Philosophy of Interdisciplinarity

Studies in Science, Society and Sustainability

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Chapter 1

Introduction

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1 Introduction

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A critical attitude towards knowledge production and technoscientific progress was once a cornerstone of inter- and transdisciplinarity. The focus was on pressing environmental problems, the challenges of global change, and side effects of technological advancement. The role of science and of the entire academic system in causing the non-sustainable state of our lifeworld came under scrutiny. The mindset of modernity, including the power and authority of science to dominate our way of framing and conceptualizing nature, was questioned. Occasionally, interdisciplinarity—along with its cognate transdisciplinarity—was deemed a fundamental challenge to the academy within late-modern knowledge societies.

Today, however, interdisciplinarity has lost its critical momentum and its original spirit. It has been reduced to a trendy, tame, and toothless notion. The term is omnipresent in science, technology, and economy as well as in society and higher education—fuelling the rhetoric of knowledge politics in our late-modern knowledge societies. It is increasingly being used as a synonym for application-oriented research and, in particular, for the commercialization of the university in neoliberal times.[1] Most researchers, politicians, and economists regard interdisciplinarity as a positive factor and value in itself which merits and compels support.[2] The National Academy of Sciences (2005), for instance, has declared "facilitating interdisciplinary research" one of its chief goals. Interdisciplinarity is seen as a kind of a panacea capable of curing pathologies of academic and entrepreneurial knowledge production (cf. Frodeman 2014). Clearly, no one is willing or able to resist its pull. Who would not subscribe to interdisciplinarity?

Since Erich Jantsch (1970, 1972) introduced the umbrella term to a larger audience in the early 1970s, "interdisciplinarity" has experienced an impressive career of wider recognition.[3] It is attributed to a plethora of research, innovation, or education programs. A highly esteemed initiative of the National Science Foundation regards the development of "Converging Technologies"—namely nanotechnology, biotechnology, information technology, and cognitive science (NBIC)—as being necessarily interdisciplinary (Roco and Bainbridge 2002). Interdisciplinarity serves as a fashionable label for innovation programs, for economics, for business and management studies, for military research, or for programmatic strategies of institutions

of higher education.[4] Even basic research programs seem to be highly inter-disciplinary; for example, physical cosmology has become established as an interdisciplinary effort at the intersections of physics, mathematics, chemistry, geology, and computer science.

In addition, interdisciplinarity is ascribed to issue-driven research at the interfaces between science, technology, and society: technology assessment, global change studies, sustainability science, risk management, and social ecological research.[5] Some scholars have identified the emergence of joint problem solving among science, technology, and society, which often is referred to as transdisciplinarity.[6] The particular attribution of transdisciplinarity and, more recently, the labels of transformation or transition[7] seem to be strong new threads in the discourse on interdisciplinarity. Other scholars prefer cognates, such as multi-, pluri-, cross-, meta-, or infra-disciplinarity.

Generally, inter- and transdisciplinarity are seen as central notions for the diagnosis of a current shift in the mode of scientific knowledge production, most popularly characterized by terms such as mode-2 science, post-normal science, post-paradigmatic science, post-academic science, technoscience, problem-oriented research, post-disciplinarity, triple helix research, transformative research, transition science, and citizen science.[8]

This book does not solely investigate whether the programmatic catchwords carry any distinctive content and any *differentia specifica*. In addition, it aims at a different view of the things attached to the concepts.

Interdisciplinarity—here provisionally used as an umbrella term to include the popular cognate notion of transdisciplinarity—is virtually ubiquitous, but what ends and purposes does it serve? What does interdisciplinarity entail, and what is its significance?

Going beyond the hype of the catchwords, by shifting the focus onto what is at stake when it comes to our natural environment and our socio-ecological life-world in the age of the *Anthropocene*, a philosophic approach rooted in rich cultural tradition could strengthen critical voices amid the recent hype. These voices—questioning the function and role of science within society and advocating a different way of viewing nature and a new relation of humans to nature—do not constitute the mainstream today.[9] However, a review of the term's history reveals that, right from its origin, interdisciplinarity has always carried an inherently normative dimension interlaced with a critical momentum: Interdisciplinarity has served as a synonym, *first*, for a cultural and social critique of knowledge production and specifically for a critique of the sciences within society and their view of nature and, *second*, for the engagement of the academic system in bettering socio-ecological *praxis and poiesis* of the human–nature relation. The critique was loudly and broadly articulated during the student revolt and amid the first wave of recognition of environmental problems in the late 1960s and early 1970s—when the term "interdisciplinarity" became prominent.[10]

Beyond today's strong and narrow focus on the involvement of extra-scientific actors, lay people, and other stakeholders,[11] inter- and transdisciplinarity

are, according to Jantsch (1972, 107/100f), the key notions for "renew[ing] the education and innovation system."[12] For Jantsch, there is an obvious need for a renewal: He observes "degrading side-effects of technology on the systems of human life," particularly on the "natural environment." Moreover, "there does not seem to be any alternative if a rational, one might even say, an ecological approach to science and technology is mandatory, as indeed it has to be so considered in the present situation" (ibid., 111/120). What is strongly required, Jantsch states, is a different way of shaping and designing the "joint systems of society and technology" (ibid., 119). In this vein, Jantsch argues for a new agenda and a different orientation of science and society—an orientation that, today, is frequently labelled with the umbrella term "sustainable development" (WCED 1987). Recognizing deficits in the academy and research practices, Jantsch sees inter- and transdisciplinarity as a lever and as a momentum for a self-renewal of the academic system (ibid., 100). The *Philosophy of Interdisciplinarity* set forth in this book concurs with Jantsch's intention. However, his specific line of argumentation, which was formulated about 50 years ago in times of planning optimism and control euphoria, will not be further pursued.

In contrast to the term's ubiquitous usage today, the original idea(l) of interdisciplinarity was more distinctive and richer in content when Jantsch first used it. Interdisciplinarity was intertwined with concerns about the environment and loss of biodiversity; it was interlinked with an in-depth consideration of the human–nature relations and with the predominantly scientific view of nature and the environment; it was interlaced with a call for scientists (and the sciences) to take responsibility and accountability for society at large; and it was interwoven with the recognition of the inherent ambivalence of science (and technology) throughout the emerging knowledge societies: Scientific knowledge is a doubled-edged sword. Science has contributed to inducing the environmental crisis, on the one hand, but at the same time it is deemed key to finding possible solutions. The ecological crisis is, in fact, a cultural and societal crisis.

The cultural background of the crisis, entailing a disciplinary blindness regarding the complex human–nature relations, has been seen as intricately interwoven with the sciences and the academy.[13] In this vein, John Ziman (1987) raises doubts as to whether disciplinary "knowing everything about nothing" is a reliable ground for shaping the future of our knowledge societies: Interdisciplinarity is the response to the overspecialization of the academy and to the isolated silos created by disciplinary methods, languages, and frameworks. Certainly, the shift towards interdisciplinarity is undeniably a good move—and we are on the way to establishing interdisciplinary practice on various levels in the academy and beyond. On the other hand, is such an overall positive appreciation of interdisciplinarity a plausible position? Is it the adequate approach for meeting the present-day environmental challenges facing the sciences in society?

This book asks whether such a position is delusive or, at least, one-sided. If we are aiming at a sustainable orientation of the academy embedded in

late-modern societies, we need further differentiations and a different take on inter- and transdisciplinarity. The basic distinction set out and advanced throughout this book is that made between an instrumentalist or strategic account of interdisciplinarity, on the one hand, and a critical-reflexive or communicative kind of interdisciplinarity, on the other hand—a differentiation also roughly undertaken by others.[14] Other frequently suggested distinctions such as the involvement—or non-involvement—of lay people and stakeholders in the process of knowledge production are seen to be of minor relevance.

Present-day inter- or transdisciplinary practice, as well as the scholarly debate about it, is dominated by an instrumentalist or strategic viewpoint:[15] Methods and management procedures are prioritized. Recipes and organizational guidelines to facilitate interdisciplinarity are being developed (National Academies of Science 2005; Newell 2001; Newell 2013; Repko and Szostak 2017). Talk of "integration methods" is prominent.[16] In order to foster procedures of interdisciplinary integration, a new field, termed "science of team science," in which interdisciplinarity is seen as a collaboration and management challenge, has been established. But to what ends and what purposes does interdisciplinarity serve? If interdisciplinarity is the answer or the remedy, then what is the question? More specifically, what is the problem to be tackled?

The mantra that we need *more* interdisciplinarity to respond to and to overcome the overspecialization of the academy is no doubt more than convincing. However, this true but trivial statement hinders a deeper and more thorough reflection on (and justification of) the ends and purposes of interdisciplinary engagement. Symptomatically, instrumentalists and strategic actors tend to remain silent on normative aspects of science and society: They hardly reflect explicitly (as part of their scientific action and their research practice) on goals, problems, values, underlying convictions, or institutional structures.[17] Instead, instrumentalists accept given purposes as the point of departure for starting their research and moving ahead. Although they are aware that values can originate from different sources—from curiosity and epistemic contexts or from non-epistemic contexts such as ethical, societal, economic, or even religious contexts (cp. Machamer and Wolters 2004; Gethmann et al. 2015)—and that pursuing certain value-related goals might be preferable to striving for others, instrumentalists do not consider it part of their interdisciplinary endeavour to explicitly examine or justify goals.[18] The reflection on and (possibly) the revision of values or goals (or both) seem beyond the scope of their professional inclinations and even competences as scientists. Central to this means-centred view is its strict solution orientation: The feasibility of finding an ultimate and benign solution is associated here with the term "problem." Instrumentalists advocate *solutionism*,[19] namely that solutions exist and, furthermore, that these solutions ensure an ultimate elimination of the problem.[20] Interdisciplinary projects, it appears, develop means and instruments to reach solutions.

Accordingly, instrumentalists approve the traditional separation between science and society or between the academy and politics. In doing so, they

perpetuate the chimeric view that science—including interdisciplinary research—has to be value-free in its epistemic core or that it can, at least, be purified and cleansed from its intertwinement with the societal domain.[21] Consequently, they share the ideal of means/ends rationality and rely on traditional action theories that draw a dividing line between means, delivered by value-free research, and ends, provided by the social, political, or ethical sphere.[22] Interdisciplinarity shows up as an organizational and management challenge—regardless of the aims of the various projects in the diverse fields such as quantum cosmology, synthetic bio-materials, nano-optics, personalized medicine, military research, nuclear reactor design, innovation studies, risk management, sustainability studies, or geoengineering.

The critical-reflexive approach, as pursued in this book, does not deny the existence of deficits in the organizational means, in the management tools or institutional procedures to foster and facilitate interdisciplinary practice—that is not at all the case. But it takes the focus to a deeper level of reflection. Deficits are perceived in the underlying rationality and in the dominant, means-focused production of knowledge, which is intertwined with how nature and the societal relations to nature are viewed. This is where the critical-reflexive position sets in: It scrutinizes knowledge production in our late-modern societies, focusing in particular on what is acknowledged as scientific knowledge. It urges scientists to rethink science—a helpful catchphrase advanced by Nowotny et al. (2001) and others (Nicolescu 2002, 2008). The critical-reflexive position argues that there is a need to rethink thinking—and this book presents examples: We should seek alternative ways of framing nature and different configurations of knowledge that are not related to the Baconian power mode of action and not as reliant on the modern dichotomist mindset as the Cartesian or Kantian viewpoints. We cannot tackle problems with the same kind of thinking we used when we created them. This post-Baconian/Cartesian/Kantian perspective can be linked to a different kind of accountability and responsibility of scientists with regard to society at large and, specifically, with regard to the natural environment.

Following this line of argumentation, critical-reflexive interdisciplinarity can be seen as a synonym for self-awareness, self-critique, and self-reflexivity: briefly, of self-enlightenment of the academy in neoliberal times. It is linked with the search for alternative views of nature[23] and for a different mindset—in other words, with the quest for other directions of scientific progress. Clearly, such a critical-reflexive approach draws on the critical theory and cultural critique of the Frankfurt School (Horkheimer 1972; Horkheimer and Adorno 1972), and it shares many dimensions with Habermas's concept of communicative action (Habermas 1984, 1993).[24]

Although both positions—the strategic-instrumentalist and the critical-reflexive—exist in interdisciplinary practice, the former is much more common. Besides being present within inner-academic interdisciplinarity, it determines most transdisciplinary technology-centred practices as well as science policy and innovation programs.[25] A further aspect, and one which

this book finds important to consider from a critical perspective, is that it also features prominently in a subset of transdisciplinary engagement, namely in problem-oriented interdisciplinarity—a field that also includes an extra- or trans-scientific perspective, but in a specific way, as we will see.[26] The following examples illustrate the breadth of this standpoint: Klein et al. (2001) characterize transdisciplinarity as "joint problem solving among science and society." Jochen Jaeger and Martin Scheringer (1998) call it a "problem-related form of science." Gotthard Bechmann and Günter Frederichs (1996) locate it as "problem-oriented research in between public policy and science" (see also Newell 2013; Repko et al. 2017). Britt Holbrook (2013, 1867) argues (from a critical angle) that "transdisciplinarity refers to the integration of one or more academic disciplines with extra-academic perspectives on a common (and usually a real-world, as opposed to a merely academic) problem." Wolf Krohn (2010, 33) takes this parlance further when he states: "Any research field or research project that addresses real-world problems is considered to be essentially interdisciplinary." In sum, the view shared among many scholars is that the task is to provide solutions to extra-scientific, real-world problems—based on the assumption that they are in principle solvable.

This book shows that such an instrumentalist approach is, indeed, a step forward because it conceptualizes science as being not only curiosity-driven but also trans-epistemic–oriented *and* shapeable by stakeholders; epistemic and non-epistemic values are interlaced. However, given the current situation of the global change crisis, it seems necessary to question whether the instrumentalist account of interdisciplinarity is strong enough to cope with the above-mentioned challenges. For example, in a different field, the instrumentalist approach to solving problems such as growing traffic jams could be to build bigger highways or more garages. However, this solution fails to address the continuous production of new problems and the origin of the problems (e.g., more cars induce more traffic jams) caused by people's misguided habits and the worldwide misconception of mobility. There is a great need to complement "problem solving" with "problem prevention"—based on a "problem radar" to anticipate and to detect socio-ecological issues before they even emerge. The instrumentalist focus is too narrow to be able to address the wider cultural fundament of global change problems. Since the instrumentalist approach does not question the internal configuration and logic of knowledge production in the disciplines, it seems far too tame and weak to enhance self-reflexivity and responsibility among the academic communities and their disciplines—or to address the root of continuous problem production.

A closer examination of the relationship between the instrumentalist view and the critical-reflexive approach reveals that the distinction is not absolute; we find a kind of 'dialectic' relation, which is not disjunctive or antagonistic in the sense that it requires us to subscribe to either one or the other understanding. Rather, the instrumentalist position can be taken as a necessary first step towards a critical-reflexive type of interdisciplinarity.

In short, the latter complements the former. Not only is the critical-reflexive understanding based on instrumentalist considerations but, moreover, it can be regarded as instrumentalist on a higher or deeper level—since it aims to achieve a much bigger impact on a sustainable development of science, technology, and society. In light of the foregoing, the *Philosophy of Interdisciplinarity* proposed here aims to deepen and strengthen the instrumentality of inter- and transdisciplinarity—beyond the shortcomings of instrumentalism with its reductionist focus on means and its non-recognition of the role of science in neoliberal societies: How can the impact of interdisciplinarity and transdisciplinarity—and thus the contribution of the academy to sustainable development—be improved in such a fundamental way that it reaches the underlying cultural, cognitive, and intellectual basis of human action in late-modern societies? In this regard, the critical-reflexive approach in interdisciplinarity can be seen as *meta-instrumentalist* or as *deeply instrumentalist*.

Advocating a critical-reflexive concept entails going beyond the analytic tradition that dominated the philosophy of science throughout the 20th century, at least in the Anglo-American world. The analytic approach in philosophy was certainly decisive in facilitating philosophic inquiry based on criteria of clarity, distinctness, and precision. There is, however, a flipside. It has also narrowed philosophy's self-understanding and self-conceptualization; in particular, it has led to a retreat of philosophy from the public arena to the ivory tower, as Robert Frodeman (2014) argues (cp. also Frodeman 2010; Frodeman and Briggle 2016). The core question today is how to make philosophy more "relevant and pertinent" to the world we live in and at the same time avoid the shortcomings and ineffectiveness of mere application-oriented approaches.[27] Interdisciplinarity thus can be perceived as a fundamental challenge to philosophy itself. It urges us to rethink what philosophy is, as an academic discipline, and what it ought to be.

In essence, the envisioned *Philosophy of Interdisciplinarity* is not intended or to be regarded as a new subdiscipline of philosophy in the same way as, for example, philosophy of science, epistemology, neuro-philosophy, or bio-ethics, which presuppose domain-restricted approaches or ontologies. Such "hyphen-philosophies" or "philosophies of" merely increase the total amount of fragmented knowledge (cp. also Frodeman 2014). In contrast, the *Philosophy of Interdisciplinarity* facilitates a larger perspective of things and a wider approach. Many philosophical subdisciplines are involved: from ethics, anthropology, and the history of philosophy, through social, cultural, and political philosophy, to philosophy of science and technology. However, that is not all: *Philosophy of Interdisciplinarity* goes even further by reflecting on and synthesizing the insights of other disciplines—and, if necessary, knowledge of stakeholders and life-world actors. The *Philosophy of Interdisciplinarity* is thus interdisciplinary *and* genuinely philosophical: In comparison with the disciplinary mainstream of 20th-century philosophy with its subdisciplines, its reductionist approaches and regional ontologies

(cp. Frodeman 2014), the *Philosophy of Interdisciplinarity* can be characterized as truly interdisciplinary. Furthermore, it is genuinely philosophic because it is based on the rich and colourful intellectual tradition of philosophy that addresses fundamental metaphysical questions and develops frameworks of orientation. In other words, the *Philosophy of Interdisciplinarity* aims to (re)open the academic discipline of philosophy towards other disciplines and, beyond that, to society at large. It resonates with an interdisciplinary-oriented philosophy and therefore could also be called *interdisciplinary philosophy*.

Such philosophic engagement in the general discourse on interdisciplinarity is not reserved exclusively to professional (disciplinary) philosophers. Philosophic thinking also takes place outside the domains of institutionalized philosophy. Embracing this broader understanding of philosophy as an art of inquiring, questioning, and critique is a prerequisite for any endeavour that can be called *Philosophy of Interdisciplinarity*. It is essential since interdisciplinarity is undoubtedly an interdisciplinary topic. This circular nature of interdisciplinarity needs to be considered. None of the academic disciplines institutionalized in the 20th or early 21st century can claim to be the one and only appropriate authority or to have an exclusive grasp on interdisciplinarity. The word "philosophy" used in the title of this book encompasses a wider understanding of philosophy that traces back to the intellectual tradition of non-disciplinary philosophy prevailing throughout pre-19th-century cultural history.

Such a critical-reflexive concept of interdisciplinarity, which aims to inject a fresh wave of rethinking thinking and to cultivate a critical mindset in the academy, does, indeed, not stand in isolation. It comes close to what Julie Thompson Klein (2010, 22f) calls, from a somewhat different angle, "critical interdisciplinarity." Liora Salter and Alison Hearn (1996) consider "critical interdisciplinarity" a "fundamental challenge to the disciplines" and to disciplinarily organized knowledge production. Referring to the Frankfurt School of critical theory, Peter Euler (1999, 299) discloses a "critical attitude attached to the notion of interdisciplinarity" that "challenges the seamless web of science and technology on the one hand, and global capitalism on the other hand."[28] Diana Hummel, Thomas Jahn, and others (2017) conceptualize "social ecology as a critical, transdisciplinary scientific research program for studies of societal relations to nature": By drawing on elements of the Frankfurt School and criticizing what they see as the "dualistic mindset of modernity," they claim that "transdisciplinarity allows for a reflection of the social contexts of scientific knowledge production" (ibid., 15). Going back to the 1980s, Jürgen Mittelstraß (1987) argued in his seminal publication that interdisciplinarity is "a reminder of the original ideal of science" to provide a "normative orientation knowledge" that goes beyond strategic and means-focused "disposition knowledge":[29] Orientation knowledge in this sense can be provided only if research succeeds in synthesizing diverse approaches and disciplinary propositions—and in this process re-installs the unity of rationality.

In a similar vein, but without such a strong emphasis on rationality, Steve Fuller (2010) advocates a concept named "deviant interdisciplinarity." This kind of interdisciplinarity differs from what he terms "normal interdisciplinarity" and features—in the tradition of philosophical thinking in the wake of German Idealism—a critical and synthetic orientation; its focus is to reflect on and, where appropriate, to shape the various underlying worldviews of nature and of societal relations to nature.[30] A critical line of thought is also pursued by Basarab Nicolescu (2002, 2008) in his programmatic "Manifesto of Transdisciplinarity," in which he advances criticism of the dualist mindset of modern knowledge by referencing quantum physics and its holistic concept of nature: Transdisciplinarity offers novel ways of perceiving and thinking which transgress modern dichotomies, in particular the "split between science and meaning, between subject and object" (Nicolescu 2008, 13).

Other thinkers may also support the basic premise of this book. Michael O'Rourke's and Stephen J. Crowley's "Toolbox Project," which might convey an instrumental connotation at first glance, in essence fosters critical reflexivity among scholars and researchers by means of specific, well-chosen "philosophical interventions" in the various cognitive processes underlying interdisciplinary communication (O'Rourke and Crowley 2013). O'Rourke and Crowley develop a strong approach known as "philosophic intervention research" and "engaged philosophy" and in doing so promote an "understanding [of] philosophy in both its critical and facilitative roles" with respect to the various societal challenges attributed to interdisciplinary research (ibid., 1939).

Robert Frodeman, most notably, takes a different and in-depth critical-reflexive approach in his editorial introduction to the *Oxford Handbook of Interdisciplinarity* (Frodeman 2010) and in his book advancing *A Theory of Interdisciplinarity* (Frodeman 2014). According to Frodeman, interdisciplinarity questions the fundamental premises of what is referred to as the knowledge society—namely that the pursuit of knowledge is always good and beneficial. He critiques the curiosity-driven ideal of the infinite growth of scientific knowledge. Frodeman (2010, xxx) advocates an inherently critical element in interdisciplinarity, for instance, when he addresses the question of what is "pertinent knowledge" and whether "knowledge is pertinent at all."[31] Interdisciplinarity sets out to "dediscipline philosophy" and to conceptualize "philosophy as interdisciplinary." Frodeman's inspiring seminal work and his take on inter- and transdisciplinarity are very much in line with the objective of this book, in particular when he speaks of "critical interdisciplinarity" (Frodeman and Mitcham 2007).

There are two central questions that the *Philosophy of Interdisciplinarity* needs to address. *First* of all, what is the essence of "interdisciplinarity" and cognates such as "transdisciplinarity"? How can we characterize the phenomena and the history of interdisciplinarity? *Second*, how should "interdisciplinarity," and in particular "transdisciplinarity" and "problem-oriented interdisciplinarity," be understood in a normative sense? In other words, how should we interpret the notion of interdisciplinarity in

order to value and foster self-reflexivity, self-awareness, and self-critique—and which meaning enables us to facilitate responsibility and accountability within the academy for society at large? How can we reduce the rate of continuous problem production of the joint systems of science, technology, and society?

These questions are not solely of academic interest. How interdisciplinarity is framed and defined has implications for knowledge politics, public research policy, and research practices.[32] Interdisciplinarity therefore can be regarded as a signifier of the centrality of a debate on the future of knowledge. An objective of this book is to provide an understanding that will enable us not only to draw clear lines in the jungle of definitions of interdisciplinarity but also to inject a more critical-reflexive approach into recent knowledge politics—and to further substantiate the pathway to environmentally oriented sustainable development.

The *Philosophy of Interdisciplinarity*, as proposed in this book, offers a framework for such an engaged program. The task it seeks to accomplish is to not only keep up with the evolving area of inter- and transdisciplinary practice but also to advance critical-reflexive potential concerning the future of science, society, and sustainability in neoliberal times. The argumentation of the *Philosophy of Interdisciplinarity* is built around seven areas of focus:

- Taking stock and providing clarification of different types of interdisciplinarity and transdisciplinarity;
- Addressing and assessing the knowledge and research politics of interdisciplinarity;
- Tracing the historical roots of the dominant instrumental account of interdisciplinarity and linking interdisciplinarity to the discourse on technosciences;
- Explicating and reflecting on societal problems and opening science to society, giving substance to transdisciplinarity in particular;
- Engaging with the grand challenges and reinforcing the approaches of environmental ethics;
- Searching for alternative directions in the sciences and conceptualizing a different view of nature that stops the continuous production of environmental problems;
- Advancing and facilitating a prospective technoscience assessment to trigger a change in knowledge and research politics.

This book is structured around these seven areas of focus that the *Philosophy of Interdisciplinarity* intends to promulgate.

More specifically, the *Philosophy of Interdisciplinarity* takes its point of departure from the recognition that both "interdisciplinarity" and "transdisciplinarity" are poorly understood notions requiring further philosophic engagement. Chapter 2, entitled "Philosophy and Plurality," reveals different interpretations of the generic term "interdisciplinarity" and includes current popular concepts of "transdisciplinarity." To provide conceptual

clarification, key epistemological questions behind "interdisciplinarity" are addressed. The driving idea is to develop a philosophical fundament for a critique of innumerable usages of the term.

Moreover, philosophers can go beyond an analytical classification and give more substance to the evolving discourse. On scrutiny, the term "interdisciplinarity" can also be perceived as a political buzzword in knowledge policy which is charged with strong promises and high expectations with regard to innovation. The *Philosophy of Interdisciplinarity* aims to provide a critique of recent technoscientific programs: Chapter 3 is dedicated to "Politics and Research Programs." It addresses the "politics of interdisciplinarity." Although an analysis of this kind is by necessity concept-centred, the basic intention has a practical dimension: to disclose the guiding values and ideals behind research programs that pre-determine our societal future*s* and to enable a broader public awareness and political discourse. This chapter reviews the assumptions of one of the most influential technoscientific research programs of the last 20 years, which presses for a strong instrumental kind of object-centred interdisciplinarity.

Viewing interdisciplinarity in this way is by no means novel. Chapter 4—"History and Technoscience: Tracing the Historical Roots"—offers further insights into the instrumentalist account of interdisciplinarity by tracing it back to the beginning of the modern age and to Francis Bacon. The historical perspective also encompasses a review of the present-day discussion surrounding the popular label "technoscience." Technoscience and object-oriented interdisciplinarity turn out to be twins.

In subsequent chapters, it is argued that a more critical-reflexive perspective is possible—and indeed needed in the discourse and practice of interdisciplinarity. Chapter 5—"Society and Societal Problems: Conceptualizing Problem-oriented Inter- and Transdisciplinarity"—opens science to society at large. Focusing attention on societal problems might seem indicative of an instrumentalist orientation. However, this is not the whole story since a critical-reflexive account is also central to this notion of interdisciplinarity.

A short interlude chapter addresses some shortcomings of the instrumentalist view of interdisciplinarity. Then, Chapter 6—"Ethics and the Environment: Engaging with Grand Environmental Challenges"—moves to an ontological focus and metaphysical reflection intersecting with ethics, sciences, and philosophy of nature.

An understanding of critical-reflexive interdisciplinarity as an ethical and environmentalist concept is developed and applied to two fields of endeavour: to the development of novel and different ways of viewing nature based on alternative concepts of science and scientific knowledge, on the one hand, and to knowledge politics and technoscience assessment, on the other hand. Chapter 7, headed "Nature and the Sciences: In Search of Alternative Concepts of Nature and Science," develops an intra-scientific critique of the mainstream sciences and seeks to come up with different, science-based concepts of nature. Chapter 8 on "Technology and the Future"

advances a critical-reflexive and prospective-oriented approach in Technoscience Assessment and develops a critique of synthetic biology.

Although this book approaches inter- and transdisciplinarity from a theoretical perspective, the intention is essentially a practical one: to reach, in the classic sense of philosophic thinking, the *praxis* of the sciences and the academy in *and for* society. Motivated by the challenge of the global change crises in the age of the *Anthropocene*, the aim is to support the recent momentum towards a transformation (a) of the research enterprise and the academy and (b) of the way nature is viewed. The *Philosophy of Interdisciplinarity* stands in the environmentalist tradition. It subscribes to the thinking of the environmental philosopher Hans Jonas, who states that the recent socio-ecological crisis should be viewed as a cultural and societal one that questions our ways of thinking and perceiving—briefly, our mindset and attitude in our societal relations to nature.

In other words, the call for inter- and transdisciplinarity has to be associated with the ideal of sustainable development and socio-ecological transformation on a deeper level; it entails a cultural critique of knowledge production since the knowledge production is, in fact, strongly interlaced with the ongoing problem production. Such a perspective counters the mainstream rhetoric through which "interdisciplinarity" has become an omnipresent buzzword supporting the commercialization of the academy in neoliberal times. Interdisciplinarity holds a hidden critical, and transformative, potential; it carries momentum to raise fundamental questions in order to open up avenues and stimulate a broader engagement of the academy towards a sustainable future. This mindset is today mostly labelled "transdisciplinarity," although not all transdisciplinary approaches are societally centred and critically reflexive (see the next chapter for an in-depth discussion). In sum, the general discourse on "interdisciplinarity" can be seen as a signifier of what Ulrich Beck (1992) calls "reflexive modernization."

Concisely, this book argues that the buzzwords "inter- and transdisciplinarity" are not only indicative of a wound in the established culture of knowledge production, which can be cured by some minor (management) re-adjustments. It asserts that inter- and transdisciplinarity signify a thorn digging in the heart of the academy and the sciences. The relevance and pertinence of traditional academic knowledge for our late-modern society are at issue. In addition, and complementarily to the plausible instrumental and strategic demand for new means and new kinds of management capabilities, inter- and transdisciplinarity call for deeper reflection on and a revision of the values and norms, ontological backgrounds, and metaphysical convictions governing our framing, perceiving, and understanding of nature and of science in societies. In sum, inter- and transdisciplinarity challenge the modern dualistic mindset and the way in which nature is perceived and conceptualized.

Put succinctly, inter- and transdisciplinarity urge us to rethink our thinking and to reframe our framing of nature; also, they compel us to reflect

on and change our practice in science, research, and education. Those are the main messages conveyed by this book, building on the intellectual spirit and original momentum of both philosophy and interdisciplinarity. A philosophic endeavour of this kind cannot be apathetic or indifferent about the world. It is not a value-free enterprise. Rather, it is concerned with the world's state of affairs: with the grand environmental challenges and global change issues facing late-modern societies under the pressure of the capitalist market. The *Philosophy of Interdisciplinarity*, in this light, is part of what is called *transformative* or *transition research*: research *for* (and not only *on*) transformation (Hummel et al. 2017; Krohn et al. 2017). It not only reflects on an epochal break in the culture of knowledge production (that goes beyond questions of stakeholder involvement) but also aims to foster and facilitate a new critical-reflexive practice in (and of) the academy.

Notes

1 A neoliberal dimension in the discourse on inter- and transdisciplinarity is observed by Maasen (2010) and Frodeman (2014).
2 There are some exceptions; see, for instance, Jacobs and Frickel (2009), Jacobs (2013), and Graff (2015).
3 Although the term's origin is a matter of dispute, most scholars cite Jantsch (cf. Klein 1990, 1996), whereas Nicolescu (2002) credits Piaget (cp. also Kockelmans 1979). For the history of "transdisciplinarity," see also Bernstein (2015).
4 Examples include innovation studies (Fagerberg et al. 2005). For a critical take, see Cozzens and Gieryn (1990).
5 These fields of interdisciplinary engagement are vigorously promoted, for example, by Kates et al. (2001), Decker (2001, 2004), Decker and Grunwald (2001), Becker (2002), Norton (2005), Becker and Jahn (2006), and Lingner (2015).
6 This is a commonly held view among those who are engaged in the discourse. See, for example, Klein et al. (2001), Pohl and Hirsch Hadorn (2007), Hirsch Hadorn et al. (2008), or Bogner et al. (2010); for a consideration of different meanings of the terms, see Wickson et al. (2006), and for a distinctly different approach, see the work by Mittelstraß (1987). A thought-provoking explication of transdisciplinary research is given by Krohn et al. (2017).
7 See the debate on transformative research: Schneidewind and Singer-Brodowski (2013), Strohschneider (2014), and Grunwald (2015).
8 The literature on these topics is overwhelming, particularly in sociology of science and in science and technology studies (STS). Here is a short list of publications: Gibbons et al. (1994), Funtowicz and Ravetz (1993), Elzinga (1995), Böhme et al. (1983), Ziman (2000), Bammé (2004), Haraway (1991), Latour (1987), Nordmann (2004), Nordmann et al. (2011), Schmidt (2004), Ihde and Selinger (2003), Chubin et al. (1986), de Bie (1970), Bechmann and Frederichs (1996), Becker and Jahn (2006), Becker (2002), Norton (2005), Holbrook (2015), Etzkowitz and Leydesdorff (1998), Irwin (1997), Hirsch Hadorn et al. (2008), Bogner et al. (2010), Kastenhofer (2010), Moran (2010), Riesch and Potter (2014), Szostak et al. (2016), and the seminal edition by Kocka (1987). From a more philosophic perspective, see Kötter and Balsiger (1999), Hubig (2001), Schmidt (2003), Balsinger (2005), Grunwald and Schmidt (2005), Schmidt (2005), Schmidt (2008b), Frodeman (2010, 2014), Jungert et al. (2010), Holbrook (2010, 2013), Wechsler and Hurst (2011), Gethmann et al. (2015), Szostak (2015), Krohn et al. (2017), and Hummel et al. (2017).

9 Whereas some of the points raised above have been addressed over the past decades by social scientists, notably in the field of science and technology studies (STS), philosophers, surprisingly, have so far stayed on the sidelines for most of the time.

10 There are some exceptions. For example, with regard to their concept of transdisciplinarity in social ecological research, see Hummel et al. (2017), who draw on critical theory of the Frankfurt School.

11 For a critique, see Mittelstraß (2018) and Jaeger and Scheringer (2018).

12 An early critical perspective on the education system is pursued in Kockelmans (1979).

13 This thesis is defended by environmentalists such as Jonas (1984), Holsten (1988), or Hummel et al. (2017).

14 See, exemplarily, Klein (2010, 5/22f), Frodeman and Mitcham (2007), and Salter and Hearn (1996). Moreover, O'Rourke and Crowley (2013) and Holbrook (2013) draw explicitly on communication in this regard. By distinguishing between an instrumentalist and a critical-reflexive/communicative view, the approach pursued in this book also leans on Habermas's "Theory of Communicative Action" and his distinction between communicative and strategic rationality (Habermas 1984). The notion of "critical interdisciplinarity" dates back at least to Gusdorf (1977).

15 This shortcoming is also perpetuated by the National Academies of the US: "A deeper understanding of these processes [of interdisciplinary knowledge production] will further enhance the prospects for creation and management of successful IDR [interdisciplinary research] programs" (National Academies 2005, 3).

16 For a critique, see Holbrook (2013), Frodeman (2010, xxxii), Frodeman (2014), Fuller (2017) and, from a different angle, Nicolescu (2002, 2008).

17 The term "critical interdisciplinarity" is also elaborated by Frodeman and Mitcham (2007). As Klein (2010, 23) underlines, "Critical ID [= the critical-reflexive type of ID] interrogates the dominant structure of knowledge and education with the aim of transforming them, raising questions of value and purpose silent in Instrumental ID."

18 Fuller (2017), for instance, identifies an ambivalent "military-industrial route to interdisciplinarity" and reveals a "Janus-faced character of […] interdisciplinarity."

19 This notion is taken from Morozov (2013).

20 In contrast, since in many and the most urgent cases (e.g., global change) an ultimate solution does not exist, the critical-reflexive approach is not primarily centred on solutions. More fundamentally, the critical-reflexive approach deals with problems on a deeper level, in particular with the origin and emergence of problems.

21 For instance, the Roco–Bainbridge report on converging technologies sees interdisciplinarity from such an instrumentalist perspective (Roco and Bainbridge 2002, xiii/76): "The scientific and engineering communities should create new means of interdisciplinary training and communication." Yet "our nation needs to formulate a new interdisciplinary, inter-science, and systems-wide collaborative model based on converging NBIC technologies in order to move forward to create productive and efficient change." This view is dominant among the public as well as in academia.

22 By this, they subscribe to the similar split between facts and values; for an analysis, see Kincaid et al. (2007).

23 This includes societal relations to nature (Jahn et al. 2012; Hummel et al. 2017).

24 Discourse-ethical considerations are central to the critical-reflexive understanding of interdisciplinarity. Some elements going in this direction are advocated by Holbrook (2013), who identifies a "Habermas–Klein" view of interdisciplinarity, and by O'Rourke and Crowley (2013).

25 See, for example, the *Oxford Handbook of Innovation* (Fagerberg et al. 2005).
26 "Transdisciplinarity" and "problem-oriented interdisciplinarity" differ in a certain way, as will be discussed in the next chapter. The notion of "problem" will also be discussed further on.
27 My translation (J.C.S.). The approach advocated in this book shares many aspects with Frodeman (2010, xxix f, 2014) and contrasts with what Gibbons et al. (1994) labelled "mode-2-research." Clearly, a "mode-2-philosophy" is not envisioned here.
28 Euler (1999) refers to Mikosch's (1993, 55f) "critical theory of interdisciplinarity."
29 My translation (J.C.S.). Mittelstraß (1987, 156) maintains that "transdisciplinarity [...] does not leave the disciplinary things and the academy untouched. Instead, transdisciplinarity carries a momentum that could [and should] have a broader impact on the disciplines and the science system at large"; see also Hummel et al. (2017, 10), Jahn et al. (2012), and Jahn (2013).
30 According to Fuller (2010), philosophy in the "normal" mode plays an auxiliary role beside other disciplines and accepts the division of organized inquiry into disciplines. Fuller argues that philosophy should transcend disciplinary knowledge and actively promote an encompassing and synthetic understanding of reality. He refers to the long intellectual tradition of philosophic thinking and, in particular, to natural philosophy. The notion of "worldview" echoes the German term "Weltbild" and, in particular, encompasses underlying concepts of how we see and perceive the world (nature, humans, society, sciences …).
31 Frodeman (2010, xxxi) urges a reorientation of philosophy in its mindset, in its attitude and approach to the world, as "interdisciplinarity represents the resurgence of interest in a larger view of things." Philosophy should engage in the world, Frodeman argues, and to do so it needs to transform towards becoming a "field philosophy."
32 In addition, there seems to be a need for a "political philosophy of science" (Rouse 1987).