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Mind the gap: Bridging the two cultures with complex thought

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ABSTRACT

Robert Rosen's work has implications for biology and the natural sciences, but also for vital issues in society, economics and politics. Today's dominant knowledge paradigm and Anthropocene crisis are two sides of one coin: extant flaws of modern thought are part and parcel of the economic and political ideas and institutions driving both social and environmental global crises. Rosennean relational biology and Morinian complex thought shift the knowledge paradigm from modernity towards complexity, working to transcend the ontological flaws underlying the sciences to better grasp and address the social drivers of global crises. Rosen's work bridges gaps between physics and biology, and between the sciences and humanities. Rosen's work indicates that the dominant posture of monist physicalism must be transcended with a more pluralist methodological articulation within and across disciplines. I focus on just three concepts that help to evoke and advance Rosennean complexity throughout the sciences and humanities: paradox, pluralism, and perspectivism. These three concepts help to demonstrate how Rosen's work advances biology, but also, more broadly, how to more fully make crucial bridges across the two cultures gap, articulate transdisciplinary knowledge, and thus advance social, economic and political dimensions of urgent societal transition.

1. Introduction: the twin crises of knowledge and the biosphere

1.1. The anthropocene crisis, complex thought, and concepts for transition

Robert Rosen's work has deep implications, for the natural sciences, but also for changes in culture, economics, and politics today, necessary for urgent societal transition. Rosen saw how complex dynamics, such as fuller causal entailments, are needed to address or transcend errors of the two cultures gap and related flaws and distortions in science, knowledge and the dominant worldview.

In particular, I look at three concepts that help to support Rosen's view of relational biology, as part of an overall shift to more complex thought, the three concepts: paradox, pluralism and perspectivism. I nickname these three transdisciplinary concepts 3P, and discuss them in more detail later. In brief, a paradox is a statement that appears to express a contradiction, but on closer examination, the seeming contradiction may be resolved. Pluralism posits that there is more than one kind of thing in the world, contra the prevalent scientific view that all is reducible to the physical. And perspectivism holds that all social and biological phenomena are interrelated, involve observers and contexts, and take place from and within particular perspectives relative to specific phenomena.

Rosennean relational biology is part of a bigger general paradigm shift, from the dominant paradigm born of the western Scientific Revolution to the emergent paradigm, which we might call a diverse and global, Complexity Revolution.[1] Work to advance this general paradigm shift in knowledge is crucial to transition, or transforming the root and systemic causes of social and environmental crises.

In defining the causes of the so-called Anthropocene, people have pointed to fossil fuels, industrialization, combustion engines (Steffen et al., 2015), agriculture (Morton, 2016), capitalist overshoot (Kovel, 2007; Moore, 2015; Haraway, 2016), militarization (Mumford, 1934; Mumford, 1967; Bulletin of the Atomic Scientists, 2017), fuel intensive technologies (Mumford, 1967; Ammon, 2016), and more (Gibson et al., 2015; Moore, 2017). There are psychological causes, such as fear and sociopathy. While, another important way to look at the nexus of the above causes, is

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[1] My inspiration for calling our current shift the Complexity Revolution, comes from my reading across the complexity sciences and studies, and particularly Edgar Morin's complex thought, a.k.a. generalized complexity, or complexity as knowledge paradigm. See for instance Morin, 1977, 1981, 2005 and 2011.

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increased societal complexification itself: as societies develop more layers of organizational complexity, they appear to tend towards systems of oppressive hierarchical social, economic and political domination (Tainter, 1988; Sinaï, 2013; Wells, 2012). Humans however have creativity, agency, and capacity to change policy. Complexity scholars can work to comprehend the sweet spot of human organization: the overall societal energetic and institutional complexification with respect to sustaining the biosphere, beyond which a society creates conditions of overshoot, crises, and collapses. Energy, economic, technological, and other policy today must aim for that sweet spot, or range, of feasible net societal complexification.

Addressing the global crisis involves comprehending key societal organizational patterns and levers of net societal overshoot. The sciences indicate that all of these causes are involved (Meadows et al., 2004; Rockstrom et al., 2009; Hansen et al., 2016), and that both carbon drawdown and ecological regeneration are crucial. Qualitative analysis highlights the systemic nature of the issues. From a complex view, it becomes screamingly clear that just one or another institution or technology is neither culprit or fix. Just carbon sequestration or just market mechanisms are bandaids at best. Rather, the whole dominant global societal organization itself drives overshoot (Plumwood, 1993, 2002; Harvey, 2014; Moore, 2015; Servigne and Stevens, 2015; Haraway, 2016). This dominant societal organization is comprised for instance of economics, politics, and power structures, as well as the social organization of agriculture, forestry, fisheries, etc. The modern in us still sees all of these as distinct categories. But their fundamental characteristic is that of dynamical, enmeshed causal interaction.

However, in this essay, I focus on just one cause of the global crisis that underlies all these others: the dominant knowledge paradigm itself. Today's dominant knowledge paradigm underlies the impoverished ideas and ideologies that shore up of lawed societal organization. Flawed, extant modern thought reproduces and maintains all of the other social causes of the Anthropocene crisis. Generally speaking, this dominant science works within disciplines, and for many people, in many ways, this yielded dazzling knowledge, technology and quality of life. Paradoxically, however, science brings about positive or negative social consequences within contexts and perspectives. Science is simultaneously strong with respect to its focus, while also nefarious with respect to whole peoples and places. Since science is enmeshed in all realms of human lives – social, ecological, economic, technological, political, etc. – we see these paradoxical dynamics playing out across all these realms. This view is not new; it is the consensus in fields like science and technology studies. What is needed is to expand and integrate these concepts much more widely. Complex thought facilitates this widespread uptake, as it came forth in the form of breakthroughs in many disciplines – philosophy, largely qualitative social sciences, and quantitative sciences. It acknowledges characteristics of the world as that of: imbued with webs of feedbacks, networked causalities, hierarchically enmeshed scales, enmeshed entailments, and dynamic interaction,[2] necessary to more generalized knowledge and comprehension (Morin, 2005).

This is perhaps the most needed area of change today: changing the dominant paradigm of knowledge transforms the sense of what's at stake and what's possible. It shows that since social drivers of crises like climate are complex and systemic, so are the solutions. Climate policy requires flipping key levers of systemic social organization that are driving the climate crisis, towards systemic solutions (Morin, 2011; Wells, 2012; Klein, 2014). Since 1988, just 100 companies have emitted over 70% of directly human driven global greenhouse gases, and in the same time, just 25 companies have emitted over 50% of all greenhouse gases (Griffin, 2017). Yet addressing carbon drawdown and ecological regeneration entails not simply shifting from carbon to renewables, but also systemic shifts in many areas of societal organization, and in highly differentiated ways (Kartha and Bear, 2015; Chaturvedi and Doyle, 2015; De Sousa Santos, 2014, 2015; Sinaï, 2013, 2015; Sinaï and Szuba, 2017; Martinez-Alier, 2002, 2012).

Effective climate policy, for example, involves grasping interconnections like those between justice, economics, politics, and the biosphere. When effective climate policy gets at root social causes of multiple harms to societies and environments, then it tends to bring systemic improvement in all these areas. For instance, for these 100 high-emitting companies to engage more fully in a globally just and cooperative transition to renewable energies would contribute to multifaceted solutions including greater social justice, equality, environmental conservation, and green economic growth (Kartha and Baer, 2015; Jacobson et al., 2017; Hawken et al., 2017; Hansen et al., 2016; Sanders and Boxer, 2013). Economic benefits of transition become clear when compared with viable alternatives, over time, and at full scales. Generally speaking, getting at systemic social drivers will bring systemically beneficial results socially and environmentally, economically and politically. If we define the Anthropocene not as an era to live into, but as a recognition of passing systemic global environmental thresholds, then by definition, the crisis is that systemically transforming the social drivers of that change is long overdue, which is to say, urgent. Addressing this requires thought and vision still mostly missing from today's dominant knowledge: contextual, systemic, integrative, dialectical, and dynamical.

This requires a fuller leap from modern to complex thought (Morin, 2011). To address the foundational errors in knowledge can crack open creative thinking in all of these areas. The three P terms I explore – paradox, pluralism and perspectivism – give one set of insights into that greater knowledge paradigm shift, for complex and transdisciplinary analysis.

1.2. From modernity to complexity: knowledge for the twenty-first century

To confront crises of climate, extinction and human suffering, we need to mind the gaps in knowledge, but also to mend the gaps. Rosen's work advances more complex and connective assumptions, links, and methods, across the sciences and humanities.

Today we are in the midst of a general knowledge paradigm shift, perhaps the biggest in 500 years, or in history. This is the shift past extant flaws of the 16th Century European Scientific Revolution – e.g. strong versions of reductionism, universalism, monism, determinism, foundationalism, atomism, etc. – much of which still shore up distortional scientism and physicalism through the natural sciences. All of these errors infused social fields of norms, values, economics and politics. The social realms of culture, economics and politics are innately pluralist and radically undermined by scientific ideas that subsume and suppress their full qualities. Monism, is a view that there is only one distinct type of thing in the world, and is associated with physicalism, the sixteenth concept century thesis that everything is physical (Dupre, 1994), or as philosophers say, everything supervenes on the physical.

[2] The concept of restricted knowledge is derived from Morin's concepts of restricted versus generalized complexity (2006). 'Societal complexification' refers to the degree of number and interaction of parts and roles in a society, as defined in the work of Joseph Tainter (1988). It is a key term for the Anthropocene crisis, as it entails the co-production of fossil fuels, empire, and capitalist globalization. What has ensued is a 'hypercomplex society,' a key quality in the phenomena of overshoot and collapse. I argue that humanity must seek a sweet spot: enough societal complexification, but not too much.

Monism has been shored up by the errors of, not science per se, but scientism. Philosopher of science John Dupre defines scientism as "an exaggerated and often distorted conception of what science can be expected to do and explain for us," for instance, the idea that a subset of quantitative methods can be applied to any kinds of knowledge inquiries (Dupre, 2001, pp.2-3). While others focus on scientism specifically as the false use of methods from one domain applied to another, particularly, the overreach of methods from physics to other domains (Kline, 1995).

While more generally, scientific imperialism posits that a method for one domain is the only method for all other domains (Dupre, 1988, 1994, 1995, 2001). Wedded with physicalism, monism and universalism, scientific imperialism extends the quantitative methods to all matters that in fact require other methods, e.g. qualitative methods. The absurdity of this has been masked by the stark silos of disciplinary norms, training, acculturation, and hubris, both between the two cultures, and with respect to other ways of knowing, e.g. indigenous wisdom, and the arts As Dupre describes,

> "[A]t least two approaches to human behavior, those deriving from economics and evolutionary biology, often involve clearly [scientifically] imperialist tendencies. Devotees of these approaches are inclined to claim that they are in possession not just of one useful perspective on human behavior, but of the key that will open doors to the understanding of ever wider areas of human behavior." (Dupre, 2001, p.3)

In turn, scientism and physicalism underlie myriad scientific and scholarly methods and projects, permeating knowledge with over-simplifying interpretations. These oversimplifications, in turn, support dominant economic and political theories and ideologies, which are drivers of global crises, both social and environmental. Rosen's insights into the way that biology must shift away from its scientist (not scientific) and physicalist moorings to surpass the twin errors of mechanism and vitalism, is one part of this paradigm shift occurring across all disciplines – from modern to complex thought.

Modernity produced remarkably powerful knowledge within highly specialized niches, while also spurring widespread gaps between those niches. Paradoxically, perhaps just as much as the niches give phenomenal depth and intricacy to human vision, so do the gaps detract from overall social vision and wisdom. Charles P. Snow labeled one notable chasm of modern knowledge the 'two cultures gap,' or the ignorance and incomprehension between natural scientists and what he called literati, humanities scholars, and intellectuals (Snow, 1959). For simplicity, I'll call these two camps crudely the quantitative sciences versus the qualitative humanities. Yet, the humanities here encompass a wide array of fields that are not primarily quantitative – social sciences, humanities, and general intellectual discourse. Snow argued that quantitative and qualitative thinkers should improve their understanding of each other's methods, and the integration of knowledge generally, to advance knowledge and the common good.

Today we must go even a bit farther. There is not one gap; there are several gaps in dominant knowledge systems today. One gap is Snow's two cultures split between quantitative/qualitative methods, corresponding to the sciences/humanities disciplines. A second gap is that of physicalism within natural sciences, Rosen's focus on the relationship between physics and biology. These gaps are both a cause and an effect of over-simplifications in knowledge that distort overall social vision (Rosen, 1991; Morin, 1994).[3] Rosen saw these gaps as more problematic even than that portrayed by Snow (Rosen, 1991; Mikulecky, 2012). Finally, a third gap is that between modern western knowledge and the world's many lineages of traditional and indigenous knowledge. Bridging this gap contributes to comprehension and cooperation around climate policy, according to indigenous[4] and mainstream scientists[5] and thinkers.[6] Unlike modern thought, complex thought is open to and perhaps fully compatible with all human knowledge, indigenous, traditional, global, and western, and thus may facilitate transcultural dialogue, and building bridges across all these gaps.

1.3. Mind the gap with paradox, pluralism and perspectivism

> "I can epitomize a reductionistic approach to organization in general, and to life in particular, as follows: throw away the organization and keep the underlying matter. The relational alternative to this says the exact opposite, namely: when studying an organized material system, throw away the matter and keep the underlying organization."
>
> Robert Rosen (1991, p.119)

Throughout history, there has been a more complex worldview. Generally speaking, indigenous cultures have been immersed in rich worldviews, for instance in terms of interconnection, reciprocity, animism, reverence, and embeddedness in environments. In the modern west, many intellectual movements sought to escape the reductionist flaws of modern thought, and enrich the lens – movements such as German romanticism and American transcendentalism. Even the very philosophers and scientists who formed the western paradigm, also provided seeds of today's emergent paradigm. For instance, Kant argued that paradoxically, even as we learn more about things, we cannot know things in themselves, and Nietzsche argued that reality is perspectival.

Through the 20th Century a string of major discoveries across disciplines – physics, ecology, mathematics, philosophy of science, and social theory – all broke with the flawed underlying assumptions of modernity. In fact, the debunking of modern thought has been pervasive, through all disciplines. Among natural science breakthroughs, these included: the uncertainty principle, quantum mechanics, Godel's two incompleteness theorems, chaos theory, catastrophe theory, resilience theory, complexity theory, the Keeling Curve, etc. Like any paradigm shift, the current one transforms many terms and theories, as they take on new caveats and contexts, eventually transforming whole vocabularies.

For this essay, I focus on just paradox, pluralism and perspectivism, the ontological and epistemological 3P. I examine how the 3P support relational biology, as one dimension of the emergent complex paradigm, and thus help to evoke and advance this shift to a more connective culture of knowledge.[7] (See Table A1 in Appendix A.)

[3] This has been elaborated by many philosophers and social theorists over decades. I draw on the concepts of the 'distortions' (Morin, 1994) of overly reductionist thought including 'restricted complexity' (Morin, 2005) for instance, from the work of Edgar Morin (1977, 1980, etc.).

[4] See for instance, Report of the Indigenous Peoples' Global Summit on Climate Change, 20–24 April 2009 Anchorage, Alaska, and Indigenous Knowledge and Climate Change, 2–3 November 2016, Marrakesh, Morocco.

[5] F. Stuart Terry Chapin III has written on how indigenous knowledge is necessary to resilience theory and climate policy. See for instance Chapin III et al 2015.

[6] Moreover, a fourth gap exists between the creative humanities and arts and the rest of knowledge. The mechanistic modern worldview has suppressed a fuller sense of human experience and also creative culture, meaning, existentiality, and aesthetics. In fact, these interrelations may be crucial to our ability to cope with wicked problems. See for instance, Heather Davis and Etienne Turpin, Art in the Anthropocene (Davis and Turpin, 2015). This may be crucial also for bridging gaps within western philosophy, e.g. between mind, body, and experience, see for instance David Abram, 1996.

[7] This builds on other initial terms of a complex lexicon. A consensus view has distilled terms from across disciplines of complex systems studies, such as six core concepts, found throughout all disciplines and realms: nonlinearity, networks, feedback, hierarchy, emergence, and self-organization (Wells, 2012).

2. Paradox

"It takes more than two cultures to see the Anthropocene."
Libby Robin

Analytic philosopher and logician Willard V. O. Quine defined a false or antimonious paradox as a statement that appears to express an internal contradiction, but on closer examination, that seeming contradiction may be resolved. The internal logic of a paradigm cannot address a paradox beyond that paradigmatic frame. In fact, some paradoxes are not expressions of the external world, so much as expressions of the limits of current or perhaps ultimate human knowledge (Barrows, 1999).

The ubiquity of paradox throughout knowledge, is seen clearly in physics. Physics proceeds by building paradigms up until thresholds at which they are paradoxically both retained to a degree, while also falsified by a further paradigm. It is a dance of Popperian falsifications and Kuhnian paradigm shifts. Consider the relationship between Einstein's theory of relativity and quantum mechanics. Einstein's relativity holds within some circumstances, even while physics generally is transformed by quantum mechanics. Some phenomena are partly deterministic, as in some physical laws, but they are also partly organizational, chaotic, and emergent, as in chaos and complexity theories. Paradox plays out not just within physics or between physics and other disciplines; it also plays out in societies, economics, politics, and the realm of ideas, meaning, and culture.

2.1. Rosen's paradox: articulating two cultures for one biosphere

Rosen argues that the seeming paradox of the two cultures gap between the sciences and humanities can and should be resolved. I add that the Anthropocene crisis is a call to grasp a key paradox for our times, the paradox of differentiation and interconnection is that: the one very diverse and differentiated but also interdependent human community and biosphere, requires a knowledge culture that is both highly pluralist and integrative. To acknowledge the paradox of both differentiation and interconnection, in both knowledge and in the world, is a key principle for transition policy. Quantitative and qualitative methods are both vital and necessary in different ways in different disciplines. No one discipline supervenes on or collapses to another. It is urgent to reconcile and to advance general comprehension of how the realms of knowledge are interrelated.[8] Of late, Rosen's view is getting more appreciation (Naranjo 2011; Louie 2009; Letelier et al., 2006, 2003; Mikulecky 2001).

To accept Rosen's view is to see that the processes of falsification and paradigmatic shifts applies not only in physics, but also between physics and biology, and throughout transdisciplinary knowledge. And one of these falsifications is to show that neither biology nor social sciences collapse to physics. In fact, the supremacy of physics is not just erroeneous, but also distorts our sense of the truer articulation of the disciplines, for instance, with respect to the entwined nature of the issues driving global crisis. As Rosen said,

> "Why could it not be that the 'universals' of physics are only so on a small and special (if inordinately prominent) class of material systems, a class to which organisms are too *general* to belong? What if physics is the particular, and biology the general, instead of the other way around?" (Rosen, 1991, p. 13)

Moreover, Rosen showed not only that the widespread assumption of physicalism cannot grasp core concepts in biology, as he said 'life itself,' (1991, 2000) but also that physicalism fails, even for physics. The pre-Socratics defined physics as that which is growth or becoming. As Edgar Morin argued, classical physics omitted the topic at the heart of the field, its Latin root 'physis,' or organization (Morin, 1994).

Such physicalism and scientific imperialism, applying the quantitative methods of physical laws to other domains of knowledge – biological, social, economic, etc., remains a norm even amongst physicists working on complexity. As one famous complexity physicist said to me, "I think that within 200 years we will be able to explain everything with mathematics: the self, the arts, and even love." Such flawed scientism is not anodyne; it is holding back urgent advances in the natural sciences and humanities with respect to comprehending and coping with the planetary crisis.

To represent the clashing worldviews over the role of quantitative and qualitative methods, Rosen uses respectively, the physicist Ernest Rutherford and political scientist Robert Hutchins. For Rutherford, everything we call a quality or a percept is expressible in terms of numerical magnitudes, without loss or distortion. Every quality can be quantitated, measured, computed. Physicists identify a specific family of elementary numerical qualities and the procedures for measuring them, and anchor them in physics (Rosen, 1985). There is no other science than physics; everything else that we call science or knowledge generally, is a special case of physics.

In contrast, to Robert Hutchins, a political scientist, it was precisely the extent that something was quantifiable that it was irrelevant. Hutchins accepts Rutherford's equation of science with quantitative methods. But for him, this makes the phrase 'social scientist' an oxymoron, a full contradiction in terms. For Hutchins, the features or qualities of a social structure that are of interest or importance are precisely those that are unquantifiable. Conversely, Hutchins says, a "social scientist" is "a person who counts telephone poles." (Rosen, 1991, p.3). And this, in a time of cell phones!

In Hutchin's view, physics is itself only a very special case of science and knowledge, limited precisely to those very special qualities that happen also to be quantifiable! All humanities scholars, literati, and intellectuals, base their work in qualitative methods, drawing on quantitative methods, facts, statistics, and measurements only insofar as they add something of value to what is otherwise necessarily an entirely qualitative analysis.

Rosen argued,

> "It is clear that these issues and others like them involve the deepest aspects of the relation between the perceiving mind and the perceptual universe, that the attitudes expressed by Rutherford and Hutchins in the quotations above involve radically different views of these questions, and that *they cannot both be right.*" (Rosen, 1991, p.3) . . . "There is nothing inherently illogical, or even unscientific, about either of these positions [Rutherford or Hutchins]. They differ so radically because they clearly start from entirely different philosophical presuppositions about the nature of the perceptual world and the relation of the perceived to the precepts. It is clear that Hutchins and Rutherford could hardly communicate beyond superficialities; they could not be friends. That is the dualism between 'hard science,' personified here by Rutherford, and 'soft science,' personified by Hutchins." (Rosen, 1991, p.4)

To address this, we must draw on the philosophy of science, and its' critique of the problems of monism, scientism, physicalism, and other ontological errors. As Rosen says – again in the philosopher of science John Dupre's sense of the term scientism, as an erroneous overreach of scientific methods beyond their effective domain – "Scientist reductionism is wrong in principle. Each science must

[8] This argument helps in bridging other gaps: physics and the other disciplines; sciences and humanities; western modern and indigenous; and generally, pluralist multicultural creativity.

have its own character and its own procedures, shaped by the specific class of qualities with which it must deal" (Rosen, 1991, p.4).

In other words, it appears that while mathematics is vital for some fields, and language vital for others, both mathematical quantitative and linguistic qualitative methods fail to fully comprehend the world. Moreover, both are inherently incomplete when it comes to more complex dynamics, which cannot be fully modeled, or fully articulated. The inability of language to reflect any kind of ultimate reality, is commonsense to poets and novelists. The inability of quantitative methods alone to fully grasp scientific subjects, nevermind to reflect much of the biosphere, social affairs, and human experience and meaning, must also become normalized, not just in the humanities, but throughout the sciences as well.

Of course, some reductionism is part of all thinking and analysis. Reductionism itself is a natural part of science and knowledge. The problem is a failure to contextualize, problematize and strive to comprehend those insights more fully. Reductionism alone, and also restricted complexity alone, as brilliant as the scientists may be, will still be partially distortional, and as such, produce science without full conscience. As Francois Rabelais said in 1532, "Science without conscience is but the ruination of the soul." Much of the history of ideas, at least European ideas, has been prone to gaps in both methods and ontologies – e.g. the mind-body dualism fostered by failing to articulate philosophical and empirical methods, and erroneously framing theory in one or another axis only, exclusive of the others. For centuries, philosophers have repeatedly held up and then tore down monist ontological projects. Today, no one would entertain history's strong reductions: Thales' theory that all reality is water, Berkeley's idealism, Laplace's determinism, Democritus' atomism, and so on. Yet, more generally, the monisms of scientism and physicalism are still largely upheld. A more effective complex ontology fails to more take root, and to develop throughout the sciences.

In fact, ontological axes appear to be co-existent and interwoven; materiality, physicality, biology, ecology, aesthetics, consciousness, emotions, ideas, etc. More fully overcoming monist views has been one of the clarion calls of influential inter- and transdisciplinary human science fields for a half century – philosophy of science, science and technology studies, postcolonial, feminist and environmental theory, and much more. Prominent sociologist Immanuel Wallerstein argues against monism or what he calls 'nomothetic knowledge,' defined as the ideology of universal laws and total knowledge unity. In its place, he argues for 'unidisciplinary' or synthetizing transdisciplinary knowledge (Wallerstein, 2000). Drawing on insights from Fernand Braudel and Ilya Prigogine, Wallerstein calls for a post-two cultures knowledge, integrating a middle ground of both the sciences and humanities, in which nothing is excluded, the 'unexcluded middle.'

As Wallerstein wrote:

> "Science appears to be, it is said, under fierce attack, and with it rationality, modernity, and technology." (Wallerstein, 2000, p.160) . . . "What is under severe attack is Newtonian science and the concept of the two cultures, of the incompatibility of science and the humanities. What is being constructed is a renewed vision of scientia, which is a renewed vision of philosophia, whose centerpiece, epistemologically, is not merely the possibility but *the requirement of standing in the unexcluded middle.*" (Wallerstein, 2000 p.168, my italics)

To advance knowledge with respect to the twentyfirst century's cascading crises, we need to advance complex, differentiated, transdisciplinary, but also synthesized, *unidisciplinary* knowledge. This view shifts a lot about the outmoded modern approach to science and knowledge. For one thing, it shifts the very axis of our inquiry, from considering the robustness of methods with respect to that niche of knowledge, to considering their robustness *with respect to issues of societal concern*. It is not only a question of how well methods work, but rather, how well they work, not just within a niche of knowledge, but rather, with respect to adequately reflecting the kaleidoscopic complexity of the world. According to Rosen,

> "(I)t seems to me that the duality between 'hard' or quantitative science and 'soft' or qualitative science rests on an entirely false presumption. It is not in fact a question of Rutherford versus Hutchins, i.e. a question of doing physics or not doing science at all. It is rather a relative question, of *simplicity versus complexity*" (Rosen, 1991, p.10).

2.2. The paradox of inferential and causal entailments

The nature of causality is a ubiquitous question throughout the sciences and humanities. Generally speaking, complex thought shifts the focus from more atomistic, singular, views of causality, towards more dynamical, networked, hierarchically enmeshed, and interconnected views of causality. Rosen's work advances this general shift, by interrogating the nature and role of two major views of causality, within and beyond physics and biology. Rosen defines inferential entailment as "internally generated formalisms, governed by inferential rules that generate new propositions from given ones." While he defines causal entailment as "related phenomena arising in the ambience or external world" (1991, p.57).

The paradox of inferential and causal entailments is that the flaws of modern knowledge create a seemingly unbridgeable gap between our uses of the two. Quantitative science has privileged inferential entailment, what is internally generated in models. But this omits crucial networked dynamics and networked causalities, for instance in biology: organization and interaction within and between species, emergence within and between species, and emergence of changes in species and ecosystems over time.[9] Today, in a time of highly complex and compounding global feedbacks across enmeshed, global-scale crises, it is imperative to focus more on the relations between inferential and causal entailments.

Rosen argued to complement causal entailments with ubiquitous complex causal entailments that escape formal logic. This is necessary, in order to move beyond the mechanistic paradigm. As Rosen pointed out, one of the endearing features of a formal system is that, if it is consistent, then truth necessarily percolates hereditarily from the postulates to the most remote theorem; inference can never take us out of a class of true propositions. However, "[a] question like, 'Why has this axiom been replaced by another?' can have no answer at all within the formalism itself." (Rosen, 1991, pp.46–48). Rosen argued that the methods of physics eschew greater causal entailments and thus eschew organisms and life (Rosen, 1991; Mikulecky, 2001).

> "The physicist perceives that most things in the universe are not organisms, not alive in any conventional sense. Therefore, the physicist reasons, organisms are *negligible*; they are nothing fundamental, nothing new to physics; rather, organisms are to be understood entirely as specializations of the physical universals, once these have been adequately developed, and once the innumerable constraints and boundary conditions that make organisms special have been elucidated. These last, the

[9] I use the term 'networked causalities' to refer to the fact that most phenomena, e.g. through biological and social realms, are dynamical, enmeshed, and interacting across hierarchical scales. Networkcausality is about as common as non-elephant animals. (To riff on Stanislaw Ulam's remark: "To call the study of chaos 'non-linear science' is like calling zoology the study of non-elephant animals.")

physicist says, are not my task. So, it happens that the wonderful edifice of physical science, so articulate elsewhere, stands today utterly mute on the fundamental question: What is life?" (Rosen, 1991, p.12)

In purely formal terms, a concept of final causation requires modes of entailment that are simply not generally present in formalisms. Quantitative formal systems, Rosen argues, allow us to talk about a lot of entailment in a coherent way, but from within the standpoint of the formal system "everything important that affects the formal system is itself unentailed." (Rosen, 1991, pp. 47–48).

Interestingly, the omission or suppression of causal entailment is a widespread affair. In biology, Nobel Laureate Jacques Monod remarked that one of the hardest problems in biology is how the genetic "program programs itself" (Monod, 1971, p.182). Farther afield, David Chalmers has looked at issues of entailment and emergence in philosophy of mind (Chalmers, 2006), and Edgar Morin, on these phenomena throughout ecology and other sciences (Morin, 1977, 1980).

Rosen suggested, on formal grounds, the possibility of separating finality from teleology, and of retaining the former while perhaps not the latter. For, "the incorporation of finality into our scheme of things, in the form of the additional modes of entailment it requires, is not only possible, it is crucial" (Rosen, 1991, p.49). Final causes in systems biology refer to types of causal entailments necessary to explain phenomenon of emergent, organizational, and networked dynamics of biological systems. For instance, biologist A.K. Konopka explains it as follows,

"Final cause is the causal influence by which the properties of the parts are influenced by the whole of which they are members. . . . For the past several centuries, virtually all discussion of final causation was dismissed as 'unscientific.' However, we have little difficulty admitting the concept of a linear hierarchy of causation into scientific discussion. For example, . . . if a big robot modifies [a] small robot, we can say that the big robot has entailed the efficient cause of the small robot . . . .At adjacent positions in our linear hierarchy, if efficient cause A entails efficient cause B, we have only one direction for tracing the path from A to B, and this is traditionally assigned the direction of 'upward' causation. In Rosen's complexity, the linear hierarchy is bent into a closed loop, and remarkable consequences ensue . . . .Final cause can be seen as the 'downward' influence of the loop on efficient causes that are its components." (Konopka, 2006, p.231)

How ironic, that we would start to see our way towards a more sophisticated set of causal entailments, thanks to a robot. When of course, we have been ensconced and surrounded by nothing but such complex causality all along on this biosphere. Only such looped causal entailments begin to explain many phenomena, such as: feedbacks, networks of feedbacks, networks, networked causalities, hierarchical scales, emergence, and self-organization or autopoiesis. Shifting outside the constraints of quantitative formal logic, allows us to address and incorporate these fuller causal entailments, necessary to fields of life and society.

Incorporating looped causal entailments also highlights rather ubiquitous 'sympoiesis,' or organizational dynamics collectively produced by multiple entities, and thus partly open to myriad systems causalities (Dempster, 2000). Sympoiesis captures dynamics between and amongst organisms and entities. At all scales, more loopy, webby accounts of causality, transform and complement modernist accounts of causality. Just as generalized complexity complements restricted complexity (Morin, 2005), just as more complex causation complements modernist formal explanations of causation (Rosen, 1991), similarly, sympoiesis complements autopoiesis (Dempster, 2000; Haraway, 2016). Not surprisingly, network causalities, emergence, sympoiesis, etc., have come to define much discourse not just in theoretical ecology, e.g. resilience theory (Chapin et al., 2009), but also in economics and politics, expressed in terms like: vulnerability and resilience of social communities, environmental justice, and ecological economics.

Physicists defend physicalism as necessary because of the robustness of quantitative methods. But that is only (a distorted) half of the story. Because methodological robustness is orthogonal to the significance of science *with respect to* varied aims across disciplines. Not every discipline has laws. But whether we label the complex entailments of systems biology as laws, rules, or patterns, clearly throughout complex systems studies (both quantitative and qualitative) we see non-negligible patterns of causal phenomena across natural and social disciplines. Similarly, systems-scale properties can be described via patterns that are more or less resilient. Whether they be laws or patterns, complexity concepts like emergence, organization, and networked causal interactions and entailments, are poised to further advance knowledge beyond the two cultures to complex thought.

Rosen's reasoning leads to some startling conclusions. One is that complexity is that which cannot be modeled (Rosen, 1999), or what is complex is that which models cannot fully capture. Paradoxically, quantitative methods are uniquely powerful for what they do; yet, qualitative methods are required for what interests us most for transition and human survival: systems biology, and also economics, politics, values, ecological aims, require other methods. Collapsing biology solely into physics has omitted perhaps the most important things of all – the entailment's entailment, the program's program, the being's being.

The anemic concepts of either mechanism or vitalism do not comprehend never mind protect life itself; quite the contrary. But if Bergson's 'elan vital' remains elusive, in the humanities at least, there is certainly such a thing as 'vitality'! The persistence of mechanistic vision, the failure to develop of a fuller sense of the living biosphere, facilitates the entrenched institutional drives amongst the world's most powerful, towards selling off nature (Kovel, 2007; Moore, 2015) and disposing with people (Roy, 2011; Sassen, 2014). Both scientific mechanism and vitalism appear to have reduced societies and ecosystems into abstractions, enabling the powerful to treat them accordingly. There are no people that are magically protected from this logic. However, as fields as diverse as chaos theory and literature both show, partial determinism is accompanied by human capacities for agency, learning, adaptation, strategy, and social transformation.

2.3. Paradox of scientific insights and externalities

One paradox of knowledge is that as scientists attain certain results, data, or insights, much is of course also necessarily omitted from any particular study, however, some of what is omitted may be particularly significant to the study results and analysis. Scientists gain insights, but in the process, always omit other information that may in fact be crucial to those very insights. This maps again to the dance of Popperian falsification and Kuhnian paradigm shifts. We can never leapfrog over the advancement of knowledge to some kind of imaginary final paradigm. Rather, we appear to be forever in the midst of an ever-unfolding, evermore complex worldview. I call this the Paradox of Scientific Insights and Externalities: a perhaps eternal quality of scientific insights is that, no matter what one has comprehended, there is always more that is omitted, which would transform those same new discoveries, their implications, and therefore, how these new insights influence our present view. There are always layers of future paradigmatic insights, which would transform our present view. Only

retrospectively, can we see how advances in quantum mechanics transform the role of previous laws of physics. The gradual enrichening of our view is not unique to physics, but characteristic of knowledge generally. Our worldview is always already restricted, but not our impacts.

This plays on a parallel term. In ecological economics the term 'environmental externality' refers to the many true costs that are not included in market mechanisms, but that feed back onto people and nature in the form of social costs, impacts, and losses. The upshot is that corporations and elites tend to shirk the true costs by shifting them onto the poor and onto the future. While the true costs of so-called market externalities are internalized as global disaster, escalating and imploding in biogeophysical lockstep with capitalist overshoot (Smith, 2016, Steffen et al., 2015). Our still too modern academic language often fails to evoke the degree of the troubl. This is in part due to the oddly simple and isolated way that moderns framed realms of society, e.g. how we still commonly understand 'the economy' as just one realm of society. In fact, the 'economy' is fully imbricated in a society's overall organization (Fraser, 2014, Plumwood, 2002, Moore, 2015) The global crisis is demonstrating in dramatic fashion what modernity obscured: the truly, fully enmeshed nature of our lives –'economic,' material, ecological, psychological, and all.

I use the term 'biosphere blowback' as a synonym to global tipping point, what happens as networked, cascading feedbacks compound and magnify simultaneously as further results and further causes. Some call this the revenege of Gaia (Stengers, 2009; Latour, 2015). The global social and environmental crisis can be seen as the blowback of centuries of modern thought and environmental externalities (Crist, 2013, Hache, 2014). Similarly, what lies outside of certain sciences or paradigms, even what is unknown or invisible, may nonetheless continuously be impacting back on societies and environments. What is omitted by or beyond any particular science, impacts back onto knowledge itself, but also impacts peoples and places.

Science is simultaneously both: 1) relatively robust, insightful and useful with respect to its particular aims, and 2) relatively limited, useless, or even distortional, with respect to other larger contexts and considerations. This is related to but distinct from the way that complex thought necessitates both disciplinary and transdisciplinary work. The best results and analyses of both quantitative and qualitative sciences and scholarship, do not fall along a scale of right and wrong. Rather, they fall along a scale of robustness and falsifiability. There is no such thing as being purely True or Right, when one is looking at only a piece of what are more intricate, multifactorial, and multi-causal dynamics.

Within the sciences, one could postulate that the more that scientific analysis is focused on delimited study objects, the more prone it may be to distortions from the omissions of greater interactions.[10] Because the biosphere as a whole is a relatively closed system with respect to the universe, climate science, tends to be remarkably robust on general biospheric trends. An example is the rather clear role of the ongoing demise of the West Antarctic Ice Sheet in sea level rise. Recent climate science has focused on incorporating more complexity, in the form of more types and instances of biogeophysical feedbacks, and more hierarchically enmeshed, networked and nonlinear causalities.

The term 'scientific externalities' shows a parallel between in fact two layers of causalities driving climate disruption, habitat loss, extinctions, and so many other problems. One is the way that economic theory eschews environmental externalities, both obscuring and furthering global overshoot. The second is the way that scientific studies necessarily have delimited foci that produce robust insights, but also cannot account for omissions of further contexts: scientific externalities. The phenomenon is more general still; one could say that much mainstream political theory largely eschews political externalities thinkers today use fairly restricted lenses[11] *with respect to* the degree of hypercomplexity of society.

Only in retrospect, can one see how past scientific externalities impacted on past science and society. Like environmental externalities, just because they are unknown or unaccounted does not mean they are not crucial to human well-being. In fact, these two types of externalities, scientific and environmental, represent the general phenomena by which knowledge feedbacks spur environmental feedbacks, which are also always social feedbacks. Knowledge, society, and the biosphere are co-creative. Or co-destructive.

2.4. The greater paradoxes: P/progress, T/truth, S/science, K/knowledge, and R/reality

Generally, over-simplifications and impasses in knowledge like the two cultures gap tend to obfuscate paradox. In contrast, addressing paradox works to more fully reveal and transcend over-simplifying tenets of modernity. Relational biology bridges the seeming gap between physics and biology. In the process, it helps us to get beyond paradoxes discussed above, of physicalism and the biosphere, and of inferential and causal entailments.

The overriding paradigm shift involves transforming the paradoxes of five crucial myths of modern thought: Progress, Truth, Science, Knowledge and Reality. For each, I will describe the modern view with a capital letter, and the more contemporary view with a small letter: P/progress, T/ruth, S/science, K/knowledge and R/reality (PTSKR). The complex (lowercase) version dethrones the erroneously totalizing modern (uppercase) version. Shifting from the capital to small letter views of PTSKR has been a major focus in philosophy, social theory and humanities through history, and especially over the last century.

The paradox of insights and externalities helps debunk the progress paradox, by dethroning the Progress Myth: that science, technology and economic growth yield only or primarily benefits. A rich lineage of social theorists and others worked to debunk linear and ascensionist social narratives of the Progress Myth (Anders 1956; Arendt 1958; Jonas 1979; Beck 2016, 1999; Martinez-Alier, 2012; Hanson et al., 2016). Generally, as societies have complexified (in social roles, institutions, economies, bureaucracies, etc.), they have tended to produce both benefits and harms (Tainter, 1988). Actually, again, beyond a certain sweet spot and threshold, 'progress' will produce net harms. Today, some types of progress are phenomenal, even while overall, the world is in acute overshoot (Meadows, 2004; Moore, 2016). Privileged people can choose to focus on what is most phenomenal, but over time, everyone will be increasingly caught up in the fallout of what is not.

This Progress Myth has bolstered the power dynamics of religions, empires, science, economics, politics, technological inevitability, and more. A culprit is the oversimplification lurking in the ideology of inevitable, untroubled, teleological, 'big P,' Progress. Certainly, consensus lauds 'small p' human progress: books, medical advances, washing machines, computers, increases in free time, arts, etc. Rather, the error lies in the false leap that new scientific discoveries and technologies spurs only benefits. In truth, any technological impact in societies or ecosystems, spurs dynamic networked causalities, nonlinear changes, and differentiated consequences. What drives this is a progress paradox: as societies introduce modern scientific and technological advances this necessarily accumulates both helpful and harmful consequences

[10] See for instance Allen and Hoekstra, Towards a Unified Ecology, 2015.

[11] Again, borrowing from Edgar Morin's term of 'restricted' complexity (2005).

(Jonas, 1979). Increasingly, the harmful collateral consequences interact and become mutually reinforcing and exacerbating. Other positive consequences may counterbalance the impacts, or not.

In each case, debunking the myths reveals the paradoxes. The collapse of the Progress Myth yields the progress paradox, that progress yields both benefits and harms. The Progress Myth and paradox developed in tandem with the other myths and paradoxes of PTSKR. The same principle holds in parallel when other myths crumble: T/truth, S/science, and K/knowledge. If the progress paradox is based in the intervention of singular ideas and impacts in networked complex systems, the same is revealed as evident in the outsized ideologies of absolute Truth, one Science, one Scientific Method, or the ability to develop total, static Knowledge. In fact, in each case, the pure modern conceptualization splinters on contact with real world dynamics.

Embracing the small letter versions, reveals a more intriguing sense of small 'r' 'reality.' We can now dispel various ramifications of the physicalist myth, such as what the famous complexity physicist told me, "In 200 years, we can explain everything with mathematics, even love." Dispelling old myths opens the way for new imaginaries. The emergent view loses nothing of the advances of modernity. But it has much to gain in fascination, reverence, humility, and restoration of global ethos and ecosystems.[12]

3. Pluralism

3.1. Plural styles of reasoning in quantitative sciences

Pluralism in epistemology and ontology is a part of the process of bridging gaps in knowledge. Again, philosopher of science John Dupre defined pluralism as the thesis that "there are many really distinct kinds of things in the world." (Dupre, 1988, p.31). The world is not just physical and material, it is imbued with distinct qualities of aesthetics, consciousness, ideas, emotions and more. These dimensions of human lives are both truly distinct, and also interwoven.

Modernity tended to uphold monism, or one of a variety of ways of reducing life's phenomena via any one singular lens, such as strong versions of: universalism, determinism, foundationalism, mechanistic theory, scientism, physicalism, and reductive materialism. In contrast, we need to increase methodological pluralism in sciences and other fields, and enhance forms of transdisciplinary and integrative analysis. An emeging view of knowledge tends more towards pluralism, such as: integrative pluralism (Mitchell, 2003), disunified unity (Galison and Stump, 1996), and pluriversality (Blaser, 2013; De la Cadena, 2010).

Philosophers of science have shown how pluralist methods enhance knowledge within and beyond the quantitative sciences. Alistair Crombie broke down the western Scientific Method into its constituent six methods (Crombie, 1994, in Hacking, 2004). Ian Hacking expanded upon Crombie's overview, introducing more methodologies from a broader set of sciences. Others philosophers have advocated integrative pluralism, based in both scientific necessities and compassionate aims (Feyerabend, 1993; Mitchell, 2003; Harding and Hintikka, 2003a, 2003b; Latour, 2013). In the late Great Acceleration, many thinkers have noted that, increasingly, knowledge requires valid, robust and necessarily multiple styles of reasoning *relative to* the ideological, economic, political, and cultural drivers of global crises (De Sousa Santos, 2014, 2015; Sandoval, 2000; Beck, 1999, 2016). Moreover, pluralism in scientific and everyday thought fosters effectively pluralist communal groups, public spheres and democratic praxes necessary to a society's capacity to adapt and cope with change (Fraser, 1990; Harding, 2006; Wright 2010; Mitchell, 2009; Spivak, 1999; Rifkin, 2011).

Crombie broke down the Scientific Method[13] to at least these six distinct methods:

1. Postulation, exemplified by the Greek mathematical sciences
2. Deployment of experiment both to control postulation and to explore by observation and measurement
3. Hypothetical construction of analogical models
4. Ordering of variety by comparison and taxonomy
5. Statistical analysis of regularities of populations, and the calculus of probabilities
6. The historical derivation of genetic development (Crombie, 1994, in Hacking, 2004)

Of course, many inquiries use several styles. For example, statistical analysis is used in various guises, in every area of investigation, including some branches of pure mathematics. The modern synthesis of evolutionary theory is among other things a synthesis of taxonomic and historico-genetic thought (Hacking, 1992 reprinted in Hacking, 2004).

Various styles have been reinforced and thus reified, such that subsequent scientists no longer question which method to use for which study aim. After fierce struggles, some methods just have become what it is to be reasonable in this or that domain, i.e. natural science and quantitative reasoning. Each method has proven a type and degree of self-authentification, or way in which a scientific method has shown itself to be valid and effective (Hacking, 2004). Degrees of self-authentification express the innate quasi-stability of scientific knowledge, again evoking what I call the paradox of scientific aims and externalities. Yet, as Hacking says, methodological pluralism does not mean falling prey to constructionism in the flawed, strong sense of the term. Rather, varied distinct methods apply to varied distinct study aims. In observer-context ensembles, particular methods are strong relative to particular aims. Thus, articulating plural methods can advance the power and reach of science.

Most importantly, basic science is always partly orthogonal to our most vital needs for applied science, such as global sustainability, survival of humanity, the rest of life on the biosphere, and a more ethically advanced, humanitarian civilization. That a theory is more general or universally true, is irrelevant to whether particular scientific study is even framed in terms of the vital issues of ethics, well-being, or preserving the biosphere. Basic science leads to marvelous discoveries and transformations. Yet, we should be concerned with the Anthropocene not as a new era, but as an emergency; not as a time to live into, but a set of profound mistakes to try to survive and transform. This view calls us to shift away from the modern's focus on basic science for economic profit and growth and empire. Rather, it calls for a shift towards applied science for societal transition. This involves a kind of Scientific Revolution for aims such as: fossil fuel degrowth; partial industrial economic contraction; widespread transformation of infrastructures towards renewable energies and more ecological designs; massive global ecosystems regeneration; cross class and transnational justice, equity, and cooperation; and widespread, diverse rejuvenation of global arts, humanities and cultures.

Working backwards, if we were to frame science in terms of its' capacities to address the Anthropocene crisis, then we should be developing criteria regarding robustness *with respect to the question*: What disciplines and methods are needed to successfully

[12] See for instance, Stuart Kaufmann's Humanity in a Creative Universe 2016.

[13] Crombie was not aiming for a comprehensive list of all styles of reasoning, he focused on what has been most central and enduring in the formative period of modern western science, which of course was not just western but had an amalgam of influences, such as Arabic numerals algebra, transcultural knoweldge of astronomy, ethology, botany, and more.

tackle and transform the most impactful – most systemic, interrelated, societal – causes of global ecological crises? This challenges the fundamental framing of the relationships between physics and biology, and other disciplines like economics and politics. As Rosen writes:

> "[W]hat does it mean to say that a theory is general or universal? Or that a proposition is generally or universally true? Is it true that, say, Set Theory is more general than topology, or that Lattice Theory is more general than Group Theory, or that mechanics is more general (universal) than thermodynamics? Or that physics is more general (or less general) than biology? What sense, if any, can we give to such questions?" (Rosen, 1991, p.24-5)

Paradoxically, and pluralistically, the answers to this question may *both* confirm and turn on their heads the designations of the so-called hard and soft sciences. As Hacking notes, "the taxonomic and historic-genetic styles have produced nothing like the stability of the laboratory or the mathematical style." Quantitative methods are more robust than qualitative methods. But only with respect to what they can do. And what they can do is quite limited relative to the needs of humanity to confront global crises. Just as in ecological hierarchy theory, it is always a question of the positions of the observed and context, so in methods, it is always a question of matching methods with respect to disciplinary and study foci. And, no discipline collapses to another. Relative to the ecology, economics and politics of transition, physical laws have little to say, only primarily qualitative methods are relevant.

Rosen noted how the very best physicists of the twentieth century, themselves had qualms about what physics could say and do. Rosen called Erwin Schrodinger perhaps the greatest theoretical physicist of the Twentieth century, and noted that, even while Schrodinger was "repeatedly proclaiming the 'universality' of contemporary physics, he equally repeatedly points out (quite rightly) the utter failure of its laws to say anything significant about *the biosphere and what is in it*" (Rosen, 2000, p.7, Rosen's parentheses, my italics). Moreover, Rosen notes a similar sentiment expressed by Einstein in a letter: "One can best feel in dealing with living things *how primitive physics still is* (Walker, 2017, p.33).

In fact, for the challenges of the twentyfirst century, we may need to reverse the monikers of the hard and soft sciences. For even if qualitative methods are far less robust, they are still the primary methods most *relevant to* affecting the societal drivers of global crisis today. Robust mathematical methods, alone insufficient to advancing evolutionary theory, are all the less significant to societal change. Instead, vital to coping with global crises today, are fields such as: environmental justice, ecological economics, political ecology, environmental humanities, and relational and systems biology (Shiva, 2015; Stengers, 2009; Chaturvedi and Doyle, 2015; Kallis and Sager, 2017; Hansen et al., 2016; Haraway, 2016).

3.2. Plural styles of objective and subjective reasoning: Pattee's complimentarity paradox

Theoretical biologist Howard Pattee noted what he called a complementarity principle in biological and social structures, an epistemological principle addressing the subject-object or observer-system dichotomy, and the need for integrative pluralism of qualitative and quantitative methods. I paraphrase it in this way:

> The complementarity principle states that each side of the split of quantitative and qualitative methods requires a separate mode of description that is formally incompatible with and irreducible to the other. Either mode of description alone does not provide sufficient explanatory power. However, the conjoined modes of description do provide such explanatory power (Pattee, 1978).

The classic physics paradigm has been used to model the biological, social and psychological sciences. Yet these are modeled to suppresses the qualitative, observer or subject side of the dichotomy, in order to claim unity and consistency in theory and objectivity in experimental observations. Absurdly, classic macrophysics was used as the model for everything else! But the subjective dimensions are both complementary and necessary to advances even in more fully comprehending the methodologically primarily quantitative fields.

As Pattee puts it,

> '[E}xplanatory knowledge of biological and social systems – from cells to human societies – requires the simultaneous articulation of two formally incompatible modes of description. The source of this requirement lies in the subject-object duality, or the distinction between the image and the event, the knower and the known, the genotype and phenotype, the program and the hardware, or the policy and the implementation, however one may choose to express this basic distinction. The essence of the concept of complementarity is not in the recognition of this subject-object distinction, which is common to almost all epistemologies, *but in the apparently paradoxical articulation of the two modes of knowing*' (Pattee, 1978, p.193, my italics).

In fact, any theory of social organization embodies this apparent paradox: On the one hand, the concept that we manage any system implies adding at least one hierarchical level, the management level, that oversees the whole system. On the other hand, there can never be any closed theory of social hierarchies like a dynamical theory in physics. Both cannot be true. In fact, this paradox is answered by seeing that plural methods are in fact not in conflict at all, but rather, both necessary and complimentary. In passing, it also shows the mechanistic flaws in the very concept of management common in theories of economics and politics. And it shows that a focus on *societal organization* is crucial to addressing the systemic social causes of crises like the climate.

Hierarchy theory, says Pattee, must be more like theories of language or programming that give us useful rules or methods for the most effective design and control of open systems that can continually grow and evolve new levels. Like Herbert Simon (1962) and Kurt Richardson et al. (2000), Pattee argued that there are no entirely decomposable levels, only "nearly decomposable levels," which may be discrete but are *"necessarily interacting."* (Pattee, 1978).

So, it appears to be the incompleteness or non-integration of methods that create the seeming paradox. Again, we might see paradox as that which occurs until one uses more integrated pluralist methods and vision. Shifting methods from addressing more restricted to more generalized phenomena, shifts paradox from untenable to normalized.[14] For instance, in this case, Pattee argues that articulating both quantitative and qualitative reasoning will then reconcile the seeming differences. And indeed, as Pattee concludes, the explanation of any events or phenomena 1) an objective, causal representation, and 2) a subjective prescriptive representation. In fact, the concepts of biological systems' description and function, and social systems, e.g. goals and policies, are all found to have the same epistemological basis as the concept of measurement in physics. That is, rate dependent and rate independent processes are proposed as a necessary distinction for applying the principle of complementarity to explanations of physical, biological and social systems. In fact, of course, quantum mechanical measurements have shown this classical paradigm to

[14] Here I use 'generalized,' as in Morin's restricted versus generalized complexity (Morin, 2005).

be untenable for science generally. Pattee's description here supports the need for the articulation of knowledge across realms of the one paradoxically singular but pluriversal world.

This principle is generalizable. It is also a strong argument against the basic assumptions of climatic geoengineering. Not to say that in desperation people will not argue for some, but that it is not a solution per se, any more than we could consider it a solution to play a very badly weighted game of Russian roulette. Geoengineering would be fine on an imaginary mechanistic planet; it is very likely to be disastrous on an interconnected biosphere, for which overly simple methods and interventions causes nefarious unintended consequences at small scales, never mind at the planetary scale (Ellul, 1954; Anders, 1956; Jonas, 1979; Latour, 1991; Klein, 2014). While this principle and paradigm abdicate the pretense of controllability generally, experiments at the biosphere scale make the conceit of control even more bizarre.

Pattee's argument provides some of the fundamental background concepts that shore up Rosen's view of how entailment is a concept that allows us to show both plurality and unity in transdisciplinary thought. We do not know how much we could know about particular and general entailment, but increasingly, through complex thought, new sciences and scholarship, we conclude that in some sense and form, complementarity, like causal entailment, must be significant. Kenneth Boulding argued that complexity was perhaps the backbone of science (1956). Similarly, perhaps pluralist complementarities, like complex entailments, are, as Rosen suggested, synonymous with science (1992).

3.3. Pluralistic methods for biology: Donna Haraway's tentacular thinking

Philosopher and biologist Donna Haraway has argued for more plural and advanced biological methods, and in particular, for a biology suited to address planetary crises (Haraway 2016).

Haraway calls for acknowledgement of pluralism, perspectivism and paradoxes, and for expanding plural models, methods and syntheses in biology. To illustrate complex pluralism in the living world, she gives the example of *Mixotricha paradoxa*, or *M. paradoxa*, for explaining complex 'individuality,' symbiogenesis, and symbiosis (2016), which demonstrates the need and method to embrace paradox, plurality, and the participatory, perspectival and relational nature of living systems. Biologist Lynn Margulis described M. Paradoxa as a fabulously pluralistic ensemble of creatures. Haraway paraphrases from Margulis and Sagan (Margulis and Sagan, 2001):

> Under low magnification, *M. paradoxa* looks like a single-celled swimming ciliate. With the electron microscope, however it is seen to consist of five distinct kinds of creatures. Externally, it is most obviously the kind of one-celled organism that is classified as a protist. But inside each nucleated cell, where one would expect to find mitochondria, are many spherical bacteria. On the surface where cilia should be, are some 250,000 hair-like *Treponema spirochetes*, as well as a contingent of large rod bacteria that is also 250,000 strong. In addition, we have redescribed 200 spirochetes of a larger type and named them *Canaleparolina darwiniensis*" (Haraway, 2016, pp.61-62).

In other words, M. paradoxa is not one creature or even several hundred thousand creatures; it is, we might say, a "poster protist" for participatory assemblages and pluralism. M Paradoxa is comprised of at least five different taxonomic kinds of cells with their genomes. It is what Haraway calls a "holobiont," at once in a sense a singular creature that is actually an extremely pluralist entwined agglomeration that in turn lives inside an Australian termite; hence the name Paradoxa. Like Morin, Haraway evokes a rich spectrum of cooperative and competitive strategies amongst species (Morin, 1981; Haraway, 2016).

The New Synthesis in biology has focused on bounded units: code fragments, genes, cells organisms, populations, species and ecosystems. It has focused on methods that mathematically describe bounded units and relations in equations wonderfully. Developmental biology has been based on at least seven basic model systems: a nematode, fruit flies, the mouse *Mus musculis*, the frog *Zenopus laevis,* the zebrafish *Danio rerio,* the chicken *Gallus gallus*, and the mustard *Arabidopsis thaliana* (Haraway, 2016).

Such models are strong for what they do, but not for more complex interactions. Each model provides crucial windows into the limited bounded units and relations of biology. Like all thinkers, biologists frame their work in larger stories (Zellmer et al., 2006). While biologists strictly avoid teleology, nevertheless, a constant theme is evolutionary momentum, which is always verging on modernist notions of Progress (Haraway, 2016). Thus, biology also is distorted by the modern progress paradox: linear versus dynamical notions of change.

As Rosen has said, by shifting the framing of biology from being about dynamical and interacting organisms to being about evolution, biologists have been able to, in effect "have their mechanistic cake and eat their vitalistic one too" (Rosen, 1991, p.256). Biologists continue to espouse a narrow mechanism regarding organisms. But if biology is about evolution, these mechanistic shackles can be assigned a subordinate role. One can (apparently) embrace evolution without having to deny mechanisms; but we thereby devalue evolution. It is essential both to avoid making evolution subject to mechanisms, but also to avoid asserting anything vitalistic. The only way to do this is to employ mathematics, but to deny any vestige of entailment in evolutionary processes at all. However, by doing this, capture a series of snapshots, but not the truer, fuller dynamics of nature. We turn evolution, hence biology, into "a collection of pure historical chronicles, like tables of random numbers, or stock exchange quotations." (Rosen, 1991, p.256). Biologists have continued to skate between these two pitfalls of overly simplistic framings – mechanism and vitalism – but in so doing, have failed to capture the very heart of biology: the living, the soma, the complex.

Across disciplines, delimited foci and methods fall short of capturing fuller entailment. In biology, as Haraway put it, while the bounded units and competitive relations of the modern synthesis are important, what they omit may be even more important to sustain us in the challenging coming years on Earth.[15]

Haraway proposes four areas complimentary to the Modern Synthesis to advance biology.

1. Embryology and development
2. Symbiosis and collaborative entanglements of holobionts and holobiomes
3. Vast worldings of microbes
4. Exuberant critter biobehavioral inter- and intra-actions.

Flies, frogs and other major biological model systems are excellent for studying how parts – genes, cells, tissues, etc. – fit together into cooperating or competing units. Yet, these seven individuated systems omit the much fuller inter- and intra-actions of symbiosis and sympoiesis, in heterogeneous temporalities and spatialities. Pluralistic, participatory, and always in process, symbiotic holobiont assemblages require models united to an expandable number of quasi-collective, quasi-individual partners in constitutive relatings. To study these relationalities, the aims, methods and foci must be expanded and synthesized.

[15] See also, for instance, the crucial work of Dennis Noble, e.g. Noble, 2013.

In *Life Itself,* Rosen shows how biologists have tenaciously guarded the mechanistic model as a way to keep biology squarely in the prestigious (and well-funded) domain of acceptable science. To fail at this would have been to relegate biologists to "bird-watchers and mystics" (Rosen, p.256). Of course, in a more enlightened age, we would respect both ethology and spirituality. In fact, as we shall see in the next section, respect in domains of ethology, plant sentience, related fields like agroecology, and a concomitant renewal in reverence and spirituality, may be pillars of a survivable future. The price of guarding mechanism has been to maintain the gaps in our vision that feed the rifts and collapses of our earth systems and ecosystems.

It is important to note, that not just organisms, such as M. Paradoxa, but any facet of life itself, calls for, as Rosen said, "a *relational* model" (Rosen 1991, p.254). Rosen anchors biology in "what is alive, the heart of what constitutes organism." This soma, in its operations, in the way it realizes the *underlying relational* model, cannot be a machine. That is, it cannot be expressed in terms of mere syntax; there has to be too much entailment in it for that. In a word, it must be complex (Rosen, 1991, p.254).

A reconciliation between physics and biology can only be achieved in knowledge through transcending the paradox of the false binary of vitalism or mechanism, between overly holist and overly reductionist viewpoints, and grappling towards the complex. We cannot: collapse biology to physics, or any discipline to physics. Neither can we collapse society and language, or as Pattee suggested: collapse the image and the event, the knower and the known, the genotype and phenotype, the program and the hardware. Even less can we collapse the economic, political and cultural issues involved in climate policy and transition today (Norgaard and Baer, 1995b).

4. Perspectivism

4.1. Perspectivism: pluralist ontology, diverse standpoints, & interconnection

Perspectivism in ontology and epistemology acknowledges that biological and social phenomena are interactive, involve observers and contexts, and take place from and within particular perspectives relative to specific phenomena.

Despite the power of quantitative scientific methods, there is no Universal, Laplacian abstract point of view, or "God Trick" (Haraway, 1988). Paradoxically, quantitative formal logic is both powerful within its paradigm and incomplete beyond that, with respect to various aims. Even in physics, perspective matters. The double slit experiment that helped to launch quantum mechanics shows the observer effect: crudely put, that observing a phenomenon influences that phenomenon, or that, observers and phenomenon are co-productive.

Complex ontology always notes the significance of the relations between observers and contexts and thus perspectives; it always asks: valid with respect to whom or what? Perspectivism is central to transdisciplinary complexity studies, e.g. in theoretical ecology (Allen and Hoekstra, 2015), and throughout social, economic and political theories.[16] As both Ian Hacking and Rosen argued, validity and strength of reasoning are always relative within particular disciplines and study aims. Perspectivism, however, involves none of the following: strong relativism or constructivism, or the facile view that all perspectives are equally valid with respect to all interests.

Friedrich Nietzsche defined the term perspectivism as had the philosopher Gustav Teichmuller: "The knowing subject constructs a world of intelligible objects by projecting categories such as unity and self-identity onto what can be called the chaos of sensations" (Mayer, 2014, p.200). To show how perspectivism supports Rosen's relational biology, I briefly elucidate two examples: the work of Friedrich Nietzsche, and the work of Brazilian anthropologist Eduardo Viveiros de Castro on Amerindian thought.

From the global history of ideas, I choose an example of perspectivism from both the European and Indigenous lineages partly to remind us of the way that we might consider how the relations of European empires and indigenous societies can be dialectically interrelated, both in past histories and in present and future transitions. The perspective of these cultures as for instance, so-called modernizer and modernized, owners and stewards of resources, enslaver and enslaved, capitalist owners and workers, colonizer and colonized, has produced devastating and ongoing fallout tied to issues of climate debt and reparations vital to transition (Shiva, 2015; Kartha and Baer, 2015). Moreover, a backdrop of climate policy or transition studies today, is the way that the universalist, mechanistic modern worldview enabled and facilitated the structural relationships or societal organization of empire, from the dawn of modernity to today. Coming full circle, economic growth is now destroying or endangering many Amerindian societies and cultures (Global Witness, 2014).

The scientists who advocated for the term Anthropocene drew attention to the historical moment as an existential crisis. They did so, however, within an academic establishment mired in the ongoing errors of the two cultures and other gaps of knowledge. In fact, the naming of a fully socially, economically, and politically driven, planetary crisis, with full blown biogeophysical and ecological results, is of course anything but either simply geologic or simply human. Quite the contrary, the drivers of global crisis are extremely pluralistic, nothing less than the whole nexus of flaws in the prevailing societal thought and organization, relative to the evolution of humanity.

Unwittingly or not, the Anthropocene debates, circa 2008-2016, did more than most debates in academia, to shake the walls of the two cultures. The term has ricocheted across the disciplines showing that only generalized analyses will suffice (Bonneuil and Fressoz, 2013; Moore, 2015; Haraway, 2016).[17] It highlighted the clash of disparate ontologies and histories of indigenous and European peoples, underscoring the irony of the anthropomorphism and solipsism of the privileged classes in the term Anthropocene (Crist, 2013; Stengers, 2009). While the Amerindian indigenous view of perspectivism outlined below, challenges the very basis of the scientific ontology that spawned the term. To work through these ironies is a first step towards the project of protecting peoples and places from the modern ideas and institutions driving climate disruption (Harding, 2006; Stengers, 2009; Roy, 2011; Sassen, 2014; Global Witness, 2014). The exception is modern empire and growth. The rule is the many, long millennia of human indigeneity.

In the shift towards a more complex worldview, the 3P are often in cahoots. Perpsectivism involves pluralism, but also paradox. The Earth is more singular or more pluralistic relative to various issues, views, or concerns. With respect to human affairs, pluralism and differentiation tend to be vital, but there are cases in which ontological monism holds relative to some concern. The biosphere is fairly unified and universal respective to the cosmos. The atmosphere is fairly unified and singular relative to the climate crisis. Yet, at the same time, the human population is extremely differentiated relative to historic and current responsibility for

[16] These latter social categories are vast. A sprinkling of seminal texts to supplement this comment include, for instance:(Kropotkin, 1902; Fanon, 1961; Spivak, 1988; Sandoval, 2000; Kartha and Baer, 2015; Hawken et al., 2017; Kallis and Sager, 2017).

[17] See also the conference at the College de France, Nov 5–6, 2015, online at http://www.fondationecolo.org/l-anthropocene

emissions of greenhouse gases changing that atmosphere. Though even while human responsibility and duty to climate policy is extremely differentiated, with respect to an intact atmosphere, it is the net results of overall human actions that may act to stabilize the climate. Both perspectives – unity and plurality – are urgent. The first calls for rapid collective human action, and the second calls for that collective action to carry highly differentiated responsibilities and duties to the common aim of biosphere survival and well-being.

4.2. Western perspectivism: Friedrich Nietzsche

Friedrich Nietzsche invented the modern use of the word perspectivism, and made it the core of his project (Nietzsche 1878, 1882, 1886; Hales and Welshon, 2000). He particularly outlined his view of Perspectivism in Human All Too Human (1878), The Gay Science (1882), and Beyond Good and Evil (1886). In the West, perspectivism goes back to Heraclitus' flux doctrine (Heraclitus, cerca 500 BCE), and Plato's work on Protagoras (Plato, 380 BCE). Many others made contributions to perspectivist ontology, such as: Leibniz, Whitehead, Pierce, and Deleuze. While innumerable scholars also have battled the flaws of modernity's deeper flaws of monism, universalism, and scientism.

Nietzsche's philosophy is multifaceted, often read ambiguously, and has been taken up by opposed political groups, from fascists to critical theorists and radicals. His historical situation in racist, elitist and misogynist 19th century Europe complicates interpretations. Yet, I argue that his ideas have a lot to offer transition studies, specifically to issues of social justice, energy, economic and political change. Nietzsche's perspectivist ontology prefigured key concepts in Rosen's work; Nietzsche fully retains the rigor of mathematical and empirical scientific rigor, while arguing for integrating pluralist philosophical, qualitative and other ways of knowing, necessary for a worldview that supports social liberation.

Further, I argue, one of Nietzsche's main battles was precisely against the terrible consequences of the *nihilism in the errors of modern thought*. Nietzsche lauded both science and spirituality. He clearly knew the nature and supreme power of empirical and mathematical methods, as well as the world's aesthetic, poetic, and mystical experiences. What he attacked was the way that great over-simplifications underlying both science and religion, e.g. religious dogmatism, and scientific universalism, determinism, physicalism, scientism, etc., was misused for power over people (monarchy, military empire, slavery, etc.). Instead, he wanted science to support common peoples' empowerment and well-being. At least, the core lessons of his work can advance those aims.

Because knowledge is perspectival, Nietzsche argued, we can reject or deny the privileged status of Truth, Science, Reality and other epistemic objects of modern thought (Mayer, 2014, p.206). Instead, Nietzsche saw paradox, pluralism, and perspectivism as more liberating criteria for evaluating the quality of science and thought. In other words, Nietzsche aimed to take down modern versions of Power, Truth, Science, Knowledge and Reality (PTSKR) so capable of being used to wield power over people; and instead promote ptskr for a humanistic and complex worldview.

Nietzsche's will to power was designed to supplant his modern contemporaries' perilous worship of the will to a Pure Truth, wedded as it was (and to a large degree remains) to empire, exploitation, and imperialism. Moreover, he saw, in the monism and hubris of scientific thinkers, that the project of Francis Bacon's so-called unveiling of nature, might rather become the undoing of nature.

Contra the hubris of the scientific establishment of his day, Nietzsche explicitly argued for the limitations of science and knowledge, and the significance of human well-being and freedom. Because human beings are situated at a particular point in space, time and history, Nietzsche noted, "their capacity for knowledge is inevitably limited." As Nietzsche scholar Matthew Mayer said

> "It is this empirical insight into human situatedness – physiological, instinctual and socio-historical that plays a crucial role in Nietzsche's deconstruction of the traditional objects of epistemology. Because knowledge is perspectival, Nietzsche says, therefore, we can deny the existence or reject the privileged status of epistemic objects such as [F]act, [T]ruth, [M]eaning, and [R]eality" (Mayer, 2014, p.206, my brackets).

Perhaps, Nietzsche foresaw a powerful spiritual humanitarian and ecological vision yet to be manifested. Contra many characterizations of his work, perhaps one of the significant things about Nietzsche was the way he spoke of honoring the common good, human lives, spirituality, and mysteries. Consider, for instance, this telling passage, which seems an apt retort to the quandary of today's crisis of capitalist overdrive, poverty, oppression, extinction, and overshoot:

> "The most serious problem that emerges from the [either religious or scientific] will to Truth and the quest for Objectivity, is that they eventually lead to the rejection of the pure spirit and good as such, and it is here that the will to truth morphs into a genuine will to death and thus nihilism." (Nietzsche, 1882, p.344).

Nietzsche wanted to subordinate the absolute drive to Truth to the actual needs of common human lives (Mayer, 2014, p.238). Specifically, the task of philosophy, Nietzsche said, is not to *discover* a pre-given world of Kantian things–in-themselves. Rather, in all the chaos and complexity, the philosopher's task is to help society "to create social organization and cultural value that make life possible" (Mayer, 2014, p.201). According to Nietzsche, the proper criterion for assessing judgments is not the simplistic and false scientific ideology of Objectivity or Truth. Quite the contrary, the proper criterion if complex messy *life itself* (Mayer, p. 238). Nietzsche asked, to what extent is our science and worldview: life-promoting, life-preserving, species-advancing, perhaps even ecologically and culturally flourishing?

That is, with respect to Ian Hacking's description of self-authenticating processes of scientific and knowledge methods, Nietzsche would say the best science and knowledge self-authenticates not just with respect to a particular small niche of knowledge – molecular biology, landscape ecology, etc. – but also, ultimately must self-authenticate also and primarily to the criterion: How does this knowledge self-authenticate with respect to the flourishing of whole communities and environments? (Mayer, 2014, p.205). We find echoes of this criterion of complex dynamics for instance, in Aldo Leopold's *La*nd Ethic (1952), Rachel Carson's Silent Spring (1962), and in some of the best works on social transition today. At a time when both religious dogma and scientific hubris had such a grip on the European imaginary, that was quite a reframe.

Better than anyone in his day, Nietzsche foresaw the nihilistic problematic in both scientific or religious dogma. To prevent this, Nietzsche argued for mending gaps of knowledge in many ways. He clearly and deliberately lauded the power of scientific methods, and the mystery of spiritual experience. Yet, he simultaneously opened an escape hatch from modernity, by attacking each of the false underlying ideologies of science in turn: pure physicalism, scientism, objectivity, universalism, foundationalism, mechanism, determinism, etc. Nietzsche's work advanced both discoveries of science and other ways of knowing, as well as a multifaceted sense of our world as imbued with paradox, pluralism, and perspectivism. Mocking the strong elite hubris of his era, he also foresaw the inherent limits to human knowledge.

4.3. Amerindian perspectivism: according to Eduardo Viveiros de Castro

The indigenous peoples of the American continents hold a worldview rich in perspectivism, as posited by Brazilian anthropologist Tania Stolze Lima and philosopher Eduardo Viveiros de Castro (Lima 1999, 2005; Viveiros de Castro, 2014). A more wide-ranging study of indigenous first nations of the Americas and elsewhere reveals similar ideas in indigenous worldviews and lifeways (e.g. Nelson, 2008).

In his passionate book, Cannibal Metaphysics, Eduardo Viveiros de Castro, says that Amerindian perspectivism is a reconfiguration of a nexus of ideas and practices with a vast diffusion through the American continents, and that they present a reversal of some core aspects of western ontology (Viveiros de Castro, 2014, p.49). I argue that these worldviews complement each other, and in some ways Amerindian perspectivism, like Nietzsche's perspectivism, helps to mend flaws and gaps in western ontology.

Against western concepts of universalism and mono-naturalism, Amerindian ontology is a pluralist *multi-naturalism* that emphasizes interrelations of humans and other-than-human nature, ecological aesthetics and ethos, and visible and invisible phenomena. Modern philosophers could choose to express visible and invisible as knowns and unknowns.[18] Amerindian perspectivism holds the external world to be pluralistic, polyvalent, and deeply participatory. This worldview resolves many of the paradoxes discussed in the first section, and it is complimentary to the concepts discussed under pluralism: Rosen's relational biology, Pattee's complementarity principle, and Haraway's concepts of holobionts and symbiogenesis.

Together, perspectivism and multinaturalism have provoked a reversal redefining some of the most influential areas of qualitative humanities and social theory. Specifically, Viveiros de Castro argues that perspectivism advances transcendental empiricism and speculative realism (2015, p.49). Again, in these academic fields, the terms empiricism and realism must be understood as going beyond pure formal logic, for the reasons outlined by Rosen and Pattee. For the contemporary ecologist, Amerindian perspectivism as a system has the benefits of being embedded in fully socio-ecological. It also unapologetically takes a partly humble stance, vis-a-vis the unknown dimensions, including a sense of humans as part of both greater ecologies and greater mystery. Dare one say, perhaps including a rapport between the terms unknown unknowns (Barrows, 1999) and spirituality, as compatible with science.

The radical contrast between modern scientific and Amerindian ontology offers a sharp contrast that helps to open better vistas. Viveiros de Castro particularly explores the views of the Matsiguenga peoples of Amazonian Peru, for whom the term 'human' is an indicator, not of a particular biology, but rather a term of culture, which is inherently perspectival: the terms human and cultural then, only make sense from the perspective of a particular species, with respect to other entities – other animals, plants, or spirits. Thus, the word human becomes, not a species marker, but rather, a marker of one particular species' point of view and experience.

For the Matsiguenga, the human being sees herself as what she is. Yet she is not the only one to do so. The jaguar, the snake, and the smallpox, also see that human from their own vantage point; they see the human (that particular homo sapien) as an other, from their own vantage point perhaps an other to be avoided or to be killed (Baer, 1994; Viveiros de Castro, 2015). Predatory animals and spirits, for their part, see humans as prey, while human prey may see humans as spirits or as predators.

That is, the human being sees herself as what she is. Loons, jaguars and smallpox – all of these others see humans as 'others,' and regard their own species as 'human.' Every creature in this schema – human, jaguar, loon, snake, spirit – perceive themselves as anthropomorphic beings when they are in their own houses or villages, and apprehend their behavior and characteristics through a cultural form.

> "[T]hey perceive their food as 'human' food – jaguars see blood as manioc beer, vultures see the worms in rotten meat as grilled fish – their corporeal attributes (coast, feathers, claws, beaks) as finery or cultural instruments, and they even organize their social systems in the same way as human institutions, with chiefs, shamans, exogamous moieties and rituals." (Viveiros de Castro 2014, p.57)

Animism and shamanism have deep roots around the Earth. Viveiros de Castro notes that, foregrounded in shamanic practice is the pervasive notion that nonhumans possess an invisible prosopomorphic side. Amerindian shamanism could be defined as "the authorization of certain individuals to cross the corporeal barriers between species, adopt an exospecific subjective perspective, and administer the relations between those species and humans." In such ways, the basis of shamanism is "diametrically opposed to the objectivist epistemologist encouraged by Western modernity." (Viveiros de Castro 2014, p.60).

In contrast, modernity's epistemology, and (conscious or unconscious) telos or finality, is the object: to know is to objectify by distinguishing between what is intrinsic to the object and what instead belongs to the knowing subject, which has been inevitably and illegitimately projected onto the object (Viveiros de Castro 2014, p.60). To know is thus to de-subjectify, to render explicit the part of the subject present in the object in order *to reduce it, e.g. to an ideal minimum.* In the Western view, subjects, just like objects, are regarded even as the results of a process of objectification.

> "The subject constitutes or recognizes itself in the object it produces, and knowns itself objectively when it succeeds in seeing itself 'from the outside' of a thing. Our [western] epistemological game, then, is objectification; *what has not been objectified simply remains abstract or unreal.*" (Viveiros de Castro 2014, pp.60-61).

Clearly, the advances and advantages of science and technology have been tremendous. Yet, in the so-called Anthropocene, one must stop to consider what these thinkers are saying: The very basis of western modern thought has been grounded in rendering what Rosen called "the biosphere and what is in it" (Rosen, 2000, p.7), in methods, terms, and framing of "an ideal minimum . . . abstract and unreal." (Viveiros de Castro p.60)

Meanwhile, throughout mainstream knowledge, a fuller scientific view of ecology and environments has exploded in recent decades. Ancient and contemporary knowledges are in many ways dovetailing, in fields such as: animal intelligence, language and emotions, ethnobotany, agroecology, and plant communication studies. For instance, this has included results and insights about: multispecies culture (Lestel, 2001); funeral ceremonies of elephants and whales (King, 2013; Masson and McCarthy, 1996); intricate language by corvids, cetaceans, dolphins and even prairie dogs (Bekoff, 2004; Slobodchikoff et al., 2009); communication between plants and amongst plants and animals (Kohn, 2013); ethnobotanical pharmaceutical use of and for gorillas and other primates (De Roode et al., 2013, Huffman, 2016); whale salons for composing and developing songs (Payne, 1995, Rothenberg, 2008); and even play and humor by a wide array of species like kea birds (Bekoff and Byers, 1998; Schwing et al., 2017). While the science of plant sentience and communication reveals a refreshing view of the so-called environment (Karban,

[18] See for instance, Barrows (1999).

2008; Karban et al., 2013; Pollan, 2013; Marder, 2013; Kohn, 2013). All these discoveries are bridging gaps between indigenous and modern sciences, and opening more space for vital dialogue between diverse thinkers (cross-class, transcultural and transdisciplinary) with the common aims of survival and flourishing.

Just as in Rosen's portrayal, Robert Hutchins views everything that is quantifiable as irrelevant for social science, so for Amerindian shamans, everything that is objective is irrelevant to shamanic practice. Instead, shamanic interpretation involves:

> "... seeing each event as being, in truth, an action, an expression of intentional states or predicates of an agent. Interpretive success, then, is directly proportional to the successful attribution of intentional order to an object. An entity or state of things not prone to subjectivation, which is to say the actualization of its social relation with the one who knows it, is *shamanically insignificant* ... it is just an epistemic residue or impersonal factor *resistant to precise knowledge*" (Viveiros de Castro, 2014, p.61).

Early western ontology posited multiculturalism, but both cultural (European) supremacy and mononaturalism. Early western ontology offered an extraordinary view of the Earth as not just mononaturalist, not just disenchanted and alienating, but even mechanistic and dead (Merchant, 1980). Much of scientific work has moved on today, but the ghosts of early ontologies continue to haunt society today, in both mainstream common discourse, and much economic and political theory.

But advances in both sciences and humanities are radically transforming the mainstream worldview, for instance, the 'new sciences' such as: quantum physics, chaos and complexity theories, animal and plant intelligence. Simply the two-slit experiments of quantum physics give us a window into a pluriversal and perspectival sense of space, time, matter, and being. Time and space are now not only non-universalist and non-modern; they appear to be inherently plural and perspectival (Barad, 2007). The views of quantum physicists – entanglement, superposition, potentiality, intra-activity (Barad, 2007), and pluriversal time and space – seem to less like early modern thought, and more in sync with a shamanic indigenous worldview.

Indeed, these recent mainstream discoveries echo what indigenous cultures have held all along. Humans are part of a vibrant, interconnected, intelligent web of life. Today, mainstream global science and the world's indigenous peoples, may be coming full circle. This opens the potential for a global conversation about a much more fascinating, more ecological, more indigenous 21st century worldview. We are circling back home.

5. Conclusion

As knowledge progresses, it appears to be showing a sense of the world that is increasingly relational and complex, including characteristics of paradox, pluralism and perspectivism. We are beginning to see knowledge itself as a process of exposing new paradoxes, until, via more plural and integrative methods, we may access a fuller perspective. As science resolves one set of paradoxes it reveals another, and at each turn, we see the world as increasingly complex. The perspectival lineages of, for instance, modern European and American Indigenous thought, both contribute to overcoming the flaws of early modern thought that has upheld for far too long the delusional backdrop of a mechanistic worldview, one that is profoundly anthropocentric, and one that has been misused in economic and political ways to devalue and wreak havoc on both people and the planet (Merchant, 1980; Hardt and Negri, 2009; Moore, 2015).

Indeed, the 3P are one example of the great shift away from the disastrous oversimplifications at the heart of mechanistic western modernity. In place of the modern Scientific Method, we are seeing the constellation of highly differentiated, pluralistic, and complimentary methods from transdisciplinary knowledge. In place of the modern worldview, we are seeing the co-arising of a more complex, creative worldview stemming from many sources, including: an appreciation of the unique and vital power of the humanities and arts to supplement and make sense of the results of the mathematical sciences; a western turn towards indigenous and southern ontology and epistemology; and finally, the various 'new sciences' – quantum mechanics, string theory, chaos and complexity theories – which have obliterated the last remaining bases of early modernist assumptions, such as myths of universalism, determinism, certainty, or linear progress. Rather, all of the new sciences point to a world that is beyond our wildest imagination, one which evokes awe, humility, and wonder. Such fantastical insights may even lead us to revive one of the most precious 'resources' of the 200,000 plus year heritage of homo sapien sapiens: a sense of reverence (Kaufmann, 2016, Wells, 2012).

With respect to the field of relational biology, the 3P support and advance our comprehension of relational biology and a much greater sensibility of interdependence. Advances in relational biology spur several other advances in knowledge. First, relational biology is one lever for advancing how we comprehend facets of complexity studies, e.g. towards comprehending terms like emergence and organization in biological phenomena (Morin, 1977, 1981), and towards entangled, dynamical, participatory symbiogenesis (Haraway, 2016). Second, Rosen's argument for a more relational biology of life itself, shifts the very basis of the relationship between physics and biology. Perhaps biology is not a subset of physics at all; physics and biology require plural integrative methods. Perhaps ontology is plural: there are more than one type of things in the world (Dupre, 1988). Third, relational biology shows up the fallacies not just of the quantitative and qualitative two cultures, but also of the two cultures *gap*. The paradox of Rutherford versus Hutchins is overcome by more adequately articulating and developing the appropriate methods in each field with transversal complex thought; all the qualitative fields and their methods must be supported, as necessary to advancing knowledge.

Fourth, Rosen's relational biology and the significance of causal entailments are part and parcel of a larger paradigmatic shift from a modern to complex paradigm. It both draws from and advances complex concepts across science and scholarship including: emergence, organization, hierarchically enmeshed feedbacks, network causality, superpositionality, etc. Such advances support the need to diversify and integrate quantitative and qualitative methods in the transdisciplinary knowledge needed for economic, political and cultural transition. Perpsectivism from multiple lineages, e.g. Nietzschean and Amerindian, are complimentary in advancing today's knowledge paradigm.

Together, paradox, pluralism and perpsectivism are invaluable with respect to advancing complex thought, which in turn, is necessary to societal, economic and political transition. All 3P help us to frame and comprehend the tough transcultural ethical, political and creative project of global climate policy and transition. We face issues at the foundation of systemic societal organization itself, involving ideas, norms, economics, politics and more. Many have argued that for the systemic crises we face, only systemic solutions will work (Wells, 2012; Klein, 2014; McKibben, 2016; Grenier, 2017). Systemic thought requires perpsectivism, pluralism and paradox. Not surprisingly then, the 3P are core to comprehending the ways in which successful international climate policy necessarily hinges on issues of social justice, economic equity and profound cross-cultural mutual aid and cooperation (Shiva, 2013; Kartha and Baer, 2015; Sinai and Szuba, 2017). The 3P

help us to grasp core climate justice concepts such as similar but differentiated roles and responsibilities (Kartha and Baer, 2015).

Complex concepts like pluralism, paradox and perspectivism are needed to advance integrative systems change including:rapid decarbonization (Hawken, 2017; Jacobson et al., 2017); social, economic and political transition; enhanced justice and cooperation; developing and proliferating real utopias (Wright, 2010; Gibson et al., 2017); rapid permacultural agricultural transition, reforestation, and general ecological regeneration of the biosphere. This involves a great leap beyond modernity, which is to say: advancing the most promising humanities, arts and sciences, honoring and expanding on the world's indigenous wisdom traditions, as well as focusing rapid societal transition. All of these solutions require ushering in what appears to be a pluralist, creative, and reverent emergent worldview. It takes more than two cultures to see the Anthropocene (Robin, 2015). It takes complex thought.

Appendix A.

Table A1
Concepts for Connective Knowledge: Paradox, Pluralism, & Perspectivism.

3Ps and Fields	Definitions
Paradox: environmental critical theory, political science, eco-feminism, subaltern studies	1. "An antinomy produces a self-contradiction by accepted ways of reasoning. It establishes that some tacit and trusted pattern of reasoning must be made explicit and henceforward be avoided or revised. – Willard V. O. Quine (1976, p. 3) 2. "The modern human predicament can be described as the challenge of taking informed action – as individuals, through corporations, and publicly – based on the whole of knowledge, in a world in which knowledge, both practical and scientific, is highly fragmented and dispersed." Richard Norgaard and Paul Baer (2005, p.953)
Pluralism: styles of reasoning and methods, e.g. in indigenous and traditional societies, and in transdisciplinary studies and complex thought	1. "There is a plurality of styles of reasoning: different domains of science often invoke different styles." Otavio Bueno (2012, p.657) 2. "Living cultures allow cultural diversity to thrive from the ground of our common humanity . . . as members of an earth community . . . Living cultures recognize the multiplicity of identities . . . and a planetary consciousness that connects the individual to the earth and all life." Vandana Shiva (2015, p.11)
Perspectivism: indigenous studies, humanities, transcultural ideas, continental philosophy	1. [V]irtually all [indigenous] peoples of the New World share a conception of the world as composed of a multiplicity of points of view." Eduardo Viveiros de Castro (2015, p.55) 2. "Perspectivism is the fundamental condition of all life." Nietzsche (1885, Beyond Good and Evil, Preface)

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