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Innovation, Perspectives, and Commons

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Abstract

Science is the expression of methods, techniques, and ideas shared by a community. Based on decades of experience working within multidisciplinary teams that have focused on achieving transdisciplinary goals, this chapter analyzes factors that contribute and detract from collaboration (innovation, perspectives, and commons). The perspective taken is that of *complex adaptive systems*, initially developed by a transdisciplinary team for the ARCHAEOMEDES project. Insights are presented from this cumulative work, and a conceptual, practical framework is proposed that can be shared and used to realize clearly set goals and avoid disappointment.

Preface

To understand and evaluate the arguments put forth in this chapter, it is essential to remember that I am an archaeologist and medieval historian by formal training, and an *un*trained anthropologist with experience in several non-European cultures (Syria, Mexico, Papua New Guinea, Japan) as well as in four Western cultures (Netherlands, U.K., France, and U.S.A.) in which I have lived for a decade or more. I approach the topic of collaboration (innovation, perspectives, and commons) based on theoretical insights as well as experience acquired from inspiring and managing multidisciplinary teams with transdisciplinary goals, initially in Europe and subsequently in the United States.

The perspective that I embrace in this chapter is the *complex adaptive systems* perspective that we, as a transdisciplinary team, developed for the ARCHAEOMEDES project (1991–2000; van der Leeuw 1998; van der Leeuw et al. 2003)—a project that looked at human–environment relationships in all countries of the Northern Mediterranean rim. This perspective was further developed during my affiliation with the Santa Fe Institute (2000–2019; Lane et al. 2009) and led me, over time, to develop a very personal vision on

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collaboration. Thus, the reader will hopefully forgive the unusual number of references to my own work.

From that experience, two points stand out: First, success in innovative, transdisciplinary projects depends, to an important extent, on the expectations of the participants. Frequently these are too high or otherwise not adapted to the realities of the situation, the team, the funding, the project timeline, or its scientific goals. As a result, many, if not most, transdisciplinary projects leave participants with a sense of deception because their goals were not achieved. Second, insufficient attention is often paid to the need to create a team identity, a need that is essential yet very difficult to achieve among people who have spent years creating individual identities in a particular discipline or field of endeavor. In our Western, individualist culture, the importance of such a team identity is often underrated. Science is the expression of methods, techniques, and ideas *shared by a community.* Below I will try to develop a conceptual and practical framework that can be shared and used to realize clearly set goals to avoid disappointment.

Introduction

To begin, I would like to put this chapter in a wider perspective. An earlier version focused on my personal experience with the dynamics of transdisciplinary collaboration, but during the Forum, the study of collaboration emerged as a means to improve understanding of a much wider challenge: how the emergence of institutions is rooted in collaborations, how institutions develop, what they produce, what their impact is on societies' dynamics, and how they might come to end. This domain is an increasingly important and interesting one, as collaborations play an important role in the structural evolution of societal systems, including their technologies, institutions, laws, policies, and networks. One might even say that societies' cultures are path-dependently shaped by the precise way in which their collaborations emerged, functioned, and died.

This chapter is thus aimed at presenting a personal and partial response to three primary questions, with an emphasis on the first and second:

1. How do collaborations emerge?
2. How do the results of collaborations perdure?
3. How might collaborations end?

All three of these questions were broached during the Forum, and I will summarize some of my own thinking about them as a result of these discussions. My perspectives are also informed by a research project on the dynamics of change in collective decision making, which I am currently working on with my colleague, Gary Dirks, from Arizona State University. This project is searching for a generalizable model of the dynamic that might be responsible

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for the absence of tangible action, after fifty years in which the awareness of climate change has spread across most societies.

Our approach to this issue can be summarized as follows (van der Leeuw and Dirks 2024): As societies structure themselves in interaction with their natural environment, they undergo a shift in the epistemology of their collective information processing from open, polythetic categories (groups) to closed, monothetic categories (classes). At the level of whole societies and their environments, this changes how people think and shifts information processing from exploratory to exploitation-focused thinking; in the process, it also changes perspectives on time and on the environment, on truth and falsehood, and on the relationship between solutions and challenges. In our opinion, this shift is associated with the emergence of the technosphere,[1] which limits society's options in managing its behavior. These dynamics ensured a transition from *comprehension* of socioenvironmental dynamics to *competency* in addressing them (without comprehension) and thus became a major barrier to changing societies' attitudes to their environments.

The basic idea of a shift in information-processing categories is based on the work of Tversky and Gati (1978), who argue that category formation occurs in two steps (Figure 12.1):

1. A set of observations is inductively grouped in extrinsically defined, open, and exploratory categories based on similarities among them.
2. These open categories are deductively transformed into intrinsically defined classes which emphasize dissimilarities between them and phenomena that are excluded from these definitions.

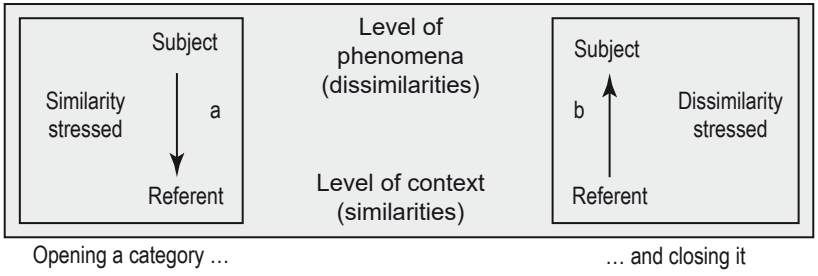

Figure 12.1 The dynamics of category formation as described by Tversky and Gati (1978). Perception and category formation are seen as a feedback cycle between the concepts (categories) created, their material manifestations, and the (transformed) concepts that derive from and are constrained by these material manifestations. In the process, open categories (groups) are transformed into closed ones (classes) (after van der Leeuw 2020:148).

[1] That part of the environment which is made or modified by humans.

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Applying this basic idea to group collaboration discussed in this chapter, I argue that the transition from open groups to closed classes is fundamental to the dynamic of collaboration. When a collaboration starts, it seems to be based on a degree of resonance among the participating individuals. As that resonance is explored, trust among them increases as a function of working together, discussing a range of aspects of the topic that is ultimately chosen as the focus of the team. In that process, the partners in the team come to understand the perspectives of their colleagues in some depth, including the epistemologies that underpin their opinions, and to explore the cognitive dimensions that they share, as well as ignore or discard the dimensions that they do not. This process generates a set of shared, open, exploratory, and multidimensional categories. As the interactions proceed and the team melds around its own identity (rather than the identities of the individual participants), it agrees on certain interpretations (and their underlying cognitive categories) of the collaborative theme as "characteristic" for their work. In doing so, the team excludes dimensions and dynamics that it considers irrelevant, and thus the initial open, exploratory categorizations are transformed into classes that are closed.

That transition from groups to classes formalizes the ideas that are the result of the collaboration. Those are then instantiated and, where possible, anchored in particular "tools for thought and action" (*inventions*), such as institutions, laws, technologies, or aspects of the external environment that are intended to perdure beyond the period of active collaboration. The next phase is that of *innovation* (i.e., the spread of the inventions in society), which aligns increasing numbers of people around the acceptance and use of the novelties concerned.

During the collaboration, the participating individuals focus on specific, shared ideas to the detriment of other ones that are not shared. As the group's "tools for thought and action" impact its environment, the latter is changed by the unanticipated consequences of the "solution" the group has implemented. As these changes emerge, they are dealt with by the individuals of the group, each in their own way or in the context of other collaborations. Ultimately, this will undermine the ideas that the group collectively put forward and thus signal the end of the collaboration.

This very abstract dynamic scheme or model is no more than another "tool for thought and action" that needs to be elaborated, detailed, and instantiated. But it provides a relevant context to our discussions at this Forum. After all, it seems to us that most human, collective ideas have emerged in this manner.

Let us now turn to the primary questions and main themes (commons, perspectives, and innovation) that underpinned this Forum. This will be followed by remarks on what is needed to focus on in the future and implications of all this for the goals of the Forum.

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Complex Adaptive Systems

For those unfamiliar with the complex adaptive systems (CAS) approach, the lens through which our team approached the ARCHAEOMEDES project, I offer a brief description here and refer the reader to van der Leeuw (1998) for extensive treatment of the way we applied this approach. Originating separately in Europe and the United States during the 1970s and 1980s, the CAS approach involves a change from a reductionist, *ex post* approach, which explains the present by invoking the past in search of origins, to an *ex ante* approach, which looks forward in time at the emergence of novelty in the past as well as in the present, thus linking past and present to the future. This allowed us to learn from the past about the present, for the future. Because the focus is then on change, this shift also changes the perspective on the relationship between stability and change. In the Western scientific tradition, following Aristotle, stability is assumed to be the norm, and change is to be investigated and explained. Instead of using this perspective, we adopted Heraclitus's approach, which views change as the only permanent thing and stability needs to be explained. The emphasis is on dynamics, and all perceived phenomena are used to (re-) construct them. The flow (of information, matter, and energy) is the structure, which is generated by a potential. Change is irreversible. Prigogine (1978) refers to "dissipative flow structures" that simultaneously structure matter, energy, and information, thereby reducing the unknown (chaos). Identifying those dynamic structures often involves extending the temporal perspective, so that apparent statics (events, socioenvironmental states, and structures) are viewed as temporary.

Another implication of this change in perspective is that the CAS approach looks at relationships rather than entities in the context of overall interactions between the different components of a system and its context. CAS dynamic structures are self-organizing because of the interactions of the entities in the system. System behavior is viewed as an interaction between individual entities that create patterns at a more general level, and these patterns in turn impact the behavior of the entities involved (Figure 12.2). In social science terms: people create societies' (dynamic) structures, and these structures impact the behavior of the people. The result of that process is not fully predictable; multiple potential futures are involved at any given time, among which the system opts for some and ignores others. The CAS approach thus emphasizes both history and unpredictability, leading to descriptions of phenomena in terms of possibilities and probabilities rather than in terms of historical causation, as is usual in the linear approaches commonly used.

This fundamental change in perspective has many implications. An important one to note is the fact that "Occam's razor" does not hold (i.e., the idea that among potential explanations, one must always choose the simplest). Indeed, complexity and context often provide more realistic explanations. For

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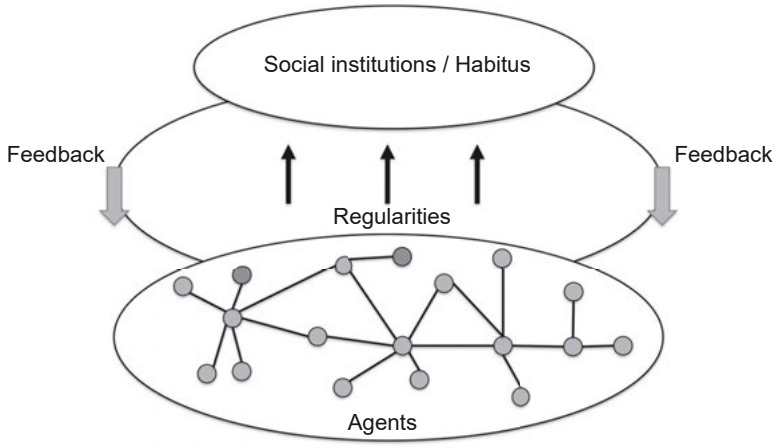

Figure 12.2 Complex adaptive systems are self-organizing (after van der Leeuw 2020:104). Interactions between individual entities create patterns that constrain the behavior of the entities. In the social sciences, much the same has been argued by Bourdieu (1972).

an overview of other implications, see van der Leeuw (2020, chapter 7). A more extensive introduction to CAS is found in Mitchell (2011).

Commons

I am adopting the ancient Greek perspective in which human cognition is the dynamic of "making sense out of chaos." Everything around a human being or a group of them is understood or partly understood to involve "chaos" until a coherent and pertinent interpretation incorporates it into a group's or society's worldview. In ancient Greek, however, "chaos" is also "the beginning" (of understanding). This reflects the fact that significance is generated by creating a relationship between surroundings and meaning, between the environment and the mind. To understand the commons, we therefore need to distinguish between two domains: the material realm (the domain of "things") and the cognitive realm (the domain of ideas). I would argue that the concept of the commons applies to both domains. In both, the commons represent the partly explored sphere that has been identified but for which no defining link has been made between an individual's (or group's) cognitive system and some aspect of the "real" (material) world. In cognitive terms, what is called the "partly unknown" is the (polythetic) domain for which different potentially relevant significances, but no specific single significance, have been identified; this defines a conceptual link between the worldview of a person or people concerned and material phenomena. Linking phenomena to meanings embeds these phenomena in a cognitive context.

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When one adopts a general perspective that is not limited to the European "Western" conceptual approach to the topic, *all potential cognitive and material resources are common*. All materials, substances, and ideas that occur on Earth are potential resources that anyone can use. They become identified resources once they have been harnessed by a community of people for use; that is, people adapt their information processing (knowledge and institutions) to include these materials into the dissipative flow structures (Prigogine 1980; van der Leeuw 2007) upon which they depend. For instance, uranium was not considered a resource until radioactivity and nuclear reactors were adopted by Western society; coltan was not considered a resource until it was found useful in the manufacturing of smartphones. Identifying a resource implies defining a link between a material substance and a cognitive concept. Rather than only identify commons as part of a resource domain in the substantive realm that does not have an assigned owner, as we commonly do, I argue that one must identify both the material domain and the cognitive domain (the cognitive tools that have generated the conception of commons) that define a resource. From that perspective, the commons are the (partly) known domains over which people in a society have no individual, group, or corporate control.

In situations where two different cultures with different cognitive systems interact, the interaction zone is one in which, in principle, each culture can view the other as a commons, because its cognitive rules do not apply there. Thus, the Amazon Forest is considered a commons by Western colonists because the Indigenous cognitive principles that its original inhabitants apply to the area are not recognized by the Western colonists. Transforming these areas into plantations or cultivation areas according to the colonists' way of life is a frontier activity. Ostrom (2015) identified domains in societies where Western rules and regulations did not apply and clearly demonstrated that for these domains, effective governance existed, or could be designed, based on adopting appropriate cognitive categories.

In our current Western capitalist approach, identified substantive resources are based on legal or *de facto* ownership, whether individual or collective, that gives people the right to exploit as well as to alienate the resource concerned. *The term commons, as used in the West, thus describes those resources that are not subject to its property rights or claims*. During much of the Middle Ages, in Europe, some of the land occupied by the inhabitants of rural villages was either not owned or collectively owned and accessible to any member of the community at will, serving as a "reserve" resource for those who could not survive on the yield of their own land. That portion of the land was (and in many cases still is) called the "village common." Forests and streams were often also considered resources available to everyone in the community, even if in some cases the legal owner was the local lord. One can extend that approach to the realm of information by arguing that in that domain, the commons are *those ideas for which no ownership has been claimed by anyone.* Some of these

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include traditional beliefs shared by members of a community, whereas others can be considered commons because no one has yet claimed them.

In the context of the current sustainability conundrum, reconsidering property or ownership rights, and thus reconsidering the institution of the commons and its role, may be essential. If that conundrum has shown us anything at all, it is that we, as humans, are part of one or more communities and societies, as well as of a single terrestrial ecosystem, and that the individualist, property-based Western perspective has been destructive because it has fragmented our societies to the point that collective action, however necessary, has become very difficult to implement. I would extend this to the topic of intellectual property rights: the Western view that ideas are in effect ownable by individuals or groups must also be reconsidered. It seems to me that the revolution in information technology (IT), in particular the explosion of categories and ideas rooted in artificial intelligence (AI), is posing important challenges in that domain (Grumbach and van der Leeuw 2021).

As to the question posed to the Forum—How do commons shape the properties of agents?—I would therefore respond that the interactive relationship between the environment and the mind shapes the properties of agents and of the commons in an interactive process of niche construction (Odling-Smee 1988).

Perspectives

Creating significance involves linking a specific cognitive perspective to a particular part of the commons so that this part is identifiably detached from what remains of those commons. That linking is based on a degree of resonance: the capacity by humans to "bend their mind around" phenomena which they observe in the outside world, a capacity which presumes knowledge that can be applied to the phenomena in an exercise of niche creation (Odling-Smee 1988).

Contrary to what is often argued, therefore, I hold that phenomena are essentially poly-interpretable. Rather than follow Ranke's idea that "opinions may vary, but facts remain," phenomena are given significance by the way in which individual or group perspectives are applied to them. *The structures in human minds that shape the perspectives and contexts for observations are therefore, in my opinion, more enduring than the observations themselves.*

Hence, one of the most insidious traps in transdisciplinary work is the (un-) intended disconnect between observations and their contexts. Each discipline has its own epistemology, linking observations both to their context and to the discipline's and the culture's techniques, methods, and knowledge systems. Transferring observations to a different (disciplinary or other) context detaches them from their epistemology and creates a different perspective, losing some of the original significance and gaining new dimensions. Because of this, it is extremely difficult, if not improbable, to create a true intellectual fusion between disciplines, schools, and cultures.

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A major challenge in this process is that it is much more difficult to unlearn a dimension that is part of an existing information-processing system than it is to learn a new processing dimension (e.g., Bonchek 2016). Transdisciplinary work involves both, because it requires all participants to adopt as close to a shared perspective as possible, and thus to ignore some of their own particular perspectives on the topic. In practice, this means that there often is a bias toward introducing novel concepts that build on or extend existing ones rather than fundamentally restructuring extant thinking.

Attempting to generate intellectual fusion between disciplines by teaching people other disciplines, developing commonly accepted (disciplinary) resources, or explaining concepts among members of transdisciplinary teams often creates an epistemological muddle. Hence the practice of transdisciplinary research I favor is one of taking the time for the participants to collectively learn about other disciplines by listening and observing how they are practiced, so that the observer learns about the phenomena studied by another discipline in its own epistemological context.

The best that can usually be achieved in transdisciplinary research is a polyfacetted "bee's eye view" (van der Leeuw et al. 2003), a juxtaposition of different perspectives that provides a relatively wide range of perceptions of the phenomena concerned, rather than a single perception. It is then up to the team, or to individual researchers, to sharpen that perspective for different purposes. This problem is manifest, but only rarely remarked upon, in the use of databases. There, data obtained from different contexts, through different disciplines, with different purposes, and with different epistemologies, are merged to serve as the basis of "results" without clarifying their contexts or relating them together to a new context.

Innovation

In much of the literature, a distinction is made between *invention* and *innovation*. The former designates the activity of creating something new, whereas the latter points to the activity of introducing that novelty in society. Here, I will principally focus on invention. I understand that term to be the introduction by an individual or group of a novel link between the (internal) realm of ideas and the (external) realm of phenomena. In other words, a novel link between the cognitive commons (the partly known) and a worldview (knowledge base). The result of that link is the inclusion of a part of the commons domain into the cognitive (knowledge) and procedural domain of the individual or group of people that are responsible for the invention.

At the core of that process is the disembedding of specific cognitive dimensions from among the many potential dimensions in the perceptual chaos, to link the knowledge system and observed phenomena to create significance. This happens in a loop (Figure 12.3) that links niche construction of knowledge

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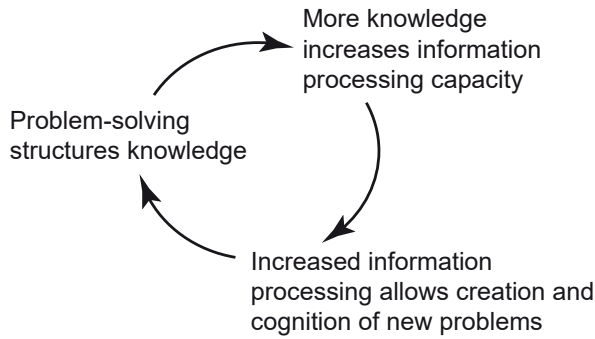

Figure 12.3 The cognitive cycle of individuals. As more information is processed, an increasing number of cognitive dimensions become disembedded. Figure from Grumbach and van der Leeuw (2021), reprinted under Creative Commons Attribution license 4.0.

in the mind with niche construction of the external, material realm (Iriki 2019). The link between those two is through resonance.

For reasons inherent in the biology of human brains (Baddeley 1986), the dimensionality of the mind's niche (its short-term working memory) is always smaller than that of the whole of the outside world. In a confrontation between the two, therefore, there are always dimensions that are novel to the internal niche, and those lead both to the inclusion of novel dimensions in the knowledge system and to unintended consequences in the external niche. That is where invention (and ultimately innovation) arises: in that confrontation, the knowledge system is driven to develop new approaches and novel dimensions that cohere with the existing ones, but the nature of these approaches is never predictable.

Responding to the question for this Forum—Are commons static physical, social, and cultural resources, or are they dynamic and constantly consumed, recreated, and produced as collaborations develop?—I would answer that commons are dynamic and constantly consumed, recreated, and produced as collaborations develop.

A particular challenge in this process concerns understanding the role of noise in the cognitive system. What I consider noise are signals that have not been linked to a specific interpretative framework that "makes sense" of them. Noise is thus a signal of potential significance that has not yet been identified. During the process of transdisciplinary collaboration, noise is continuously being transformed into signals by associating it with different interpretative frameworks based on different epistemologies. The challenge of such collaboration is therefore *to identify an appropriate epistemology that is acceptable to the representatives of different disciplines*. To an important extent, this involves uniting the team as a social community around specific visions of the world.

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Focusing on the Future

Part of the challenge that current societies face is the need to reduce the uncertainty of the future. I will therefore introduce this topic before returning to further questions posed at this Forum.

Including the future in our scientific thinking requires a break with a centuries-long tradition within which the careers of scientists were focused and determined by ways to study (and explain) the origins of the present. In the 1670s, with the founding of the Royal Society, and the following years, which saw the emergence of various academies in Europe, admission to the community of scientists was made dependent on the capacity to demonstrate or prove one's ideas. Since this is difficult for the future, careers were directed at the relationship between present and past. Although in some disciplines this has changed, much of our current scientific knowledge was created under this paradigm: striving for an understanding of phenomena observed in the present by studying the processes that led to them. Changing that paradigm, to enable a deliberate focus on the future, demands fundamental changes in our scientific optics and amounts to an articulation between the explanatory biological and societal sciences, on one hand, and the goal-focused engineering sciences, on the other, as is currently occurring in the domain of biomimicry. This will, in my opinion, be the challenge of the twenty-first century.

The first question to ask is: *How did our societies end up in the present situation?* In my opinion, the dynamic that drove this process is the emergence of unintended consequences. In human short-term working memory, only around 8 (±1) dimensions of information can be handled simultaneously (Baddeley 1986). Many of those dimensions concern the decision-making environment, which has in turn been shaped by the niche creation process of interaction between the realm of human ideas and that of the environment (Iriki 2019). Observation of (part of) the environment thus creates a heavily reduced image of its complexity in the mind. That reduced image is then confronted, when action is taken, with the environment's full complexity. That confrontation affects the dynamics of the environment in many ways that are not known to the actor: *every action, therefore, has unintended and unanticipated consequences*, both positive (opportunities) and negative (challenges). Those consequences pose new challenges to the actor's information-processing system. In a nutshell, *solutions always create problems* which then need to be solved (van der Leeuw 2012). Some of these will take everyone by surprise and force changes, while others will be ignored as externalities. Hence the evolution of a society's knowledge structure does drive the trajectory of human–environmental interaction, but only partly directs it. A community's information-processing system is always confronted with *ontological uncertainty* (Lane and Maxfield 2005) and will never be able to predict its own future trajectory in detail.

In the more than two and a half centuries in which our Western society's information processing has been confronted with the evolution of the

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environment, our current information-processing systems can no longer grasp the totality of the changes that have occurred because of these unintended consequences. There is no other solution than to fundamentally review and change their structure.

How that process has shaped our current worldview is outlined by Henrich (2020) in his book *The WEIRDest People in the World: How the West Became Psychologically Peculiar and Particularly Prosperous.* He argues that beginning in the High Middle Ages, but particularly noticeable as of the sixteenth century, Western European thought evolved in a very particular manner during the Reformation, the Enlightenment, and the Industrial Revolution that distinguished it from most other existing worldviews. Henrich (2020:296–397) characterizes this process as moving from a holistic/relational world of dense social interconnections to a world that is increasingly analytical. As the bourgeoisie and skilled craftspeople sought to gain leverage in their struggles with the aristocracy and the church, they created new kinds of communities that were transactional, rather than relational, and stressed skills and analytical capabilities such as accounts, logistics, competitive assessment, and the like (Padgett 2001; Padgett and Powell 2012). This broke down the dense social and relational connections of feudal society into interactions between entities, individuals, and discrete categories associated with specific properties. Over time, Henrich argues, this approach became the norm in Western thinking and allowed phenomena to be explained by their properties or category memberships ("it's an electron" or "he is an extrovert"). Our society thus promoted a fragmented perspective on phenomena, which in turn was reinforced by siloing of, or isolating, different communities (Tett 2015, 2021).

To implement the necessary restructuring, rather than use a reductionist, *ex post* approach (which explains the present by invoking the past, looking for *origins*), we should be using an *ex ante* approach, which looks at the process of *emergence of novelty* in the past as well as in the present, thus linking past and present to the future. This would allow us to learn *from* the past *about* the present *for* the future (van der Leeuw et al. 2011). Because the focus is then on change, we also need to recast our perspective on the relationship between stability and change. In the Western scientific tradition, following Aristotle, stability is assumed to be the norm and change the thing to be investigated and explained. Instead of this perspective, we need to adopt Heraclitus's view, in which change is the only permanent thing and *stability needs to be explained*. We need to begin looking at how Western science created illusions of stability and control and investigate how and why this has happened.

As I will elaborate later in this chapter, Taleb argues in his book *The Black Swan* (2010) that overconfidence in our knowledge and judgment is fed *by the illusory certainty of hindsight* and has blinded us to the unexpected. Kahneman takes note of "…our excessive confidence in what we believe we know, and our apparent inability to acknowledge the full extent of our ignorance and the

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uncertainty of the world we live in" (Kahneman 2012:13). The scientific community needs to ask:

1. What are the causes and procedures that have created this worldview?
2. What are the limitations of it if we wish to consider the future?
3. How do we circumvent, or break through, those limitations?

It is here that a closer and more profound examination of collaboration as a process becomes fundamental.

The CAS approach is the context in which these questions are best posed and attempts at answering them can proceed. It differs fundamentally from the approach that Kahneman and Taleb critique, in that it does indeed focus on emergence (and thus inverts the logic of searching for origins) and attempts to understand how the *unexpected* emerges, and *what role that plays in the dynamics of the world* (Mitchell 2011). Yet its focus on the future differs from that of the engineering sciences, which aim to achieve a preset goal. The CAS approach strives to envision a future that is not preset by current ideas.

Many, trained in present-day science and the worldview that it adopts, will argue that this is impossible, that we simply cannot know the future, and that any attempt to change that is doomed. To those I would say that this perspective is part of the centuries-long, path-dependent focus on the relationship between past and present in Western science, rather than on the future. Had such efforts taken a more inclusive approach, "tools for thought and action" might have emerged over the past 250 years to help us understand the relationships between past, present, and future, and thus helped us to reduce the unpredictability of the future.

Part of what we need to do now is to open up our worldview to other, less canonical, category systems than those currently in use. Our societies have increasingly transformed our "understanding" of the world into "knowledge" by applying ever stricter rules of information processing in terms of categories and narratives that, indeed, produce useful ways to deal with the realm of phenomena, but exclude from investigation ever wider domains of "noise" (signals for which we do not have interpretative knowledge). The relationship between signals and noise is a fundamental domain that needs investigating (Tett 2021), as it is at the root of how we create narratives, and thus how we make decisions.

These changes will, in my opinion, enable different perspectives on the world of phenomena and fundamentally change our value systems, norms, understanding, and institutions in yet unexpected ways. The core focus in this concerns the relationship between the epistemology and the ontology (Searle 1995) of our current values and norms, as well as our institutions. That distinction is part of the framework that underpins our "knowledge," just like the distinction between "nature" and "culture" (or nature and nurture). Such opposites have rigidified our worldviews (Hertz et al. 2020). *Breaking open the*

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currently dominant narratives and the ways in which they shape our decisions and perceptions will be a core task of the twenty-first century.

Commonalities and Differences in Collaboration

Having outlined my general perspective on these issues, I will now try to relate them to some of the questions posed by the organizers of the Forum.

Concerning the mode of collaboration among each group of approaches, a few remarks may be useful, even though there are no standard practices. One major difference, in my opinion, is the fact that the natural and life sciences see their work as a collective, worldwide effort in which many teams collaborate and compete, have a shared (mathematical and conceptual) language, and are thus able to mobilize the vast majority of their professional community. The fact that this community also has a globally recognized system of publications contributes to this.

That process of worldwide collaboration is less well developed in the social sciences and humanities, where researchers working on their own or in small teams still comprise a large proportion of the community. That fragmentation is partly due to the national origins of the social sciences. Communities in different countries have been mobilized to address different societal issues, and their epistemological and linguistic differences are difficult to overcome, particularly in areas (e.g., China, the Arab world, and India) where those barriers are substantial. The Chinese language, for example, is ideographic rather than analytic, and it is therefore difficult to map Western approaches onto Chinese concepts or vice versa.

The engineering disciplines have an easier task in this respect because they do not aim to create new knowledge by finding ways to transform existing noise into signals but strive to use existing knowledge to solve material challenges. They have therefore developed a global language and a worldwide way of conceiving their task, so that the engineering community is globally more unified.

An important aspect of collaboration is the way a project is conceived, and what its balance is between top-down and bottom-up organization. This is an issue that must be dealt with by the whole team. In my own work, I have tended to give much space to bottom-up organization, seeing myself mainly as the provider and keeper of a vision that was agreed by all partners in the phase of contracting them for the project. The contracting process for the ARCHAEOMEDES project was structured by the EU's funding strategies at the time, in which each institutional partner was given its own budget (at my suggestion, and after negotiation) and a central budget was available to solve emerging problems. The negotiation was facilitated by the fact that I either knew partners personally, due to earlier interactions, or had ample time to get to know them in the process.

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Once ARCHAEOMEDES was on its way, I strove to maintain, with modifications, the original vision (to use the CAS approach) and served as translator or problem solver during interactions between disciplines, schools of thought, people (!), and languages (there were five, of which I spoke four). Within the ARCHAEOMEDES project were representatives from all three (natural, social, and engineering) groups of disciplines, and disciplinary differences were profound. Very often, this manifested in levels of communication that were anything but transparent. For example, in one of the first general assemblies, we discovered after a whole day of discussions that the English-speaking participants understood "desertification" as the emergence of large, sandy, and dry surfaces not unlike the Sahara, whereas the French speakers understood the term to mean "inner city abandonment." Most differences of this nature, however, emerged only much later and were difficult to pinpoint and even more insidious to address. By taking a bottom-up approach, a considerable amount of time was repeatedly devoted to having people explain their view on a topic, so that others, slowly but surely, could come to understand what the terms used meant for those using them. This was, in essence, a process of "intellectual fusion" and led to success. One sure road to failure, in the academic world at least, would have been to begin such a transdisciplinary project with a top-down effort to impose a set of questions, definitions, and a language or terminology.

A fundamental difference between the disciplines is epistemological. Most natural and life science data are not accepted in the disciplinary communities concerned unless they are quantified with respect to one or more scales of measurement. This requires that such data are *monothetic*—that they are part of one, and only one, recognized interpretative and measurement framework in the context of the transdisciplinary project concerned. However, many societal data are essentially *polythetic* because many societal issues belong in the category of "wicked" problems—problems that involve so many dimensions that monothetic clarity cannot be achieved.

The classic example of the distinction between polythetic (wicked) and monothetic (soluble) problems was expressed by Churchman (1967; cited by Batty 2012) when he asked: "Why is it that we can get to the moon, but not to the airport?" Getting to the moon is a question of solving monothetic challenges—challenges clearly defined in terms of a limited number of known dimensions. Getting to the airport through a huge bottleneck of cars is a question of solving a polythetic challenge with a much higher number of dimensions (those governing the behaviors of all the different drivers) which partly overlap, so that ambiguity dominates.

This difference in the nature of the interpretations of observed phenomena makes the debate about using quantitative or qualitative data unsolvable. These two categories of data have different roles. Quantitative data refer to "closed" categories of observation—categories that are intrinsically defined in terms of a limited number of dimensions that have universal validity. Qualitative data

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are extrinsically defined in terms of a set of dimensions that is not limited by any single conception of the phenomena concerned. They are "open" rather than "closed" categories.

What is the relationship between organizational design and collaborative dynamics? I think that the role of the leader in a project is of great importance and will vary with the project's principal investigator. In my experience, in view of the differences between disciplines, the organization of the project should be as flexible as possible. In the case of ARCHAEOMEDES, I chose the project's partners and negotiated with each as to what their role in the project would be. My main criteria in choosing partners were their potential scientific contribution and, importantly, whether I felt I could get along with the people chosen. In the few cases where I made a mistake, I did not continue collaborating with a partner after the initial contract. The main reason for discontinuing participation was when a partner did not get on with other partners or with people in their own team.

The basic structure of the team was therefore that of a group of institutions, each with their own specialty and their own research project, bound together by a more or less shared vision. The aim of the project was to use the different approaches and case studies to move toward a more coherently shared vision of dynamics and research approaches, methods, and tools. To achieve that, we devoted very long and frequent sessions to discussions (which cannot and should not always be planned). That process emphasized horizontal communication between project members over vertical communication between project members and the leadership. Alongside formally organized meetings, an important place in the project involved informal interactions. Field excursions, meals with wine or beer, and spare time for members of the team to speak to one another in one-on-one or similar configurations are as essential as formal meetings to create bonds between members of the team and promote a shared identity.

In many projects, there is a tension between the role of the leadership and that of the participants. To put this in terms of extremes, the leadership can either see itself as working for the project, or the project as working for the leadership. How this plays out is not always predictable, as it emerges in the interaction between the two over time. In academia, the personality of the person chosen as leader or PI is a major factor, rather than how that person is selected (appointed from the outside, by personal initiative, or bottom up). In other milieux, such as industry and business, which are more used to very structured teamwork, personality may play a less important role. I expect there are both successful and failed instances in all these approaches. I do think, however, that both co-leadership and a bottom-up majority choice of leader among academic partners adds risk to the whole enterprise because over time, many factors of individual or team preference emerge that could not be foreseen and may lead to misunderstanding or conflict. Again, shaping transdisciplinarity is principally a social convergence process shaping a scientific one.

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In the case of ARCHAEOMEDES, I did not establish clearly defined roles because, in my opinion, the success of a transdisciplinary project is dependent on the ways in which the participants create a community of ideas and a shared identity. That process is bottom-up and can be helped along, but not structured from above. Thus, in my experience, the concept of a leader working for the team is preferable because this solidifies the community that carries the ideas. The leadership should lead in three ways: (a) to maintain course on the overall goals of the project, once that course has been negotiated and agreed by all participants; (b) to act as a broker translating, where needed, between disciplinary or intellectual positions and where possible subsuming those under a higher-level set of concepts; (c) to handle any emotional issues that emerge as part of the transition between individual identities of people and the construction of a group identity. All three are necessary to bring the project to a successful end!

Core Constraints and Drivers

At the risk of grossly simplifying, I would argue that although the perspectives of the biological, social, and technological disciplines in their knowledge domains are in origin epistemologically different, they have in recent years been impacted by a growing awareness that as humans we live in an integrated dynamic world and thus these differences must be bridged as far as possible.

- Under the impact of Darwin and the Neo-Darwinians, the *biological perspective* has focused on an autonomous dynamic of change that is assumed to apply universally to all such systems. In recent years, it has incorporated the idea that such systems have both linear and nonlinear aspects, and both positive and negative feedbacks; growth, stagnation, and decay are included in one conceptual approach. It assumes that these are the result of emergent dynamics regulated at the genomic regulatory control level, and that they generate an unpredictable future.
- The *social disciplines* have originated mostly independently in different cultures, and although they have recently shown universalist tendencies, they have in my opinion never been able to fully overcome epistemological and linguistic differences. Until very recently, they considered human social dynamics rather independently from their context, at best focusing on the impact of those dynamics on the environment in which humans find themselves. Some of the disciplines concerned, but not all, have adopted a fully dynamic perspective that includes the change of change. Much of macroeconomics, in particular, still adopts a *dynamic equilibrium* perspective, which considers first-order change, but not second-order change (change of change) (Gowdy et al. 2016).
- The *technological disciplines* differ from both of the above in that they have a constructivist and predominantly mechanistic perspective, in

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which human beings create (aspects of) the niche in which they find themselves. They are thus future oriented and goal driven, rather than focused on system-endogenous emergence and explanation of the present and observed phenomena, as are the biological and social disciplines. Whereas the biological perspective, until very recently, did not assert control over the outcome of the dynamics involved, in the technological perspective, outcome control is fundamental. Technological disciplines focus on definable and solvable challenges but cannot deal with "wicked" ones.

Practitioners of all three disciplinary groups have become increasingly aware that the world is an integrated dynamic system and that they therefore need to collaborate with other disciplines. To this end, sustainability science has served as an important driver, and dynamic modeling has been an important facilitator. Together they are increasingly enabling scientists to be confident in adopting a dynamic perspective on the emergence of novelty in integrated socioenvironmental perspectives on the systems that impact our world. As part of that trend, to variable degrees, the focus has shifted from qualitative to quantitative approaches, while elements of the CAS perspective have also been incorporated. Although both developments have facilitated closer integration between disciplines, the shift toward quantitative approaches has reduced the scope of the phenomena that our knowledge systems address.

The Relation between Commons and Features of Collaboration

What is the exact relation between commons and the features of collaboration? I have defined the commons in a very different way than is usually done, by applying it to both the material and cognitive spheres and, in many ways, by emphasizing the role of the latter over the former. I would therefore invert the way this question is posed, by arguing that *the features of collaboration shape what is known and what is not (noise), as well what is partly known (the commons).*

This also implies a different perspective on the relationship between the realm of phenomena and that of ideas. That relationship is bidirectional: features of collaboration shape the commons and the commons shape the features of collaboration. As simple as that is when expressed in these terms, this actually represents a major change in approach. Rather than projecting the effect of changes in the environment on society, as has until recently been done in much of environmental and sustainability science, and asking society to adapt to environmental changes, under this perspective society is increasingly seen as the driver of environmental change, which poses the burden of attaining sustainability on society in a different way: as initiator rather than as respondent. Currently, sustainability science is in the midst of that transition.

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This new perspective raises very different questions, notably concerning the ways in which societies shape their information-processing frameworks, how they identify environmental and societal signals, what they ignore as noise, how they make decisions, and what category systems and narratives are used to underpin such decision making. I would therefore argue that a better understanding of the dynamics shaping both our knowledge systems and the ways we use them will make a major contribution, not only to the way one may address the sustainability conundrum but also to the dynamic of transdisciplinarity.

How does this involve the features of collaboration? First, we must move away from the thematic, disciplinary approach that currently reigns across the scientific community to a holistic approach that focuses on relations rather than entities. Rather than emphasizing transdisciplinary *collaboration*, which implies trying to attain solutions by bringing together different approaches, we should find ways to favor relations over distinctions, considering opposites not as mutually exclusive or even contradictory but as complementary to each other, as different aspects of the same wholeness, just like the two sides of the same coin.[2] Focusing on complementarities would also imply a focus on essential dynamic balancing of opposites.

At another level, it is important to shed the goal-oriented focus in much of science, which is part of the constructivist approach dominant in the sustainability debate. Collaboration necessitates a vision, but the exact plan to realize that vision is not predictable with precision. In view of the ontological uncertainty I referred to earlier, we cannot at any time conceive of a specific outcome of socioenvironmental dynamics, irrespective of the extent to which our societies are aiming for particular outcomes. The future cannot be transformed into a reachable goal. Thus, rather than striving toward such a goal, or even projecting a trajectory into the future under the concept of "progress," we should assume an open future in which many fundamentally different scenarios can play a part. These need to be evaluated against each other from many perspectives, including various kinds of uncertainty and risk.

More difficult to accept for the scientific community is the need to move beyond the concept of "the truth" in science. In his book, *The Black Swan*, Taleb argues that overconfidence in our knowledge and judgment is fed by the illusory certainty of hindsight. In Western society, he argues, reduced-dimension knowledge, formulated in closed categories based on established experience—and thus ignoring the full complexity of the world—has been elevated to a widely accepted vision of the world that does not take the potential of unexpected occurrences into account. It is prone to overestimate how much it understands about the world and to underestimate the role of "chance" events that

[2] A Chinese saying goes more or less like this: "A man who desperately wants to separate the two ends of a stick cuts the stick and then sees that instead of having two separated ends, he has now two sticks, both of which have two ends of their own! He continues to cut these sticks, and ultimately realizes that he ends up with an infinite number of sticks, each of which still has two ends. It is impossible to separate the two ends" (cited in van der Leeuw and Murase 2021).

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may be driven by unknown dynamics. That same point is made by Kahneman when he describes "a puzzling limitation of our mind: our excessive confidence in what we believe we know, and our apparent inability to acknowledge the full extent of our ignorance and the uncertainty of the world we live in" (Kahneman 2012:13). One manifestation of this challenge is the substitution of "knowledge" for "understanding." Critically looking at what science has not done and to explore signals that are currently considered noise will be an important task for the future. IT will be both a help and a hindrance in doing so.

The Impact of Information Technology

With the emergence of IT, the picture has changed both in a positive and in a negative sense. Communication has become easier and faster, and so has distant collaboration via the Internet. The increasing reliance of scientists on electronic data processing, of course, facilitates much research because rather than collecting data for one's own research in the field, one can simply access data from existing databases. The resulting Big Data movement, however, poses challenges for the transdisciplinary use of such (sensor and other) data because, while these data are gathered within a specific (explicit or implicit) epistemic context, that context is often lost once the data are included in a database. In other words, the true significance of said data is lost. To counteract this requires very thorough, critical examination of data used, particularly in computer models.

The use of IT communication does indeed facilitate long-distance asynchronous or synchronous collaborations between distant scientists. Its use, however, poses substantive challenges in creating truly integrated communities of scholars and scientists, as working over Zoom or other software is less efficient in drilling down into unexplored areas that substantively affect interaction, which are often deeply hidden in cultural assumptions. The nature of Zoom sessions, often limited to two hours because beyond that fatigue sets in, does not promote in-depth discussions that face-to-face meetings allow. It also does not enable the free-flowing interactions over meals that shape communities around specific topics. This constraint is particularly relevant to transdisciplinary projects.

There are two aspects of the increasing use of IT that I want to highlight: (a) the fragmentation of communities and values and (b) the increasing use of AI. To the first, as I have extensively argued (van der Leeuw 2020), modern web-based (and especially social) networks have made it easy to communicate one-on-one worldwide but they have also facilitated the fragmentation of communities. Opinions, in science as much as anywhere in society, are shaped by the networks in which an individual partakes. Until the advent of e-network communications, the variety of opinions in a society was constrained by the accessible information sources (e.g., press, television) and the people with whom

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an individual could communicate either orally or by mail. With IT networking, this constraint has been removed, and an increased number of network-based communities with specific opinions have emerged. This is both an advantage (more opinions get aired and examined) and a disadvantage because communities can, and do, fragment. The current opposition of opinions in politics shows the disadvantages of this process. It is much more difficult to set a course to handle such issues.

As to the impact of AI, a recent paper (Grumbach and van der Leeuw 2021) has posited the danger of category, narrative (and theory) formation by means of AI. Notably, machine learning (ML) can create categories of phenomena that are completely machine made and thus disconnected from human theory formation. This poses a fundamental challenge to scientists: Are they interested in building coherent information-processing mechanisms that link data to interpretations, or are they not? If they are, using ML-based category systems seems to require a complete revision of our current scientific interpretations, which are based on highly partial and biased perceptions of reality that have emerged out of the path-dependent evolution of our scientific efforts. Such a revision could offer opportunities for different kinds of transdisciplinary research, but one cannot but wonder how the scientific community would deal with such a change.

Conclusion

Clearly, there are many other aspects to consider in moving toward a different kind of transdisciplinarity, just as there are many more dimensions of collaboration to investigate to improve our understanding of its role in shaping cultural institutions. Here, I have highlighted a few of these, which to me seem fundamental. The discussions at this Strüngmann Forum have allowed us to go into more detail about the shift in research approach proposed here, the results of which are summarized in Chapter 16 (this volume).

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