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The Scope and Range of General Systems Transdisciplinarity

David Rousseau[1,2,3,4,5 *], Jennifer Wilby[6,7,8,9,10], Julie Billingham[11,12], and Stefan Blachfellner[13,14,15,16,17]

[1] *Director, Centre for Systems Philosophy, Surrey, UK*
[2] *Visiting Research Fellow, Centre for Systems Studies, Business School, University of Hull, UK*
[3] *Member of Scientific Council, Bertalanffy Center for the Study of Systems Science, Vienna, Austria*
[4] *Honorary Research Fellow, Religious Experience Research Centre, School of Theology, Religious Studies and Islamic Studies, University of Wales Trinity Saint David, Lampeter, Wales, UK*
[5] *Member, Centre for Spirituality Studies, Faculty of Arts and Social Sciences, University of Hull, UK*

[6] *Senior Visiting Fellow, Centre for Systems Studies, University of Hull, UK*
[7] *Visiting Researcher, Willumstad School of Business, Adelphi University, Garden City, NY, USA*
[8] *Academician, International Academy for Systems and Cybernetic Sciences, Vienna, Austria.*
[9] *Vice President, International Society for the Systems Sciences*
[10] *Member of Scientific Council, Bertalanffy Center for the Study of Systems Science, Vienna, Austria*

[11] *Scientific Advisor, Centre for Systems Philosophy, Surrey, UK*
[12] *Industry Principal, Business Strategy and Programs, Demandware Inc., Boston USA*

[13] *Managing Director, Bertalanffy Center for the Study of Systems Science, Vienna, Austria*
[14] *Managing Director, European Meetings on Cybernetics and Systems Research, Vienna, Austria*
[15] *Vice President, International Federation for Systems Research, Vienna, Austria*
[16] *Lecturer, University of Applied Science Upper Austria, Campus Steyr, Austria*
[17] *Lecturer, Danube University Krems, Krems, Austria*

ABSTRACT The pioneers of the general systems movement envisioned the development of a new scientific 'meta-discipline' grounded in a "General Systems Theory" (GST), a theory that encompasses universal principles underlying the systemic behaviours of all kinds of "real-world" systems. In contemporary terms we can identify this as a vision for a "transdiscipline" and we discuss its relationship to other conceptions of transdisciplinarity. In line with arguments presented elsewhere we identify this transdiscipline as "General Systemology", and the application of it "General Systems Transdisciplinarity" (GSTD). The founders of the general systems movement argued that GSTD would be important for assisting the transfer knowledge between disciplines, facilitating interdisciplinary communication, supporting the development of exact models in areas where they are lacking, and promoting the "unity" of knowledge. In this paper we defend this view, and infer that the scope and range of GSTD is wider than hitherto recognized, and argue that GSTD would potentially be the most powerful of the transdisciplines.

KEYWORDS General Systemology, General Systems Transdisciplinarity, GSTD, exploratory science, General System Theory, GST, GST*

* *E-mail address:* david.rousseau@systemphilosophy.org

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1. Introduction

The founders of the general systems movement (Ludwig von Bertalanffy, Kenneth Boulding, Anatol Rapoport and Ralph Gerard) called for the development of a new discipline with "interdisciplinary" and "meta-scientific" aspects (von Bertalanffy, 1972, p. 421), grounded in a "General Systems Theory" (GST) that would encompass the principles underlying the systemic behaviours of all kinds of systems (Boulding, 1956; von Bertalanffy, 1950, 1969; Gerard, 1964; Rapoport, 1986).

The term "General Systems Theory" has however come to stand for a wide range of meanings, including the foundational general theory of systems and the new meta-scientific discipline(s) which it would enable. In order to disambiguate between these meanings we have recently proposed (Rousseau, Wilby, Billingham, & Blachfellner, 2016a) that:

- the foundational general theory of systems be called GST* (pronounced "g-s-t-star");
- the discipline that seeks to develop, apply and promote GST* be called "General Systemology" (in line with an earlier proposal by Bertalanffy scholars David Pouvreau and Manfred Drack (Pouvreau & Drack, 2007));
- the disciplinary field of systems, of which General Systemology is a component, be called "Systemology" (in line with an earlier proposal by Russ Ackoff (Ackoff, 1973, p. 669).

We will employ this terminology in the present paper.

The "Bertalanffy Circle" envisaged that this new "meta-science", would support interdisciplinary communication and cooperation, facilitate scientific discoveries in disciplines that lack exact theories, promote the unity of knowledge, and help to bridge the divide between the naturalistic and the human sciences (von Bertalanffy, 1972, pp. 413, 423–424; Laszlo, 1974, pp. 15–16, 19; Rapoport, 1976). The pioneers of General Systemology saw this as a strategy and action plan for averting looming social and environmental crises, and opening up a pathway towards a sustainable and humane future (Laszlo, 1972; Hofkirchner, 2005, p. 1; Pouvreau, 2014, p. 180).

General Systemology is still a nascent discipline (Francois, 2006, 2007), but interest in its development remains active (Troncale, 2009; Friendshuh & Troncale, 2012; Billingham, 2014a; Rousseau & Wilby, 2014). Recent times have seen an upsurge of interest in both GST* and General Systemology (Drack & Schwarz, 2010; Hofkirchner & Schafranek, 2011; Billingham, 2014a, 2014b; Denizan & Rousseau, 2014; Drack & Pouvreau, 2015; Rousseau, 2015b; Rousseau, Wilby, Billingham, & Blachfellner, 2015a) and the present authors have recently called for concerted action towards advancing the development of this meta-science (Rousseau, Wilby, Billingham, & Blachfellner, 2015b, 2016b).

What von Bertalanffy called a "meta-science" would in current terms be called a "transdiscipline", and in fact Bertalanffy's call for a GST in the 1930's has attained a place in the history of transdisciplinarity as the moment when it became clear, as a scientific position, that objects and their environment interdepend, and hence that single disciplinary approaches would be insufficient for scientific analysis of complex problems (Balsiger, 2004, pp. 410–411). When the term "transdisciplinarity" was coined at the first conference on interdisciplinary research in 1970, one of the contributors, Jean Piaget, suggested that transdisciplinarity would support maturation and convergence between fields in terms of the general structures and fundamental patterns of thought, and that this would in turn lead to a general theory of systems (Apostel, Berger, & Michaud, 1972, p. 26). In his *Foreword* to a post-mortem compilation of previously unpublished work by von Bertalanffy (edited by Edgar Taschdjian), Ervin Laszo called General Systemology "a new paradigm for transdisciplinary synthesis" (Von Bertalanffy, 1975, p. 12). We support these views, and in 2015 launched a *Manifesto* calling for the development of "General Systems Transdisciplinarity (GSTD)" as representing the attitude and forms of action of General Systemology.

However, due to the rapid expansion of interest in transdisciplinarity the term "transdisciplinarity" has acquired a diversity of nuanced meanings, and so the term should be used with care.

The purpose of the present paper is to explain some of the differences and commonalities between varieties of transdisciplinarity, clarify our perspective on the nature and value of transdisciplinarity, and present our vision for the potential reach and value of General Systemology understood as a transdiscipline.

2. What is transdisciplinarity?

The term "transdisciplinarity" was coined in a typology of terms devised at the first international conference on interdisciplinary research and teaching in OECD-member countries, held in Paris in 1970 (Apostel et al., 1972), where it was defined generically as "a common set of axioms for a set of disciplines". Since then interest in transdisciplinary has grown rapidly, and it is currently "marked by an exponential growth of publications, a widening array of contexts, and increased interest across academic, public and private sectors" (Klein, 2014, p. 69).

2.1. The scope of transdisciplinarity

As a relatively new academic development there is as yet "no universal theory, methodology, or definition of transdisciplinarity" (Klein, 2013, p. 189), and there is a considerable diversity of opinions about its nature, scope, value and potential.

Sue McGregor called it a philosophical movement, (McGregor, 2014, p. 1) while Basarab Nicolescu identified it as a new kind of methodology (Nicolescu, 2002), but claimed it is not a new kind of discipline (Nicolescu, 2010a). Michael Gibbons and colleagues deny that it involves a methodology, but do claim that it is a new means of producing knowledge (Gibbons et al., 1994). According to both Predrag Cicovacki and McGregor, it requires a distinct axiological underpinning (Cicovacki, 2009; McGregor, 2014), but according to Nicolescu it does not (Nicolescu, 2005). Nicolescu has identified three kinds of transdisciplinarity which he classifies as respectively "theoretical transdisciplinarity" (which is concerned with developing transdisciplinary methodologies), "phenomenological transdisciplinarity" (which is concerned with using trans-disciplinary principles to build models and making predictions), and "experimental trans-disciplinarity" (which is concerned with doing experiments using transdisciplinary methodologies) (Nicolescu, 2010b, p. 23).

2.2. The aims of transdisciplinarity

Despite this diversity of views about the *nature* of transdisciplinarity, there is considerable coherence in claims about its *aims*. Klein indicated that it is about addressing unsolved problems, especially societal ones (Klein, 1986), Gibbons and colleagues say it is about joint efforts to address problems pertaining to the interplay between science, society and technology; problems that are not circumscribed in any existing disciplinary field (Gibbons et al., 1994). McGregor says it is an approach to solving deeply complex, interconnected problems that are too complex to be solved from within the boundaries of one discipline or by using a conventional empirical methodology (McGregor, 2014, pp. 3–4). For Seppo Tella, transdisciplinarity is intended to address the complex, wicked problems facing humanity (e.g., climate change, unsustainability, poverty) (Tella, 2005), and for McGregor it is about interconnecting science, politics and technology with society in a way that respects the survival of humanity in a future that is worth living (McGregor, 2014, pp. 2–3).

2.3. The character of transdisciplinarity

Klein's analysis of the discourses of transdisciplinarity (Klein, 2014) shows that all forms of transdisciplinarity engage with at least one of three overlapping concepts: transcendence, problem-solving, and transgression:

- "Transcendence" is about overcoming the barriers between disciplines, and in this sense transdisciplinarity is close to the ancient quest for the unity of knowledge, although the notion of "unity" has changed over time, to include aspects such as compatibility and consilience;
- Transdisciplinary approaches to problem-solving deviate from traditional approaches by placing great emphasis on "real world" problems, by involving feedbacks between organizations involved in research, design, education, services, and policymaking, and by a commitment to social, environmental, economic and ethically sustainable development;
- "Transgression" is about questioning the constraints of traditional disciplines. This is not a rejection of the ethics or rationality of disciplinary inquiry, but an acknowledgement of uncertainty and a willingness to critique, reimagine, reframe or reformulate the status quo. This attitude allows established boundaries and limitations to be challenged and existing knowledge to be recontextualised, and in so doing opens up new routes to discovery, insight, and innovation.

2.4. The varieties of transdisciplinarity

Transdisciplinarity is currently a dappled arena, with much consistency in its overall aims but also much diversity in how those aims are pursued. Klein has explained that "transdisciplinarity is simultaneously an attitude and a form of action" (Klein, 2004, p. 521), and this characterisation is helpful in understanding the diversity of forms transdisciplinary currently takes, when taken together with the definition of transdisciplinarity as "a common set of axioms for a set of disciplines". There are many kinds of "axioms" that can be proposed as assumptions, beliefs or principles that would, if adopted, lead to the kind of "better world" that transdisciplinarity is focused on. The "attitudes" that inform transdisciplinary "forms of action" have ranged over distinct frameworks such as general systems, post-structuralism, Marxism, feminist theory, cultural critique and sustainability (Klein, 2014).

This diversity highlights a key question for transdisciplinarity, namely whether it represents a discipline in its own right or merely modulates the attitude with which existing disciplinary work is undertaken. We propose that this issue could be resolved in the light of the systemic model of an academic discipline we have presented elsewhere (Rousseau, Wilby, et al., 2016a). This represents a discipline as an "Activity Scope" informed by a "Knowledge Base" and conditioned by a "Guidance Framework", which for short we call "the AKG model" (see Figure 1).

The AKG model provides a way of distinguishing between a topic, a theory, an activity, an attitude and a complete discipline. In the light of this model we can see that the current diversity of kinds of transdisciplinary can be characterised in terms of two major types. The first type involves a concern for the application of specific transdisciplinary values such as equal opportunity or sustainability. These kinds of values can be applied across multiple disciplines, but this serves only to extend the guidance frameworks of existing disciplines rather than generating transdisciplines as such. In the second type, transdisciplinarity involves the application, under a guidance framework (which includes values), of transdisciplinary theories such as GST* or Cybernetics. For this second type it is appropriate to speak of transdisciplinarity as the application of a transdiscipline, since there is a distinct discipline involved *in addition to* the orthodox ones over which its applicability might range.

In this light we can not only understand the origins of the diversity of kinds of transdisciplinarity that we have today, but we can see that the first type of disciplinarity is likely to evolve into the second type, as its proponents firstly develop methodologies for applying those value systems in different disciplinary contexts, and as theories are developed that explain the

utility or appropriateness of those values and hence ground those methodologies in principled ways.

From this we can view "type 1" transdisciplinarity as "early-stage type 2" transdisciplinarity, and see its evolution from "type 1" to "type 2" as a maturation from an intuitively compelling form of activism to an objectively compelling species of scientific endeavor.

However, we can also see that the value systems of current "type 2" transdisciplines will increasingly evolve under the influence of "type 1" transdisciplinarity to include transdisciplinary values, shifting them further from the classical ideal of science as a "value-neutral" endeavor to one that accepts responsibility for its impact in the world.

We can thus foresee an evolutionary trajectory for all kinds of transdisciplinarity, involving the development of transdisciplines that incorporate transdisciplinary theories, methodologies and values. Transdisciplinarity can begin with any of these three components, but in viable forms of transdisciplinarity all three components will eventually be present.

Moreover, we can anticipate that on the basis of an emerging consilience between transdisciplinary theories, methodologies and values the diverse transdisciplines might coalesce into a coherent transdisciplinary field.

For the purposes of this paper we will henceforth discuss transdisciplinarity only in terms an "ideal type" that (potentially if not yet actually) is the expression of a transdiscipline involving transdisciplinary theories, methodologies and values, and whose values align with a concern for building a "better world".

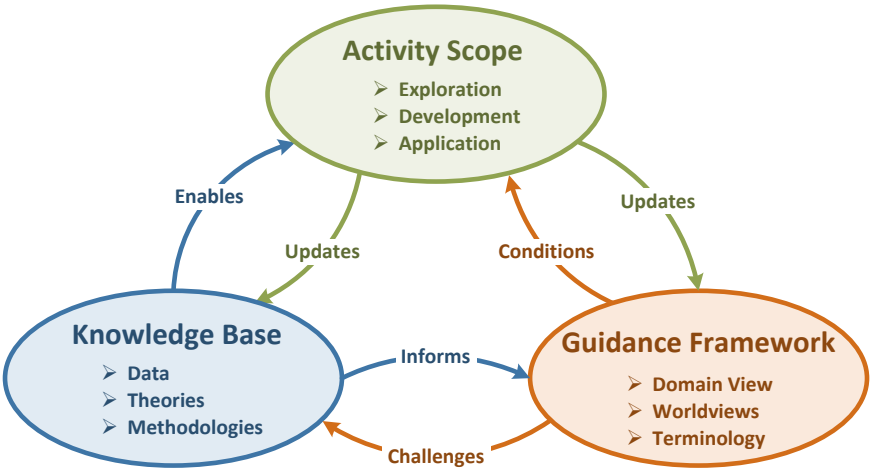

Figure 1: The AKG Model of a discipline
(Rousseau et al., 2016a, p.23, reproduced with permission)

3. Kinds of disciplinarity

The focus of transdisciplinarity on problem solving calls for an explanation of how transdisciplinarity differs from other kinds of disciplinarity in its approach to problem solving, and how its particular value arises. Several kinds of disciplinary are now recognised (see, e.g. Tress, Tress, & Fry, 2005; Salmons & Wilson, 2007; Klein, 2010; Nicolescu, 2010a), as follows:

(i) *Mono-disciplinarity*: this involves only a single discipline and is suitable for addressing simple phenomena or a single aspect of a complex phenomenon;

(ii) *Multi-disciplinarity*: this is used for addressing multiple aspects of a phenomenon by making use of several disciplines. It acknowledges their differences but involves no attempt to bridge between them;

(iii) *Cross-disciplinarity*: this is used where several academic disciplines are interested in the same aspect of a complex phenomenon. The different disciplines' distinct methods are brought to bear on the same problem in a coordinated way, establishing a kind of middle ground;

(iv) *Inter-disciplinarity*: this involves combining several disciplines, attempting to synthesize them into something that provides a new perspective on the given problem;

(v) *Transdisciplinarity*: this involves disciplinary frameworks that are developed from generalisations based on patterns[1] that recur across or connect between several disciplines, and hence it involves insights about the general nature of the world rather than the special natures of specific kinds of phenomena (Klein, 2004, p. 515; Rousseau & Wilby, 2014, Rousseau, Billingham, Wilby, & Blachfellner, 2016a). In contrast to other kinds of disciplinarity which bring the means of one or more specialised disciplines to bear on a specific problem, transdisciplinary frameworks are relevant to the phenomena studied in several disciplines, and hence transdisciplinarity introduces new means that can enhance the effectiveness of the disciplines it is partnered with (Nicolescu, 2002, pp. 44, 46).

These distinctions are illustrated in Figure 2, which is adapted from (Rousseau & Wilby, 2014). Here the specialised disciplines are indicated by numbers D1-D3, the meta-discipline representing trans-disciplinarity by D*, and any form of disciplinarity *other than* transdisciplinarity by DX.

The kinds of disciplinarity illustrated in Figure 1 follow a progression of increasing complexity and power beyond that of the specialised mono-disciplines, reflecting engagement with increasingly complex problems or increasingly deep questions.

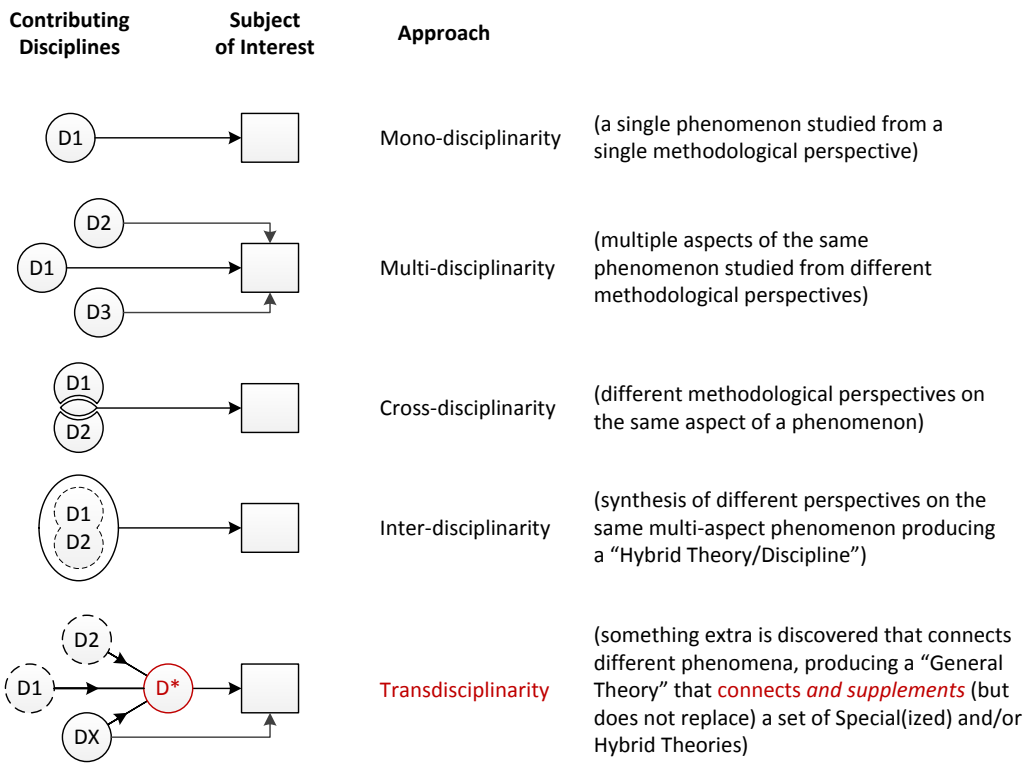

Figure 1: Kinds of Disciplinarity
(*adapted from Rousseau & Wilby (2014)*)

[1] The term "patterns" here can be taken to range over both concrete patterns such as patterns of structures, processes and behaviours in natural systems, or abstract patterns observed in social systems, value systems and patterns of thought.

Note that transdisciplinarity is different from the others in that it adds something new to the disciplines it generalises over, rather than combining or merging existing disciplinary resources. Its value is realised when it is used in conjunction with one of those disciplines to address problems originating in those disciplines.

4. The range of General Systems Transdisciplinarity

In general, different kinds of disciplinarity are called for depending on the complexity of the phenomena being addressed. The problems any discipline tries to address can be divided into three broad categories, as shown in Figure 3, namely "Routine" (problems that can readily be addressed by established explanatory models and theories), "Difficult" (problems involving phenomena not yet understood but that appear analysable using existing research methods) and "Radical" (problems involving phenomena that cannot be analysed given the kinds of theories/methods available in the discipline). These are provisional categories, because it is never certain that a given phenomenon has been correctly or fully explained, is really readily analysable, or actually does lie outside the current analytic capacity of the given disciplinary framework.

In every discipline the central objective is to maximize the scope of what can be explained, predicted, managed or utilized. Doing this calls for different kinds of disciplinarity depending on the complexity of the issue, as shown in Figure 3.

When dealing with a specific challenge the kinds of disciplinarity are typically engaged in the order of their relative complexity, in order to find the solution in the simplest possible way. However, given the nature and range of phenomena that still lie beyond scientific explanation, it is likely that scientific investigation will increasingly call for transdisciplinary working.

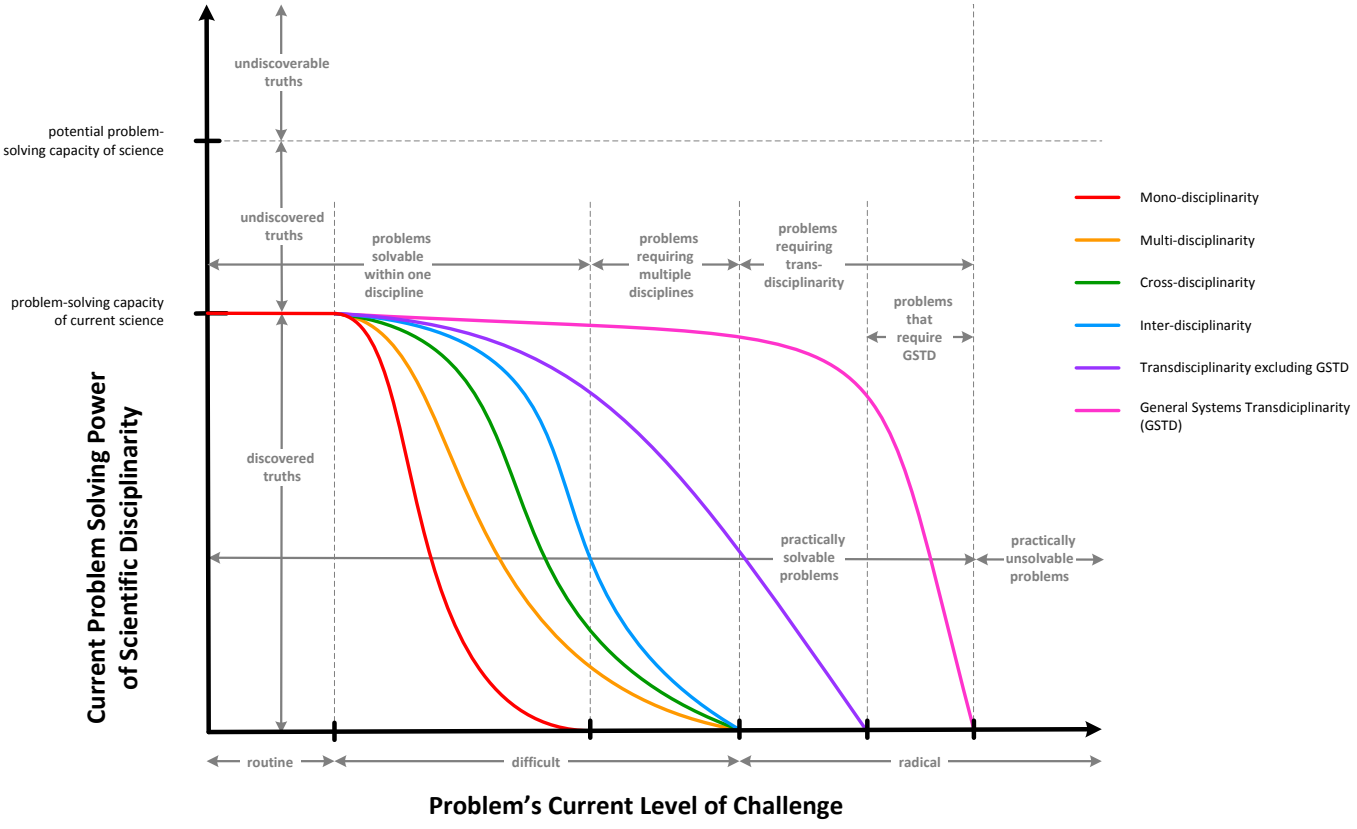

Figure 3: The application areas of kinds of disciplinarity

Transdisciplinarity is grounded in insights about patterns that recur across or connect between disciplines, and therefore it tells us something about the fundamental nature of the world that is not

readily evident from within the specialized disciplines. Because of this it can powerfully enhance problem solving techniques in specialised areas, and thus be especially useful where specialised disciplines are addressing apparently intractable disciplinary problems, e.g. ones that reflect deep ontological or epistemic issues.

Amongst the transdisciplines, General Systemology is arguably the potentially most powerful, because it is grounded in the deepest of the general principles applying to the "real" world, as we have discussed elsewhere (Rousseau, 2015a; Rousseau, Billingham, Wilby, & Blachfellner, 2016b; Rousseau, Wilby, et al., 2016a).

5. The scope of General Systems Transdisciplinarity

Figure 3 illustrates our claim that GSTD is more versatile than other forms of transdisciplinarity. This is so because GST seeks to identify universal principles underlying the origin, evolution and behaviour of all kinds of complex systems (Friendshuh & Troncale, 2012; Rousseau, 2014a; Billingham, 2014a; Rousseau et al., 2015a). As such its concepts, models and methodologies could be relevant in all areas of investigation and theory development.

The transdisciplinary insights of General Systemology might be used not only to address complex problems, but also to support exploratory science, i.e. to develop testable hypotheses about unexplained complex phenomena that are not considered to be problematic but are nevertheless part of the context in which problem-solving is undertaken. For example, many familiar human abilities such as creativity and abstract thinking remain largely mysterious, and yet understanding them would contribute much to achieving the thrivable future that is the focus of transdisciplinary ambitions.

The transdisciplinary nature of General Systemology also positions it uniquely to support translational science. From a very wide perspective science can be seen as supporting a cycle which addresses human needs by seeking discoveries that can be turned into insights that can support innovation towards products and practices that fulfil those needs. Translational science is concerned with expediting the transition steps from discovery to insight to innovation to application, and from need identification to exploration for discovery (Drolet & Lorenzi, 2011; Woolf, 2008). Translational Science faces many challenges (Fang & Casadevall, 2010), and it has been suggested that the systems perspective can enhance the effectiveness of Translational Science (Kijima, 2015). The founders of General Systemology already envisaged that General Systemology would facilitate co-operation and transfers of knowledge between disciplines via its common framework of general concepts, principles and models. This would increase the effectiveness of disciplines by reducing duplication of effort. We can however now see that GSTD would also facilitate communication and cooperation between research organizations, academic institutions, industries and practitioners within a discipline. In this way GSTD can also help to accelerate the cycle whereby discoveries lead to innovations and those in turn become products and services.

The way in which GSTD can support these new developments is illustrated in Figure 4. We have here used the same color scheme as we did for the AKG Model of a discipline we showed earlier, using blue for components of the Knowledge Base, orange for components of the Guidance Framework, and green for components of the Activity Scope. The diagram illustrates the key components of General Systemology and shows the scope of its activities. As can be seen in the diagram, the activity scope of General Systemology has two transdisciplinary aspects. In the first, shown in the left half of the diagram, General Systemology functions as the unifying transdiscipline for Systemology, refining and extending the general theory (GST*) that applies across the specialized and hybrid systems disciplines, as we discuss elsewhere (Rousseau, Wilby, et al., 2016a). In the second aspect, shown in the right half of the diagram, GSTD leverages the methodologies of General Systemology to support/extend other disciplines and fields.

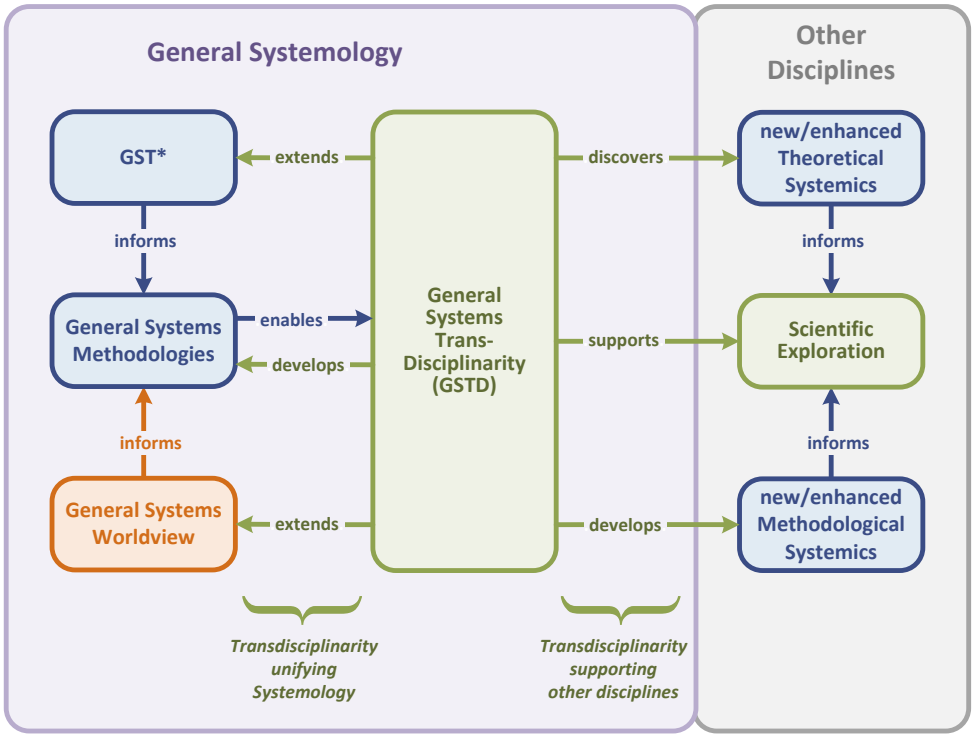

Figure 4: General Systems Transdisciplinarity as the activity scope of General Systemology
(adapted from Rousseau, Billingham, Wilby, & Blachfellner, 2016b, p.71)

Amongst the transdisciplines, General Systemology is perhaps the only one that has a *scientific strategy* for finding transdisciplinary patterns, by following von Bertalanffy's injunction to look for isomorphies of structures, behaviors and processes present in the designs of different kinds of systems under the guidance of the GSW, as we discuss in (Rousseau, Billingham, et al., 2016b). As a worldview GSW embraces the framework of Broad Naturalism and Moderate Critical Realism that is dominant in the "hard" sciences. However, it must be noted that unlike the "hard" science ideal of neutrality General Systemology has from the outset maintained a concern for meaning and value (Hammond, 2003, 2005) and a commitment to building a "better world" (Hofkirchner & Schafranek, 2011). As such it has always pursued the ambition of bridging the gap between the object-oriented and the subject-oriented disciplines in a way that preserves the merits of each, and recent developments in General Systemology suggest that such a bridge can in fact be attained via the development of GST* and the GSW (Rousseau, 2014b, 2015a). In this light, General Systemology is likely to contribute significantly to the discovery, problem-solving and cultural transformation that will be needed to help us attain and sustain a thriving eco-civilization.

We have elsewhere (Rousseau, Blachfellner, Wilby, & Billingham, 2016) presented a detailed *Research Agenda* outlining the issues to be addressed towards achieving such a profound and empirically significant General Systems Transdisciplinarity.

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