary. In their contribution, Sarah R. Davies, Cecilie Glerup, and Maja Horst point out the contingency and multiplicity of the notion of responsibility by firstly exploring how this concept is articulated within the academic literature. Their discourse analysis conducted on 250 journal articles shows that social responsibility in scientific practice is addressed in two opposing ways: on the one hand, responsibility relies on separating science and society as far as possible; on the other hand, it calls for a greater connection between them. Secondly, a similar diversity arises from the Authors' discussion on how responsibility is performed in the National Science Foundation-funded Center for Nanotechnology in Society at Arizona State University (CNS-ASU) and in the US private sector nano industry with which CNS-ASU sought to interact. While the former performs a broad model of responsible development of nanotechnology, for example by paying attention to its societal dimensions, for the latter responsible development is primarily about ensuring safety. This variety of 'responsibility' both in the literature and in practice calls then for a discussion on what kind of responsibility and responsible development we are looking for. In the following chapter, Paolo Magaudda raises a different perspective about the relationship between responsibility and nanotechnology by focusing of the way responsibility is performed in the actual work of a nanotechnology facility in Italy. In this case, the focus of the analysis is moved to a different perspective, which regards the activation of different forms of mutual responsibility between the actors involved in the work of nanotechnological innovation. Specifically, in the case of innovation performed by a 'boundary organization', we see from the research work of Magaudda that the construction of frameworks of responsibility is linked to at least two aspects: on the one side, to the organizational forms developed to give life to the collective actors emerging during the planning of the research center considered; and on the other, to the strategies and practices of collaboration with other actors, implying the establishment of frameworks of responsibility as well as of distribution of risks and of the

construction of regimes of reciprocal trust. In the final chapter of the section, Simone Arnaldi examines the news stories about nanotechnology in the Italian daily press to identify the different representations of responsibility in the coverage. The chapter extends the current research on the definition of responsibility by nanotechnology practitioners and highlights how responsibility is predominantly defined in the terms of the 'traditional contract of science'. This implies that scientists' responsibility is primarily to further scientific knowledge and deliver to society the benefits promised by scientific advances. Also, the analysis shows that the underlying division of labour underlying the 'traditional contract of science' also limits the number and variety of topics on which different social actors can be rightfully considered as sources for the coverage. More specifically, the discussion of radical uncertainties surrounding the nanotechnology enterprises, of precautionary measures, of new institutional arrangements for deliberation on science and technology, is left entirely to civil society organizations, citizens, and humanities scholars.

Finally, an *Epilogue: Nanotechnology beyond nanotechnologies* has the goal to link the discussion on responsibility in nanotechnology development to the broader debate on responsible governance of science, technology and innovation. In this final chapter, Armin Grunwald examines the approach to Responsible Research and Innovation (RRI) and traces back its roots in the debate on nanotechnology. In so doing, the Author shows that the relevance of the debate on nanotechnology and ethics is by no means limited to nanotechnology itself and, instead, it decisively affected the development of a more general 'model' for dealing responsibly with new and emerging sciences and technologies. RRI is presented as an integrative approach to current available instruments to shape science and technology and a multi-fold understanding of responsibility is introduced, which acknowledge three important dimensions (epistemic, empirical and normative). The chapter then examines how, historically, the RRI notion emerged in the context of the nanotechnology debate from the National Nanotechnology Initiative of the U.S. on and how it was then taken up by the European nanotechnology policy. The debate on the Code of Conduct for nanotechnology research and development set in practice by the European Parliament is presented as a landmark in this process and the 'career' of RRI up to the new European research framework programme Horizon 2020 is then recalled. In sum, the chapter shows the parallel development of nano-ethics on the one side, and the debate on Responsible Research and Innovation on the other, thus supporting the view that the emerging debate on the ethics of nanotechnology, as a new and emerging technology promising revolutionary potential but also unclear risk, contributed to the shape of the broader notion of RRI.

1.3 Dealing with an Intractable Object: Perspectives on Responsibility

The overall picture that emerges from this volume reflects the theoretical and empirical diversity of the concept of responsibility. Indeed, by catching and disentangling the different ways in which responsibility can be understood and discussed in

nanotechnology development, the concept of responsibility turns out to be complex, multiform and, above all, lacking an univocal definition.

This collection of essays and the tripartite structure described above offer useful entry points to explore the meanings of responsibility, and its junction with nanotechnology. This section of the introduction briefly illustrates three major, horizontal themes that are developed in the essays.

1.3.1 What's in a Name: Responsibility and Social Relationships

Although the different contributions in this book cannot offer a comprehensive picture of all aspects of responsibility, they can be scrutinized to seek (implicit or explicit) similarities and differences in their dealing with definitions and concept building, thus offering useful perspectives for further refinements of this notion.

As a starting point, Grunwald's chapter offers 'a four-place reconstruction [that] generally seems to be suitable for discussing issues of responsibility in scientific and technical progress' (cf. Grunwald). According to this Author, responsibility implies the following elements:

- *someone* (an actor, e.g. a nanotech researcher) assumes responsibility or is made responsible (responsibility is assigned to her/him) for
- *something* such as the results of actions or decisions, e.g. for avoiding adverse health effects of nano-materials, relative to
- *rules and criteria* which orientate responsibility from less responsible or irresponsible action, and relative to the
- *knowledge available* about the impacts and consequences of the action or decision under consideration, including also meta-knowledge about the epistemologic status of that knowledge and the uncertainties involved.

Responsibilities are, therefore, assigned or assumed, thus implying different degrees of active, autonomous commitment of an agent. Assignments and attributions of responsibility affect concrete actors in concrete constellations and are the result of situated social and organizational configurations, which variously connect these four elements. For instance, 'rules and criteria' can define what is relevant as an object of assessment in terms of responsibility ('something'), and what knowledge is relevant for individuals, groups and organizations in such an assessment ('knowledge available'). In turn, the 'knowledge available' can either narrow or broaden what constitutes a consequence (e.g. side effects, long term impacts, etc.), and help define new 'rules and criteria' for responsibility orientation.

Drawing on their discussion of the etymology of the word responsibility (from the Latin word *re-spondeo*, with the two related meanings of 'responding' and 'ensuring'), Ferrari and Marin distinguish four, connected meanings of this notion: (1) responsibility as responding for something, (2) responsibility as responding to someone, (3) responsibility as responding for someone, (4) responsibility as ensuring. In their account, action and its consequences ('something') are central

in the discussions about responsibility (*responsibility as responding for something*). Responsibility can be either assigned to or assumed by an agent for her past or future (see below for a development of this aspect), but also, in several cases, for others' action or condition (*responsibility as responding for someone*). Taking responsibility implies the idea of making a commitment to use one's own knowledge, skills, and capacities for ensuring that such a commitment is met (*responsibility as ensuring*). However, no responsibility is possible without a constituency: someone is always responsible (for something, somebody or both) to somebody else, be it a concrete agent (e.g. you, your children, your dog) or an abstraction (e.g. future generations, the people) (*responsibility as responding to someone*). Listening to the needs, desires, questions of others is therefore an undeniable condition of responsibility, because '[a]s a matter of fact, an answer requires both that there is a question and that the content of the question is being listened to' (cf. Ferrari and Marin).

Referring again to Grunwald's four elements, these different forms of responsibility are all assessed against diverse 'rules and criteria' that orient assumption, assignment, and their evaluation. On 'rules and criteria', the chapters in the book adopt different stances, that correspond to two general orientations in the academic debate. On the one hand, several chapters adopt a *descriptive approach* to this aspect, considering requirements and attributions of responsibility to concrete actors in concrete constellations are examined (Bos and van Lente; Fleischer, Jahnel and Seitz; Daloiso and Spagnolo; Pellegrini; Magaudda; Arnaldi; and, partly, Davies, Glerup, and Horst). On the other hand, *normative criteria* for orienting responsible action are sought on a more general level by resorting to utilitarian (cf. Colussi) or other approaches (cf. the 'responsible stewardship model' proposed by Zullo).

The different contributions in this volume can be integrated in a simple, but coherent scheme underlying the understanding of responsibility in the whole book (see Fig. 1.1). Such an understanding places responsibility squarely in the context of social relations, broadly understood, i.e. responsibility has no meaning if it is not a *responsibility to someone* (to be understood as specified above). On a broader level, organizational configurations and policy mechanisms grant institutional force to specific rules and criteria, thus setting boundaries, constraints, and directions for responsible actions (cf. in particular Bos and van Lente; Pellegrini; Magaudda for a reflection on this dimension). Eventually, responsibility is affected by what, in a loose sense, we may call structures, i.e. the material and discursive settings defining science, technology and society relations, which shape the general frame for discussions about responsibility (cf. Davies, Glerup, and Horst; Arnaldi). The contents of responsibility, the dynamics of assumption and assignment, the possibility and conditions of assessment of 'responsible' action are articulated across these three dimensions (see below the next section of the introduction for a development of this topic).

Also, the chapters converge remarkably in treating responsibility in forward-looking terms. The distinction between backward-looking (or retrospective) and forward-looking (or prospective) responsibility has an important place in the definitional