
What Makes New Science and Technology Meaningful to Society?

Intensive and sometimes controversial debates about new forms of technology, especially those embodying a visionary perspective, have become a dominant field of communication between science, technology and society in the past decades. They make up the largest portion of the debates in the field of responsible research and innovation (RRI). In this introductory chapter, I ask how the social and ethical interest in new technology arises – in other words, how scientific and technical developments in the laboratory or in modeling are given real social meaning. The directions I examine in this book exist in a practical context. The objective is to clarify RRI studies and discussions about their roots and thus to contribute to a more transparent democratic debate over the direction and utilization of scientific and technological progress. The generation of sociotechnical meaning, which – according to my thesis – is essential for making new technology interesting for RRI debates, is not a task for scientists and engineers alone but requires public involvement.

1.1. Motivation and objectives

The debate on responsible research and innovation (RRI) [OWE 13a, VAN 14a] has so far been focusing on a comprehensive understanding of innovation [BES 13], on participatory processes to involve stakeholders, citizens and affected persons in design processes and decision making [SYK 13], on understanding responsibility in industry [IAT 16], and on ethical conceptions of responsibility [GRI 13, GRU 14a, GIA 16]. Furthermore, it is concerned to a large extent with identifying specific characteristics of RRI in order to distinguish it from established approaches to reflection on science and technology, such as technology assessment [GRU 09a], value sensitive design [VAN 13a], science, technology and society (STS) studies

[WOO 14] and applied ethics [CHA 97]. Considerable effort is spent on profiling RRI among these approaches [OWE 13b, GRU 11a, VON 12].

These topics are without a doubt central to the further development of RRI. However, other aspects might also be crucial and must not be neglected. A question that has so far attracted hardly any attention is how the issues and challenges that are analyzed, discussed and reflected from different perspectives in the context of RRI come into being. My supposition is that this question is uncharted territory for RRI that is untapped in both an analytical and a practical sense. The goal of the book is to undertake some first steps toward exploring this uncharted territory. To provide a brief outline at the outset, I would like to make five observations at the beginning that should motivate the analyses presented in this book:

1) A *first observation* motivating this book is that RRI debates in the field of NEST¹ (new and emerging science and technology) do not focus on those technologies *as such*. For RRI debates to arise at all, the respective NEST developments such as synthetic biology, human enhancement or autonomous robotics must rather show relevant *meanings* [VAN 14b] in ethical, cultural, economic, social or political respects. A purely scientific breakthrough or a huge experimental success in laboratory research does not have any societal meaning *per se*. They may be scientifically or technologically fascinating but will not find resonance beyond unless a *further step* is done: it is only the *sociotechnical* combination of scientific and technological advance or projections, on the one hand, and their possible societal consequences and impacts, on the other, which triggers RRI debates. There would not be any RRI interest in NEST developments without the technological advance stories being related to expected, promised or feared societal consequences and implications. Only this second step makes new science and technology meaningful to society and a fascinating and often contested issue in society and its RRI debates. Then, questions will arise as to what might be in store for us or for future society, what might be at stake in ethical, political or social respects and what the NEST developments under consideration could mean in different respects for the future of humans and society. It is precisely these questions on the sociotechnical meaning of NEST that constitute the paramount object of the often controversial RRI debates. Thus, it appears obvious that we must deal explicitly with the issue of how these meanings are created and attributed, what their contents are, how they are communicated and disseminated and what consequences these attributions of meanings have in the RRI debates and beyond, e.g. for public opinion forming and political decision making.

¹ RRI is obviously not restricted to NEST fields and also covers innovation in more mature fields of technology, such as technologies for transforming the energy infrastructure. However, in this book, I will focus on NEST fields and consider case studies in this area only (see Chapters 5–8).

2) The *second observation* guiding the analyses in this book concerns the role of futures for the creation and assignment of meaning, in particular the role of techno-visionary futures in NEST fields. A large body of research literature of the recent years legitimates stating that a major mechanism of assigning meaning to NEST developments is telling stories about the future impact and consequences, the expected benefits and risks of new technology under consideration for the future development of society, humankind or individual life. Techno-futures, in particular techno-visionary futures, play a key role in the attribution of meaning to NEST developments. In these futures, projections of new technology are associated with future images of humans and society, often in a purely hypothetical and thus also speculative manner:

“Those anticipations are meaning-giving activities, and their function is to prevent choices being taken blindly, or on the basis of too narrow fantasies of future actions which focus only on a sub-selection of possible follow-up actions and ignore significant groups of stakeholders” [VAN 14b, p. 102].

This observation (see Chapter 3) makes it possible to productively use the knowledge acquired in the previous decade about the role of techno-futures and visions [SEL 07, ROA 08, GRU 12a, COE 13, NOR 14] in order to investigate how meaning is assigned to new technologies by relating them to narratives of the future. These narratives involve perceptions, issues being considered as problems, expectations and hopes, worries and anxieties that give rise to questions and controversies. This field of “contested futures” [BRO 00] provides plenty of substance for RRI debates.

3) While the observation of the meaning-giving role of futures has already been discussed sporadically over the last years, the issue of how new sciences and technologies are defined and characterized and what the corresponding scoping processes and debates on an adequate characterization add to the meaning of those sciences and technologies has not been explicitly considered yet. Despite the fact that we have witnessed extensive and complex debates on the definition of nanotechnology [SCH 03, DEC 06], on the understanding of synthetic biology compared to other fields of biology and biotechnology [PAD 14], and on the understanding of human enhancement [GRU 12b], there is no conceptual debate on the meaning-giving function of these debates and processes. This seems surprising because obviously answers to questions such as what is substantially different between the NEST developments under consideration and existing lines of research and development are of high importance to attach societal meaning to them (see Chapter 4). Thus, the *third observation* to be substantiated in this book is that processes and controversies around the definition and characterization of new sciences and technologies are of major relevance for assigning meaning to them.

4) At this point, a *fourth observation* motivating this book becomes apparent. The attribution of meaning to a new technology by relating future stories to it or by proposing specific definitions usually takes place at a very early stage of development. In most cases, it will precede the respective RRI debate or accompany it in its nascent stage, but can then strongly mold the debate's further development. Whether, for example, enhancement technology is attributed the meaning of offsetting inequalities in the physical and mental attributes of different humans and thus of leading to more fairness, or whether it is supposed to be used to fuel the competition for influential positions in the sense of promoting super-humans illustrates the great difference. Depending on which prevails, the respective NEST field will be assigned to one of these completely different discussions and put in a different context. The example shows that the assignment of meaning can heavily influence public debates and can possibly be crucial to public perception and attitudes by highlighting either chances or risks. At the end of the day, the assignment of meaning may even be decisive for social acceptance or rejection of that technology as well as for policy and decision making on the promotion or regulation of research and development. Thus, the possibly high impact of assigning meaning to NEST developments leads to the postulate of an early critical reconstruction, analysis and assessment of those meaning assignment processes, their results and their communication in order to enlighten the debate and to shed light on blind spots of those processes and debates (see section 1.2).

5) The *final basic observation* guiding the analyses to be provided in this book is that uncovering processes of assigning meaning to NEST developments involves considerable conceptual and methodological challenges. The assignments of meaning via techno-visionary futures, on the one hand, and by processes of definition and characterization, on the other hand, are interpretations, associations and, in the case of futures, partially speculations showing an epistemologically precarious nature and lacking strategies of proving them objectively. Mostly, it is extremely difficult or even impossible to say anything about the validity and reliability of those meaning-giving propositions – which, however, might have a major impact following the fourth observation above. This observation raises the questions of how to provide a well-reflected orientation for society and decision makers involved in NEST debates and policies. Provision of orientation knowledge is at the core of RRI – however, in the situation of lack of valid knowledge, traditional approaches based on consequentialist reasoning do no longer work (see Chapter 3) [GRU 14b]. If RRI and technology assessment nevertheless is to substantially contribute “to achieve better technology in a better society” [RIP 95] by analyzing meaning-giving processes, new approaches have to be developed. The *hermeneutic approach* sketched in this book will contribute to the development and application of a new type of reasoning and policy advice in debates on future technology beyond traditional consequentialism. Its objective is to

allow deciphering the meanings assigned to NEST developments as early as possible in order to allow and support more transparent and enlightened debate.

These five observations are illustrated in Figure 1.1, which presents two elements:

– first, the creation and development of meaning and its attribution, whether by means of technology futures or characterizations, are regarded a *hermeneutic circle*: the available meanings on offer are communicated and discussed and, in the process, supplemented or modified. The history of the definition of nanotechnology [SCH 03] is an excellent example of this (see Chapter 5);

– second, this hermeneutic circle itself must have been created at some point. There must have been acts in which meaning is attributed, representing the first steps, and the hermeneutic circle mentioned above can then develop out of them. For nanotechnology, Richard Feynman’s famous lecture [FEY 59] or the book *Engines of Creation* [DRE 86] might have been such first steps or at least early steps in the process of creation.

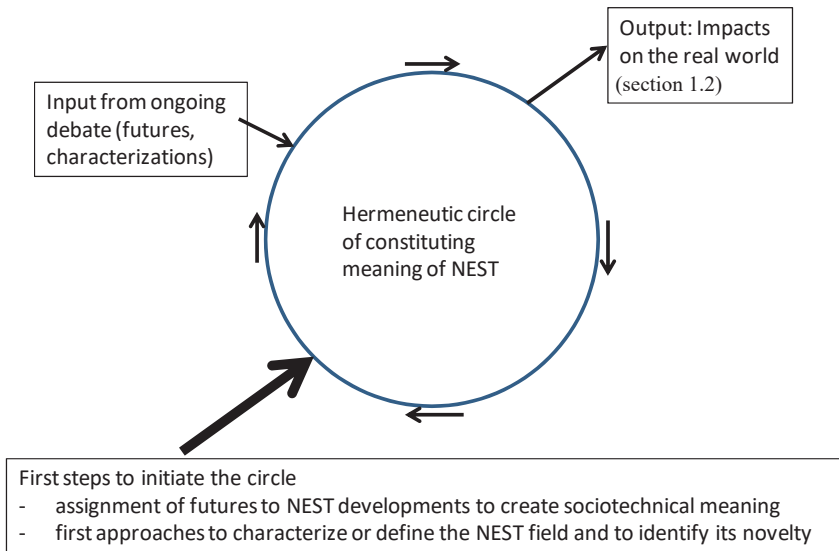


Figure 1.1. *The creation of meaning for NEST in a hermeneutic circle, including its stimulus*

The illustration makes it clear how great an influence such initial steps can have by decisively molding the ensuing debate and that in the hermeneutic circle these steps can only be gradually modified by alternative suggested meanings. On the other side of the image, so to speak as the output of the hermeneutic circle at a

certain point in time, are the real consequences (section 1.2), for example with regard to funding for research or shaping the social debate. Clarification of the workings of the hermeneutic circle, in particular of its beginnings, is therefore a central task for us to be able to discuss the real output in as transparent a manner as possible, for instance, in the framework of public debates.

It is interesting to observe that the concept of hermeneutics – the study of understanding and meaning themselves – has been mentioned from time to time, although not frequently, in the RRI debate in the last few years. Probably, this is neither a coincidence nor simply a passing fashion. On the contrary, the use of the word “hermeneutics” signifies a growing accumulation of knowledge and diagnoses that have been obtained from technology assessment (TA), science, technology and society studies (STS studies), sociology of expectations [VAN 93], applied ethics and the philosophy of technology in working with the new and emerging sciences and technologies. This result is especially the consequence of studies of techno-visionary projections of the future [NOR 07a, SEL 08, FER 12] putting more emphasis on the meaning of these projections as expressions of today’s diagnoses, perceptions, expectations, attitudes, hopes and fears instead of interpreting them as anticipations of what the future will or might bring. In particular, the word “hermeneutic” has been used in the following contexts:

– *reinterpreting the nature of futuristic visions*: the idea that visions could anticipate future worlds that we would have to prepare ourselves for was reinterpreted to be the question as to what these visions say *about us today* [GRU 14b]. This reinterpretation, which was the result of a discussion about vision assessment [GRU 09b, FER 12], has turned attention to understanding techno-visionary futures as a means of preparing a diagnosis *of the present*;

– *understanding instead of predicting*: the expectation that technology assessment is supposed to predict future developments more or less precisely, as is mentioned over and over again, frequently cannot be realized, especially in the field of NEST. Qualitative understanding must come first. Helge Torgersen [TOR 13] sees a hermeneutic task of technology assessment in analyzing NEST;

– *attributing meaning to new areas of technology*: Simone van der Burg [VAN 14b] sees visionary futures as a means of giving sense and meaning to NEST, such as via the visionary embedding of technical developments in future social constellations. This production of meaning, not the anticipation of future developments, is the primary function of uncertain and speculative futures according to van der Burg.

While these references seem to be more or less isolated, they will be used as points of departure to expand them in this book in order to enable a more systematic study of hermeneutic questions in the NEST debates. The hermeneutic approach to

better understand processes and contents of assigning meaning to new technology will add meta-information to the RRI debates about the techno-visionary futures dealt with there and about the processes of definition and characterization of NEST developments. This meta-information includes information about *the respective current world* in which the techno-visionary futures are created and communicated, but not statements about the future as a coming reality. The hermeneutic turn [GRU 14b] changes the perspective: understanding the meanings of techno-visionary futures leads us back to the present. It is this meta-information that heightens a debate's reflection and transparency and thus helps make the debate open and unbiased in the sense of a deliberative democracy. Similarly, a hermeneutic analysis of processes of defining and characterizing NEST should help uncover the background of present diagnoses and perceptions motivating these proposals.

This perspective, based on the normative ideal of a deliberative democracy in the field of designing and governing the development and use of new technology, claims to add new accents to the RRI debate so far. It is based on the five above-mentioned observations that serve as questions or hypotheses guiding the analyses and argumentation presented in this book. Briefly, they may be summarized here as the major starting points:

1) *The attribution of meaning* to new technology plays a large role in the NEST debates and in the respective deliberation processes and controversies [VAN 14b]; subjects of RRI debates are not new technologies *as such* but are rather sociotechnical meanings assigned to them.

2) *Techno-visionary futures* and other types of narratives of the future constitute a major medium of assigning meaning to new technology; they usually *cannot anticipate* future developments but fuel *current and ongoing* debates and controversies to form opinions and make decisions today.

3) Debates *on the definition and characterization* of NEST are highly relevant to assigning not only scientific and technological but also ethical and social meaning to them and should thus be included in a hermeneutic enlightenment of the emergence of meaning.

4) *Orientation* for society and decision makers is needed because the assignment of meaning may have major consequences despite the lack of knowledge about expectable future consequences.

5) The *hermeneutic perspective* will investigate and uncover these meanings in order to increase transparency, expecting *that democratic deliberation and argument-based reasoning* will benefit.

This means that we are required, not merely entitled, to reflect conceptually and methodologically on the creation and attribution of meaning in the RRI debates on NEST fields. The identification of two major origins of the production and assignment of meaning – techno-visionary futures, on the one hand, and approaches to define and characterize new fields of science and technology, on the other hand – has structural consequences for this book. Both roots of meaning will be described conceptually in more detail their dedicated chapters (Chapters 3 and 4), while the case studies on various NEST fields (Chapters 5–8) will address both tracks by applying a hermeneutic perspective.

The book extends the state-of-the-art concerning the hermeneutic perspective on futures and definitions of NEST, and their use by different actors in conceptual and methodological terms adds several new aspects to the RRI debate, and will motivate further lines of exploration and reasoning in this direction. As the first monograph on the hermeneutic side of RRI and its accompanying NEST-related debates, it will bundle and focus research done so far, provide insights by applying a more comprehensive and comparative perspective and give orientation for further research on NEST-related techno-visionary communication.

1.2. The need for orientation in NEST fields

This book – which is by all means theoretically oriented, as shown by the issues it pursues – ultimately owes its origin to practical interest. The backdrop for this is the practical claim of technology assessment, for which I stand [GRU 09a], as well as that of RRI to provide orientations that are based on knowledge and research in order that research and innovation can be conducted in a responsible manner and lead to ethically and socially good results [VON 13, VAN 13a]. With this goal and obligation in mind, the observations made above show that their realization requires a deeper look at the processes of creating and attributing meaning to developments in NEST. Both the philosophically motivated questions as to meanings and their provenance, on the one hand, and the theory-driven and empirically underpinned answers, on the other hand, remain fundamentally tied to a practical interest in pursuing knowledge: the objective is to improve the prospects for RRI to meet the expectations placed in practical orientation. In order to underpin this primacy of practice, I will initially specify the central arguments as to why orientation is at all necessary in the field of NEST.

NEST developments are by definition at an early stage of development (section 1.3) and still strongly rooted in basic research. Does it make any sense at all to demand public debate on such topics and to expect political and social orientation? Should we not instead let scientists doing basic research continue their research? Are the positive and negative visions linked to them anything more than simple

speculation? Are the rudiments of definitions and characterizations anything more than conventions that serve bureaucrats to manage the new phenomena and do not contribute anything to the issue itself?

Thus, it is not a matter of course at all that orientation beyond basic research is needed. One could argue that many NEST debates are so speculative that they are hardly of any practical consequence, as suggested by some arguments in the context of speculative nanoethics [NOR 07a]. It might accordingly be interesting in an abstract philosophical but merely academic sense to discuss some obviously speculative questions, such as overcoming death. There might be some interest in circles of intellectuals or in the feuillets of magazines. Yet, in view of the speculative nature of those questions, serious concern was expressed that the intellectual effort and the resources spent might be completely irrelevant in a practical sense [NOR 09]. Also the effort spent on defining and scoping processes (Chapter 4) might be regarded as driven by mere academic interest without any practical consequences. However, this argumentation is misleading [GRU 10a].

While futuristic visions and other types of techno-futures ranging from high expectations to apocalyptic fears are often more or less fictitious in content in the NEST fields, such stories about possible futures can and often do have a real impact on scientific and public discussions [SEL 08]. Even a picture of the future lacking all facticity can influence debates, the formation of opinion, acceptance and even decision making [GRU 07a] in at least two ways [GRU 13a]:

- techno-futuristic stories and images can change the way we perceive current and future developments of technology, just as they can change the prospects of future societal constellations. Frequently, the societal and public debate about the opportunities and risks associated with new types of technology revolves around those stories to a considerable extent, as has been the case in the field of nanotechnology (see Chapter 5) [SCH 06] and as is still the case in human enhancement (see Chapter 7) [COE 09]. Visions and expectations motivate and fuel public debate because of the impact the related narratives may hold for everyday life and for the future of important areas of society, such as military, work and health care. Furthermore, they are related to cultural patterns [MAC 10]. Positive visions can contribute to fascination and public acceptance and can also attract creative young scientists to engage themselves there, just as negative visions and dystopias can cause concern and even mobilize resistance as was feared in particular in the early debate on nanotechnology [GRU 11b];

- techno-futures exert a particularly great influence on the scientific agenda which, as a consequence, partly determines what knowledge will be available and applicable in the future [DUP 07]. Directly or indirectly, they influence the views of researchers and, thus, ultimately also exert influence on political support and research funding. For example, even the speculative stories about improving human

performance [ROC 02] quickly aroused great interest among policy makers and research funders [NOR 04, COE 09]. Projections of future developments based on NEST expectations therefore might heavily influence decisions about the support and prioritization of scientific progress and the allocation of research funds, which then will have a real impact on further developments.

In this context, I can draw on some practical experience gained in recent years which indicates that policy makers are well aware of the factual power of techno-visionary communication and are seeking policy advice in the areas involved. As an early example: a chapter about techno-visionary communication on human enhancement, converging technologies (nano-bio-info-cogno convergence) and other far-reaching visions compiled by the Office of Technology Assessment at the German Bundestag (TAB) was very well received by members of the Bundestag as part of a comprehensive TA study on nanotechnology [PAS 04]. The authors came to the conclusion that this techno-visionary discourse played an important and to some extent new role in the governance of science and technology at least in civilian research and development, while also entailing new challenges for TA. Interestingly, several policy makers and also experts in nanoscience and nanotechnologies communicated to the TAB team, or even publicly commented, that they found the study's discussion of futuristic visions and description of the networks promoting them very useful. The TAB team's initial concerns that discussing these often far-fetched visions in a study that would become an official document of the parliament and an influential early publication on nanotechnology could cause irritations thus proved to be unfounded [GRU 11b]. Subsequently, TAB was requested to conduct several other projects to explore various issues in the field of converging technologies in more detail: studies on the politics of converging technologies at the international level [COE 08a], on brain research [HEN 07], on *pharmacological and technical interventions for improving performance* [SAU 11] and on synthetic biology [SAU 16]. Recently, the ceremony of the 25th anniversary of the foundation of TAB in 1990 was – upon request of members of parliament – dedicated to the issue of blurring the lines between humans and technology, e.g. by developments toward human enhancement and autonomous robots.

The interest of policy makers in techno-visionary futures is also evident at the European level, where NEST developments have been addressed by a fairly large number of projects (see, for example, Coenen *et al.* [COE 09] on human enhancement) and other advisory activities such as the reflections on nanotechnology, synthetic biology and ICT implants conducted by the European Group on Ethics in Science and New Technologies [EGE 05]. The situation is much the same in the United States (see, for example, the work done by the Presidential Commission for the Study of Bioethical Issues [PRE 10]). Thus, demand for policy advice on NEST developments is evident, and a large number of respective studies have been delivered over recent years to meet this demand.

Definitions of nanotechnology, synthetic biology and the meaning of the word “autonomous” in autonomous robot systems have long been topics of controversy. We can learn from these and other stories about definitions that the definition and characterization of new technological developments are by no means a purely academic activity for simply creating order. On the contrary, definitions and characterizations play a decisive role in determining the nature of what is new. Yet, whether something is classified as *radically* new or as something developing bit by bit out of something familiar has immediate consequences for the social attribution of meaning. Definitions and characterizations as well as futures can also be distinctly influential (see Chapter 4) because such associations are often directly linked with associations of meaning. For example, whether the genetic modification of organisms is categorized as a new type of biotechnology without any role models in human history or as the further development of breeding techniques can have consequences for the course of social debates and lead to controversies that definitely also have something to do with the meaning of NEST.

The practical purpose of this book can be summarized as putting the spotlight on the beginnings of the hermeneutic circle of reaching an understanding on the meaning of NEST developments (see Figure 1.1). It is at these initial stations of the attribution of meaning that far-reaching decisions with possible path dependencies are made that can (or are supposed to) limit the diversity of alternatives in the subsequent RRI debates. The interest in clarifying these origins that stems from democratic theory consists of the fact that attributions of meaning can have real consequences (see above), that they are aligned with power, and, in view of the possible far-reaching consequences of NEST, that they should be the object of a transparent democratic debate. To make this possible is the purpose of the hermeneutic perspective.

An open, democratic discussion of visionary sciences and technologies and their possible meanings is a prerequisite for a constructive and legitimate approach to shaping the future research agenda, regulations and research funding. The factual significance and power of visions, on the one hand, and of definitions, on the other hand, for the governance of science and in public debates are a strong argument in favor of the necessity of providing early public and policy advice in the NEST fields. Policy makers and society should know more about these positive or negative visions, their genesis and their background, as well as about implications of definitions and characterizations. The postulate to open the “black box” of the creation and assignment of meaning and to make the implicit explicit is supported by calls for a more democratic governance of science and technology [SIU 09]. Its realization requires uncovering meanings, values and interests hidden in the technofutures and communicating proposals of definition. Thus, gaining a comprehensive understanding of the meaning of the NEST developments under consideration forms the necessary basis for reflecting on responsibility and is an indispensable part of

RRI processes (see Chapter 2). Because the use of techno-futures to assign meaning to lines of techno-scientific developments is a social process of construction carried out by many actors, full understanding of the (often contested and debated) meanings of techno-futures necessarily includes knowledge about the strategic actor constellation in which the respective assignments of meaning were made. Something similar holds for the various and in parts competing and controversial attempts to give adequate descriptions of the new fields and to work toward a meaningful and operable definition which should be as clear as possible.

Thus, the main purpose of the hermeneutic approach proposed in this book is a practical one in the tradition of technology assessment [GRU 09a]: it aims to support or even enable an open and transparent democratic debate on RRI during the early stages of development by providing a specific kind of knowledge and orientation [GUS 14a].

1.3. Short propaedeutic

The notions of NEST developments (section 1.3.2) and techno-visionary (section 1.3.3) futures being central to one of the meaning-creating processes need a propaedeutic clarification. These clarifications are preceded by a brief introduction of the crucial notion of meaning itself (section 1.3.1).

1.3.1. The meaning of “sociotechnical meaning”

The subject area of this book is the sociotechnical meaning of NEST developments as the topic of RRI debates. Initially, the word “meaning” refers to understanding. The object is to examine how meanings originate and what influence they have on science and technology debates. Corresponding to the first observation at the beginning of the chapter (section 1.1), NEST fields only become interesting for RRI debates when such sociotechnical meanings are involved. It is not the fields of science and the area of technology as such that are the subject of such debates, but rather their sociotechnical meanings. These, in turn, can consist of connections between scientific-technical projections into the future, on the one hand, and social developments, on the other hand, or express themselves in definitions and characterizations of these fields. At a conceptual level, the book is dedicated to understanding the creation and the communication of these sociotechnical meanings.

From this perspective, the book forms part of the meanwhile comprehensive literature on science and technology in which they are no longer viewed as something external to society but from the beginning as inherent components of society. Concepts such as the coevolution of technology and society [BIJ 94] or

socially embedded technology [WOO 14] and talk about sociotechnical transformations of infrastructures [GEE 02] stand for this integrative view, just as does talk of “science in society” instead of “science and society” [SIU 09].

The concept of “meaning” can be further unfolded from the perspective of language pragmatics. Meaning is then not abstract, but must always be made more precise as the meaning *of something* (object) *for someone* (addressee) in a specific context. It is only in this constellation that it is possible to ask about the arguments for specific attributions of meaning. This also makes it clear that meaning is not an ontological quality that is objectively linked to its object, but that meaning is *attributed* by using arguments. The concept of meaning thus stands – just as, for example, that of responsibility (Chapter 2) – in a social and communicative context in which arguments for attributions are expected but can also be controversial. Hermeneutics is the art of understanding meanings and the processes of the attribution of meaning and has to be, as such, conceived in an interdisciplinary manner (see Chapter 9).

1.3.2. NEST: new and emerging science and technologies

The notion of NEST refers to several new lines of scientific research and development of the past approximately 20 years, such as nanotechnology, synthetic biology, enhancement technologies, robotics, the different “omics” technologies and climate engineering. They have in common several aspects, of which three are of particular significance for the subject of this book: (1) NEST developments blur the classical boundary between science and technology and lead to the emergence of *technoscience*; (2) NEST developments provide *enabling technologies* with only little knowledge about future consequences; (3) particular *communication patterns* have evolved around NEST areas:

1) The scientific-technological development of the past decades has made the traditional boundaries between technology and the sciences more permeable. One example is that technical interventions in the sphere of molecular biology have led to genetic engineering, which can be understood as a classical (natural) science but as technology as well. This observation led to the notion of *technoscience* [LAT 87, IHD 09] describing recent developments in science and engineering as overcoming traditional boundaries. This diagnosis also applies to synthetic biology [KOL 12]. In particular, it has consequences for the assignment of responsibility because the traditional boundary between technology-oriented applied science and cognition-oriented basic research is disappearing. While traditionally basic research is confronted with expectations to take over responsibility only for the research process itself but not for possible later outcomes in terms of technology and innovation, the situation in applied science is different. Because its target is to develop knowledge to be used and applied, e.g. in technology, the reflection on

responsibility issues related to those applications intimately belongs to applied research. Following the diagnosis of NEST fields being *technosciences* belonging to both areas gives rise to the question of an adequate distribution of responsibilities specifically regarding this situation and of a specific NEST-ethics approach [RIP 07];

2) NEST developments lead to *enabling technologies*. Their aim is not to create products and innovations in specific areas of application, but they are open for a multitude of applications in greatly differing fields. They enable these applications. For example, nanotechnology was regarded as an enabling technology [FLE 08]. There are some original nanotechnology products such as nanoparticles for medical applications. But in many more cases, a nanotechnology component will be a decisive part of a much more complex product where the nano content might not be identified or recognized easily. These products are and will continue to be increasingly used in a number of fields, such as energy technology, information and communication technology or biotechnology. For many nano-enabled technologies, it therefore might become increasingly problematic to attribute their consequences to nanotechnology (alone). Another example is synthetic biology. Despite the fact that it is predominantly laboratory research which raises fundamental questions far away from concrete application, there are great promises of some protagonists of synthetic biology to create artificial organisms, to produce biomass or novel materials [BEN 05]. However, the feasibility and realization period of these visions are difficult if not impossible to assess. This is a general property of NEST: their “enabling” character is linked with a wealth of possible futures that are epistemologically very difficult to assess (Chapter 3);

3) It is precisely the futures that are difficult to assess (e.g. the techno-visionary futures) that lead to a specific form of communication: high to extremely high expectations, on the one hand, but just as dramatic anxieties, on the other hand, make these types of technology candidates for hope, hype and fear. They are believed to have the potential to solve global problems (hope), they are associated with far-reaching visions of the future and with over-reaching expectations (hype), and because of their impacts that are difficult to foresee and even less to control they raise concerns no matter whether they are well founded or not (fear). Therefore, these technologies attract a high degree of public and political attention, which might have huge impact on opinion forming and decision making (section 1.2).

These three characteristics of NEST developments are obviously central to the topic of this book. They influence the issue of defining new developments and are linked to the emergence of techno-visionary futures in scientific, social and political debates.

1.3.3. *Techno-visionary futures*

Since the industrial revolution and the success of the mobile and consumer society that is dependent on technology and innovation, modern society has pursued its further development primarily in the medium of technology. This scientific and technological progress and the opportunities tied to it as well as its limits, setbacks and unintended consequences are frequently a topic of social debate. These in turn mold the activity of development in the engineering sciences and become part, for instance, of the conception of a more sustainable society. Social futures are frequently sociotechnical images of the future, e.g. in the form of visions and utopias of nanotechnology or as futures of the energy supply. They enter social debates; initiate, structure and frame communication over opportunities and risks; and influence the public's perception of technology, research funding and political decisions. Even early ideas on new types of technology depend on evaluation, and evaluations depend on conceptions of future developments – goals, potentials, scenarios, risks, etc. – in the context of the respective type of technology. They have to work with technology futures. Technology futures thus constitute a frame of reference both for assessments and for the basic approaches to design in the most diverse fields, from philosophy to engineering sciences.

These technology futures can be very different in nature, such as energy scenarios, technology road maps, visions or even plans. Techno-visionary futures are at the focus of this book with its interest in the attribution of meaning to NEST. In the past decade, there has been a considerable increase in visionary communication on future technologies and their impacts on society. In particular, this has been and still is the case in the fields of nanotechnology [SEL 08, FIE 10], human enhancement and the converging technologies [ROC 02, GRU 07a, WOL 08a], synthetic biology [SYN 11] and climate engineering [CRU 06]. Visionary scientists and science managers have put forward far-reaching visions, which have been disseminated by mass media and discussed in science and the humanities. I will call them techno-visionary futures [GRU 13a].

The emergence of this new wave of visionary and partially futuristic communication [COE 10, GRU 07a, SEL 08] has provoked renewed interest in the role played by imagined visions of the future [JAS 15]. Obviously, there is no distinct line between different types of visions communicated in these fields and other imagined futures such as *Leitbilder* or guiding visions which have already been analyzed with respect to their usage in policy advice [GRI 00]. However, the following characteristics may circumscribe the specific nature of techno-visionary futures:

- techno-visionary futures refer to a more distant future, some decades ahead, and exhibit revolutionary aspects in terms of technology and culture, human behavior, individual and social issues;

- scientific and technological advances are regarded in a renewed techno-determinist manner as by far the most important driving force in modern society (technology push perspective);

- these futures are as other futures, too, social constructs – they have authors (section 3.2);

- the authors of techno-visionary futures are mostly scientists, science writers and science managers, such as Eric Drexler [DRE 86], Ray Kurzweil [KUR 05] and Craig Venter; but also NGO's and industry are developing and communicating visions;

- milestones and technology roadmaps are to bridge the gap between today's state and the visionary future state [ROC 02];

- high degrees of uncertainty are involved; this leads to severe controversies with regard not only to societal issues [DUP 07] but also to the feasibility of the visionary technologies [SMA 01].

Techno-visionary futures address possible future scenarios for visionary sciences and their impacts on society at a very early stage in their scientific and technological development. As a rule, little if any knowledge is available about how the respective technology is likely to develop, about the products such development may spawn, and about the potential impact of using such products. According to the control dilemma [COL 80], it is then extremely difficult, if not impossible, to shape technology. Instead, lack of knowledge could lead to a merely speculative debate, followed by arbitrary communication and conclusions (see Chapter 3).

The communication of technology futures represents an *intervention* in ongoing communication [GRU 12a]. It can trigger a turn in a debate and influence decisions, possibly depending on how consistent, plausible or scientifically well grounded the respective futures are. The reception of George Orwell's novel *1984* or the consequences of the report of the Club of Rome, *The Limits of Growth*, from 1972 are examples of this. It is this interventional character that leads to the known effects of being a self-fulfilling or a self-destroying prophecy and points to the special responsibility that is linked to the creation and communication of statements about the future. "Playing" with technology futures in social debates on technology, whether with warnings or hopes, is also a power game linked to values, interests and intentions.

1.4. A brief guide to this book

In order to explore the initial observations and the hypotheses on the origins of assigning meaning to new science and technology, a combination of theoretic analysis and learning from case studies is chosen (section 1.4.1). This approach together with the abstracts of the individual chapters (section 1.4.2) allows clarifying the claim of novelty and advance provided in this book (section 1.4.3).

1.4.1. *The flow of argumentation*

A twofold approach will be applied to scrutinize, unfold and underpin the initial observations presented in section 1.1:

1) Conceptual and theoretical analysis will be presented demonstrating limits to existing approaches as well as offering pathways to elaborate and apply new or extended hermeneutic concepts and methods. This is not to replace existing approaches but rather to complement them. The analysis mainly builds on theoretical and epistemological analyses of prospective knowledge and bundles preceding work (Chapter 3).

2) Observation-based analysis will be presented by introducing several case studies in order to substantiate and control the theoretical work. As a participant in many NEST debates over the past 15 years, I will draw on experiences in the fields of nanotechnology, robotics, enhancement technologies and climate engineering. The debates that have been taken place and their traces in the literature of technology assessment, STS studies and applied ethics constitute a rich corpus which can be reconsidered by applying the basic ideas of the hermeneutic approach.

Over the recent years, I have performed several case studies considering ethical and epistemological aspects of new sciences and technologies. These were accompanied by conceptual and methodological work on how interdisciplinary research could be established in order to provide better understanding of the creation, communication, dissemination and consequences of visionary thinking about these NEST fields and to explore opportunities to extract orientating knowledge for policy makers and society out of this better understanding. This book brings together work which has already been done (please see the origin and inspiration behind the chapters at the end of this book) with recent and new insights. My point of departure is existing work on the roles that techno-futures play as a medium of societal debates [BRO 00, SEL 08, COE 10, GRU 12a] and on the body of literature dedicated to techno-visionary futures in the NEST debates [NOR 10, COE 13]. In particular, this analysis builds on recent thoughts on vision assessment (see Chapter 3) [GRU 09b, KAR 09, FER 12] and on the first conceptual approaches to a hermeneutic perspective [GRU 14b].

Furthermore, I was engaged in some debates on the definition and adequate characterization of NEST fields. It was in particular the early debate on nanotechnology which involved a long-lasting and heavy controversy about an adequate definition (see Chapter 2) [SCH 03, SCH 06]. This debate led to some deeper reflections on what is expected of definitions and what they are meant to provide [SCH 03]. As far as I can see, this debate has not yet been reflected upon from a more theoretical point of view regarding the question of whether and how it has contributed to assigning meaning to the notion of nanotechnology. Shortly after, there was a debate on the understanding of synthetic biology with competing proposals for a definition [GRU 12b, PAD 14]. The debate on human enhancement, going back to the NSF publication on “Converging Technologies for Improving Human Performance” [ROC 02], was also from its very beginning accompanied by discussions about the meaning of the notion of enhancement and about the novelties involved compared to established technical support to humans. Considering these experiences, it may seem astonishing that the issue of defining and characterizing new fields of science and technology has not yet been systematically considered in the context of assigning meaning to those fields.

Conclusions from the analyses presented in the case studies (Chapters 5–8) with regard to the five initial observations will be presented in the concluding chapter (Chapter 9). Its objective is to consider the case studies from an overarching perspective and to arrive at a point of view that allows generalizable conclusions to be drawn [KRO 08]. In particular, this chapter aims to further develop the hermeneutic approach in conceptual and methodological terms, leading to both a scientific research program and a perspective to explore new types of scientific advice for society and decision making.

1.4.2. The chapters

The conceptual analyses given in Chapters 2–4 of this book and the case studies on several NEST fields presented in Chapters 5–8, as well as the final conclusions with respect to the provision of orientation (Chapter 9), aim to unfold and substantiate the initial theses and give some evidence to them as an offer and proposal for further research and reasoning. The further discourse in science and the humanities will then have to scrutinize their validity and fruitfulness. In this section, a short impression of the content of the subsequent chapters will be given in the form of abstracts in order to inform the reader briefly about the content of this book:

– Chapter 2 - *Extending the Object of Responsibility Assessments in RRI*: When using the notion of responsibility in everyday communication, this notion is usually supposed to have a more or less clear meaning. However, often this supposition does not hold in more complex fields, e.g. in responsibility debates on future science and

technology. An outline of a pragmatic approach to responsibility assignments in their social context will be given for clarification. Following this approach, assigning responsibility is a three-dimensional process with an *empirical*, an *ethical* and an *epistemological dimension*. Relevant questions in RRI debates touch upon *all* of these three dimensions (EEE). Particular emphasis will be given to the question of how the assignment of meaning to NEST developments and the postulate of responsibility are related. While the discussion about responsibility regarding NEST is usually concentrated on accountability for the possible future consequences of NEST, the question has not yet been raised as to the responsibility for attributions of meaning that are currently taking place for new developments in science and technology. In this chapter, I suggest that the subject area of RRI debates be extended accordingly because of the high degree of relevance of the attributions of meaning.

– Chapter 3 - *Assessing Responsibility by Considering Techno-Futures*: The epistemological dimension of the techno-futures in general and techno-visionary futures involved in RRI debates in particular is a major challenge to responsibility assessments. The considerable diversity of statements about the future and the divergence which often becomes apparent regarding the prospects of more visionary futures threaten the possibility of delivering the desired orientation and respective advice to society and policy making in the familiar consequentialist paradigm. The more divergent the envisioned futures, the more providing reliable orientation may have no chance of success. Against this background, three different modes of orientation provided by future studies and reflections are presented. In NEST fields, the hermeneutic investigation is of particular significance, where we can learn about ourselves from the diversity, variety and divergence of statements about the future. Policy advice can therefore no longer be expected to give concrete information about the consequences of technology but to undertake more hermeneutic and reconstructive work on the origin and content of the speculative and visionary futures. Meeting these challenges requires: (1) more knowledge about the emergence and dissemination of visionary futures as well as about the mechanisms by which they influence public debate and policy making, and (2) new assessment and reconstruction procedures concerning visionary futures. This hermeneutic approach aims at uncovering techno-visionary futures as “man-made” illustrations of the future as well as expressions of meaning given to new technology.

– Chapter 4 - *Definitions and Characterizations of NEST as Construction of Meaning*: Newly emerging fields of science and technology usually lead to challenges, uncertainties and debates about their adequate characterization and description up to clear definitions. The demand for definitions usually comes from outside science. For example, research funding agencies ask for definitions in order to become able to make clear decisions on whether an application for funding fits into the scope of an announcement, or not. Also in debates on regulation, reliable

and sharp definitions are required to demarcate the subject matter of the regulation and its boundaries. However, debates on definitions and adequate descriptions of NEST fields usually start much earlier. They are an important medium in a hermeneutic process of negotiation and deliberation on the meaning of those new fields. In particular, characterizations and descriptions of NEST developments include giving answers to the question of what exactly is regarded as new or perhaps even revolutionary compared to established fields of science and technology. This chapter presents a brief heuristics for defining and characterizing NEST fields as meaning-giving activities with short hints to the following case studies.

– Chapter 5 - *Understanding Nanotechnology: A Process Involving Contested Assignments of Meaning*: The debate on nanotechnology may be regarded as the prototype of NEST discussions. For the sake of illustrating the thesis that assigning meaning to the NEST fields is a crucial step in the early stages of development, I would like to recall three stations of the nanotech story in this chapter: (1) the issue of defining nanotechnology, (2) the issue of control versus openness, and (3) the issue of risk. In these short retrospect stories, it is easy to recognize that the attribution of meaning in the early phase of nanotechnology was an incremental experimentation, accompanied by conflicts and in parts extremely diverging future projections. In fact, this divergence was maximal, showing paradise-like futures on the one side and dark and apocalyptic fears on the other side. Contrary to many fears that this discussion would result in a massive social rejection of nanotechnology, a kind of “normalization” has taken place so far. The gradual hermeneutic appropriation of nanotechnology – the story of determining its meaning – likely made a major contribution to this enculturation of nanotechnology into society.

– Chapter 6 - *Robots: Challenge to the Self-Understanding of Humans*: Technology is becoming increasingly autonomous. Decision making is assigned to software to a strongly increasing extent. This development obviously raises ethical and juridical questions of responsibility and accountability which have already motivated several ELSI studies (ethical, legal and social implications). My interest is different. I want to uncover new and emerging constellations between humans and technology that could give rise to rethinking human self-understanding. The issue under consideration is the meaning of the frequently used notion that robots *are able to plan*. Planning, however, is according to philosophical anthropology, usually regarded as being deeply related to human capabilities, in particular regarding the anticipatory competence of humans. Based on planning theory, I will show that the analogy of both robots and humans being “planning beings” is limited to a specific model of planning. From this consideration, we can thus learn to distinguish more carefully between different meanings of planning. Planning is only one field where new constellations between humans and robots are emerging which need clarification of their importance to humans. It turns out that these developments can be subsumed under the deep-ranging ambivalence of technology between assisting

humans and controlling humans. In this ambivalence, new equilibria must be identified.

– Chapter 7 - *Enhancement as a Cipher of the Future*: Over recent years, the notion of enhancement has attracted increasing awareness in two areas: enhancing humans and enhancing animals by enhancement technologies emerging from the NBIC convergence (nano-bio-info-cogno). The notion of enhancement is intrinsically related to the idea of technological advance with its incremental approach. In contrast to notions such as optimization or perfection, it symbolizes an open-end development. Insights from a semantic analysis of the notion of enhancement will be used to better understand the debates on human and animal enhancement with respect to the attribution of meaning. While most reflections on human enhancement technologies refer to ethical questions and criteria, which usually focus on the individual level and on speculative issues, I will examine the questions following the hermeneutic turn: Are we witnessing a historical change from a performance society to an enhancement society with an inherent and infinite spiral of enhancement? Does such a shift also include increased self-exploitation and self-instrumentalization? I will pursue the hypothesis that what we can learn from the ongoing debate on human enhancement is about ourselves, society and our contemporary perceptions rather than about speculative future developments. Similarly, I will consider the recent debate on animal enhancement as an indicator of ongoing attempts to make changes transparent and conscious. Beyond the level of applied ethics issues, the hermeneutic interest addresses changing perspectives, attitudes and perceptions concerning the relationship between man, animal and technology. Uncovering meaning here is dedicated to creating more clarity on human images of animals. In both fields, it is the notion of enhancement with its semantic structure that gives rise to an extension of the object of responsibility in RRI debates beyond the consequences of enhancement for distant futures.

– Chapter 8 - *Technology to Combat Climate Change: the Hermeneutic Dimension of Climate Engineering*: Climate engineering has attracted a great deal of attention in light of expected major global problems that are generally thought to be caused by climate change. It cannot be ignored that “tipping points” may exist in the climate system with potentially catastrophic consequences. Examples of suggested measures to counter global warming that have come under scrutiny recently include iron fertilization of the oceans, air capture to reduce the CO₂ concentration in the atmosphere or the injection of sulfate aerosols into the stratosphere to induce a cooling effect. This field represents a good example of uncertain and disputed science and knowledge base involving precarious knowledge about the future, risk assessments and debates about possible strategies on a very fundamental level. Many scientists dismiss climate engineering because of unpredictable, dangerous and irreversible side effects. Others may imagine it as an *ultima ratio*, a drastic

measure to prevent a breakdown of the Earth's climate and to secure the survival of mankind. Thus, this recent field of interest also shows characteristics of a NEST field. This chapter aims to uncover underlying presuppositions, assumptions and attitudes in this field, arranged around relations between humans and nature. The hermeneutic analysis shows that climate engineering is closely related to the Baconian ideal of human dominion over nature and to unlimited techno-optimism. This leads to the postulate of extending the object of responsibility beyond the classical issues of risk and side effects in a distant future. Possibly changing attitudes concerning mitigation and adaptation strategies for dealing with climate change motivated by a new techno-optimism based on climate engineering must also be considered.

– Chapter 9 - *Hermeneutic Assessment: Toward an Interdisciplinary Research Program*: After having demonstrated the significance of assigning meaning to NEST for RRI debates in the previous chapters using paradigmatic cases, I will now briefly summarize some lessons learned. The main objective of this chapter is to roughly outline a research program for hermeneutic assessment which could serve the purpose of enlightenment. The largest part of the chapter is dedicated to developing perspectives for hermeneutic research on the processes of creation and communication of meaning assigned to NEST as well as on their consequences. These perspectives refer to the sciences and humanities to be involved as well as to appropriate methodologies. The chapter concludes with a brief epilogue with reference to the five initial motivations to write this book.

1.4.3. The achievements

The present book is based on earlier studies of mine (see the bibliography at the end of the book) and refers strongly to the debates over techno-visionary futures that have taken place over the last 15 years. In addition to rather incidentally constituting a review of the present state-of-the-art and a bundling of my works in this field, my aspiration is to transcend the present state of knowledge, to produce new insights and to develop perspectives for further consideration and research in reflecting on science and technology.

Decisive for this are the first three of the observations mentioned in section 1.1 (see Figure 1.1):

- 1) Subjects of RRI debates are not new technologies as such but are rather *sociotechnical* meanings assigned to them.
- 2) *Techno-visionary futures* and other types of narratives of the future constitute a major medium of assigning meaning to new technology.

3) *Debates on the definition and characterization* of NEST are also highly important for assigning social meaning to new sciences and technologies.

Linked to the execution of this program and the underpinning of these observations in case studies is the necessity of pursuing new paths, both conceptually and methodologically. I refer to these paths in the book by the term *hermeneutic approach*. Admittedly, my sketch of it can only allude to it, just as the case studies only illustrate it.

In the debates in the last years related to the philosophy of technology and STS, the interests of research and reflection have been pushed further and further upstream. If the innovation process is understood as a river or stream in development from its source to its mouth, then the focus of observations of consequences at the end of the innovation chain has been shifted to considerations of their first steps. It is precisely there that the debates over definitions take place and the meanings stipulated by technology futures are discussed.

In this book, the movement is pushed further upstream to the source of the RRI debates, thus completing it. Here, especially in Chapter 2, the expansion of the debate over responsibility is described starting with the first steps in the innovation process in which the social meanings of NEST developments are created and communicated, thus reaching the origin of the RRI debates. Further movement upstream is not possible. At the beginning of the RRI debates are the creation and attribution of sociotechnical meanings to the fields of NEST, the analysis of which is the topic of this book. There is simply no space to go further upstream.

The use of the stream metaphor collides with that of a hermeneutic circle for the debate over meaning (Figure 1.1). While a stream suggests linear thinking, the circle is round and iterative. At the level of metaphors, of course, this inconsistency is not a problem. For the topic of this book, the resolution consists of asking the question as to the genesis of the hermeneutic circle, since this question, such as to the meaning of human enhancement, has not always been present. These issues have been created. The goal of the book is precisely to put the focus on these beginnings, and there it does not play a role whether one works with the stream and source metaphor, on the one hand, or the circle metaphor, on the other hand.

At the beginning of the RRI debates, which we have then reached, the first facts are created for further communication and guidance. By bringing considerations of the future together with technological research and development, the latter are placed in a social frame of meaning which develops its own dynamics. This process can be self-reinforcing and lead, for example, to research funding being initiated, to massive investments being made in the affected field, and in this way to important real consequences for the agenda and the research process of science. Or the

framework of meaning that was initially chosen might be challenged or changed into its opposite, leading to social resistance and rejection.

Using this starting point, the subject area of responsibility is expanded. While responsibility in RRI is generally understood as responsibility for the consequences of NEST developments that might arise later for man and society, now the attribution of meaning via technology futures and characterizations itself enters the focus of responsibility. Now the point is not what consequences NEST could have in the distant future and whether they might be regarded responsible, but how a responsible handling of the creation and attribution of meaning can look *today*. This closes the circle in the hermeneutic approach. Instead of dealing with the anticipation of distant consequences in a more or less speculative mode, the issue is how, why and wherefore, and on the basis of which diagnoses and ethical evaluations sociotechnical meaning of NEST is currently being created and communicated.