Big History Understanding of Complexity, Informatics and Cybernetics

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ABSTRACT

Takes a Big History view of complexity, informatics and cybernetics. Through this lens, presents Big Science, complex adaptive systems (CAS), CAS operational modes, and current massive and escalating CAS change as indicators of emergence and transformation. Calls for complex adaptive system management and complex system co-design as collaboration among diverse human and non-human intelligences, from ecological to digital. Speaks to emerging potentials for the sciences of complexity, informatics and cybernetics in this unique time in Big History as humanity shifts from opaque decisions and hierarchical messaging to transparent network conversations and co-design with complexity.

Keywords: Complex adaptive systems, appreciative system, complexity, agility, complex system co-design.

1. PURPOSE

The purpose of the paper is to ask questions and start conversations around key topics. One topic is humanity's role in helping sustain deep interconnectivity, intense networked conversation, and highly coordinated action among massive numbers of diverse agents needed for complex adaptive systems (CAS) to fully-function and positively regenerate. A second is the role of complexity, informatics and cybernetics in helping humanity re-empower CAS as highly productive regenerative systems.

2. DEFINITION OF KEY TERMS

This paper seeks to optimize communication with multi-disciplinary audiences including members of the psychological and social sciences. It uses some terms differently than if it were only communicating to system science, cybernetics and control science audiences. With a belief in the importance of communicating to the broadest audience, the paper uses the following definitions.

Positive and Negative
Positive refers to system change that tends to stabilize, sustain or increase performance; while negative refers to system change that decreases stability, sustainability and performance. This differs from system science definitions, where positive feedback intensifies change and leads to instability, and negative feedback dampens change; and from cybernetic and control theory definitions of positive as arithmetically adding to inputs, and negative as subtracting from inputs

Complex Adaptive Systems (CAS)
Complex Adaptive Systems (CAS) herein refer to systems whose parts interact and co-adapt to produce more-complex behavior. CAS embrace complexity to optimize system regeneration and co-adaptation of entities and behavior among participants.

Appreciative Systems
Appreciative Systems fully participate in the complexity they help create [1]

3. STORY OF UNFOLDING COMPLEXITY

From my first introduction to big history [2], to key readings including The Journey of the Universe [3], to the current History of the World in 18 Minutes [4],. About 10 years ago, I began to focus on CAS from this perspective. Based on Swimme and Tucker [3], I embraced complexification through three transformations: 1) physical transformation of the universe, 2) ecological transformation of Planet Earth, and 3) transformation via complexification of consciousness.

Most experts see transformation powered by some dynamic tension, Figure 1. They see physical transformation powered by the tension between expansion (Big Bang) and coalescence (gravitational forces). Some people see biological transformation powered by the tension between biological innovation (mutation) and species co-adaptation (evolution) that carries innovation forward. Some people see in-progress cognitive transformation motivated by the human need to know and understand [5] and the dynamic tension in the mind between individual and collective motivations, i.e. between a desire to succeed as an individually and a desire to be part of something bigger than oneself [6]. While I have embraced this view for 25+ years, I have also recently begun to appreciate how cognitive transformation operates as a dynamic relationship of logical and analogical thinking [7] that motivates individuals and cultures to establish different worldviews, i.e., different lenses through which they see the world profoundly differently one from another.

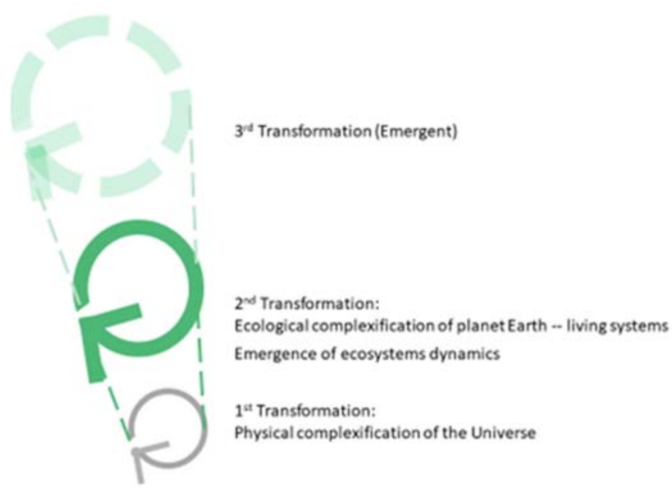

Figure 1. Big History story of unfolding complexity
Based on *Journey of the Universe* [3]

2. APPRECIATING COMPLEXITY

This paper embraces Jantsch's call for humanity to become an "appreciative system", i.e., one that appreciates the complexity it helps create [1]. Responding to this call, I typically help students of landscape architecture begin this transition by asking them to appreciate the profound complexity that emerged in biological transformation of Planet Earth. I discuss this as the complexity needed, for example, to use low-energy photons of light to transform a grey planet into the ecological diversity, dynamics and bio-capacity of Planet Earth. I ask them to appreciate that this transformation is only possible through immense levels of complexity, communication, and co-adapted behavior.

3. HOW DOES COMPLEXITY EMERGE?

So how does complexity emerge, and how do complex adaptive systems (CAS) work? Complex adaptive systems work through cycles of innovation and co-adaptation, motivated by some underlying dynamic tension, as shown in Figure 2. Now if we take the vertical cylinder formed by the spirals shown in figure 2 and bend it until it closes on itself, we have the "dough" portion of what Kate Raworth referred to as doughnut economics, the economics that provisions humanity to live within what she visualized as the "doughnut" of a safe and just world [8]. What she refers to as living in the doughnut, I refer to in this paper as living within the complex adaptive system.

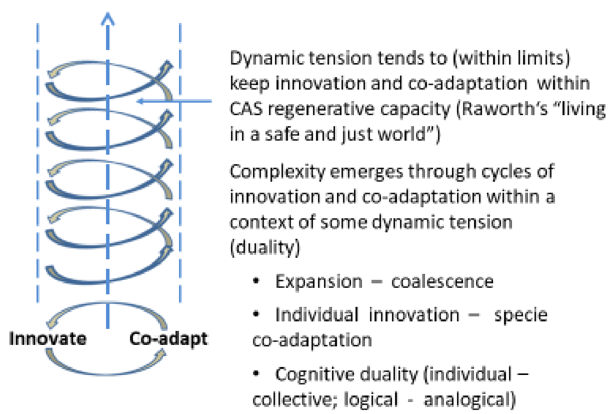

Figure 2. Complexity as cycles of innovation & co-adaptation

The contention herein is that throughout most of human history, people lived within local complex adaptive systems. Then humanity became smart enough to learn how to live outside local systems, i.e., by externalizing impacts of actions, and allowing other people to regenerate the biocapacity consumed or degraded, Figure 3. This strategy allowed people to consume excessively, and yet survive and even thrive. As a result, people ceased to appreciate the need, and even the imperative, to live within the complex adaptive system they depended upon. As a result, and with expanding science and increasingly powerful technologies, the scale of human impact grew spatially and temporally. With a growing capability to impact and an increasing failure to live appreciatively within our complex adaptive system, humanity has temporarily at least, transformed a regenerative planet Earth into a degenerating one. Having passed this turning point, humanity is now discovering a reduced capability for future generations to thrive in a safe and just world.

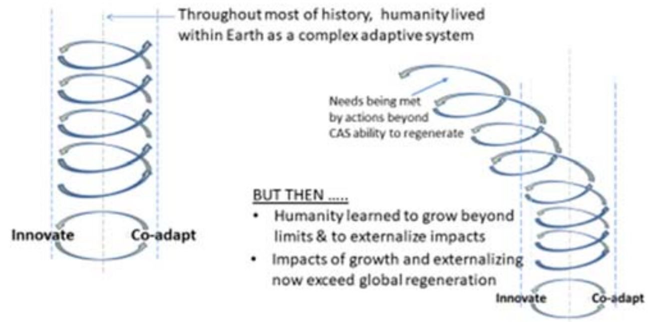

Figure 3. Human engagement in complexity

In the U.S., we reached this turning point in the late 1960's or early 1970's, Figure 4. By failing to shift to appreciative engagement with the complex adaptive system upon which we depended, we shifted our nation from a regenerative system into a degenerative one.

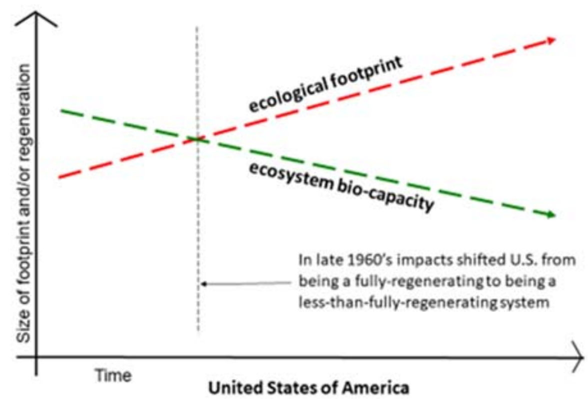

Figure 4. Engagement beyond system regeneration

In the U.S. and globally, even after passing this turning point, consumption and system degradation continued to escalate, until now humanity consumes at 1.6 times the global bio-capacity regeneration rate. We are reducing Earth's complexity and degrading global bio-capacity 1.6 times faster than they are being regenerating.

4. 21ST CENTURY CHALLENGE

Because we have been operating outside the regenerative dynamics of the complex adaptive system upon which we depend, we have created what Ramo [9] calls the Age of the Unthinkable, where increasingly decisions made for seemingly good reasons yield progressively more negative results. We are now discovering that more-and-more, the unthinkable problems we face are actually problems we have created. We have produced the unthinkable -- climate change, collapsing populations, global war, and the myriad of other problems -- by not living appreciatively in a safe and just world. We are also discovering that the myriad of environmental, social and economic crises, all intensifying and escalating at the same time, are indicators that these problems are symptoms of a much deeper causal meta-problem [10].

The contention herein is that the meta-problem producing these symptomatic problems is that humanity has not been living as an appreciative system within the complex adaptive system upon which we depend. As a result, humanity is now facing a huge, unprecedented challenge, i.e., to learn how to become an appreciative system that positively engages the complex adaptive system . . . and to do so in the context of escalating decline of that system. To address this challenge, humanity must learn how to engage appreciatively in ways that re-empower system self-regulation, self-management and full regeneration of whole-system functionality and bio-capacity.

The contention is further that this challenge is also a profound unrealized opportunity. David Armistead speaks to the economic potential of this opportunity as the “mother of all economies”. He asks people to consider how much humanity currently produces in the system we are degrading; and how much more we could sustainably produce is we positively engaged with that system. [11]

5. TRADITIONS OF ENGAGEMENT WITH COMPLEXITY

Through human history, cultures have pursued three meta-traditions of engagement with complex adaptive systems. In the first tradition of indigenous engagement, humanity lived and co-adapted within local complexity; and if people could not live and co-adapt with complexity, they suffered or perished. In the second tradition, humanity progressed through waves of increasingly unsustainable consumption, impact and degradation, using ever-more powerful technologies to address the problems of the previous wave and, as a result, creating even more unthinkable new problems. Rushkoff explored the most recent of these waves in detail in *Throwing Rocks at the Google Bus* [12].

The contention herein is that humanity is entering the third meta-tradition of engaging with complexity. In the emergence of this third tradition, humanity is trying to learn how to become an appreciative system and how to live, sustain and regenerate complexity into the future. This third tradition, Figure 5, is all about cognitive transformation. The contention herein is that when humanity becomes an appreciative system, we will have transformed from a species that is shutting down complexity to one that is actually re-empowering complexity.

Figure 5. New potential of living within complexity

The contention is further that when humanity becomes smart enough to function as an appreciative system that lives within the complex adaptive system we help create, that we will empower complex system co-management and complex system co-design (CSCD). In this CSCD shift, humanity will embrace collaboration among the full diversity of human and non-human intelligences, from ecological to digital. This co-design engagement will allow new potential to emerge from the sciences of complexity, informatics and cybernetics. This human shift to functioning as an appreciative system and full-participant in complex system co-design will catalyze the third transformation of planet Earth, i.e., cognitive complexification.

6. SUSTAINABLE COMMUNITIES INSTITUTE, INC.

Sustainable Communities Institute, Inc. LLC, that I co-founded and where I now am educational consultant, is a think-and-do institute. It helps communities live within complexity and embrace the education, research, demonstration, and collaboration needed to identify and answer core questions and thereby empower cognitive transformation. SCI helps communities integrate energy, water and food systems to optimize the energy-water-food nexus, and the amount they can sustainably produce within that nexus.

About 8 or 9 years ago, I began to articulate the complex interconnectivity and co-adapted nature of ecological, social and economic systems. I expressed my growing concern with the parasitic nature of the increasingly popular notion of environmental services, with its focus on one-way services that the environment provides to humanity or, more specifically, the economy. I rather proposed that humanity adopt an inter-system services approach grounded in a balanced co-adaptive inter-system services view. I began asking questions like “in addition to services environmental systems provide to economy, what services do economic systems provide to environment?” Taking a triple bottom line approach, I began to speak for a co-adapted balance of three key inter-system flows, Figure 6. These included balanced inter-system flow of services the economy provides to environment, and environment provides to economy; balanced flow of services society provides to environment, and environment provides to society; and balanced flow of services society provides to economy, and economy provides to society. I contended that when we have balanced, closed-loop flows between all three sets of inter-system services, we will be living within systems, or as Raworth says living in the doughnut of a safe and just world [8].

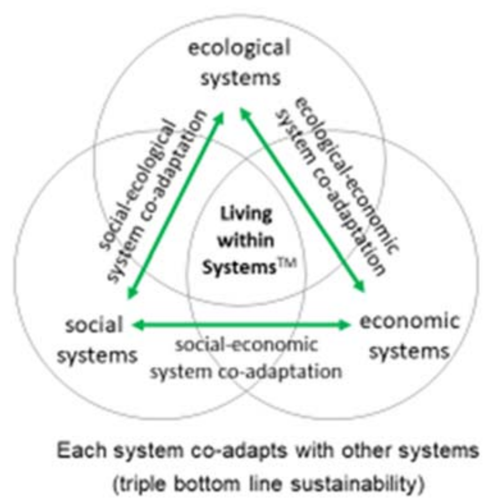

Figure 6. Living in Systems ™

7. RE-EMPOWERING COMPLEXITY THROUGH WHOLE-SYSTEM METABOLICS

Sustainable Communities Institute also helps people thrive by re-provisioning their communities into regenerative local networks that re-empower complexity by optimizing whole-system metabolic functionality. SCI helps communities move from functioning as through-put systems that flow resources through the system in ways that do not provide inter-system services, do not fully-regenerate system complexity and whole-system functionality, and that thereby convert resources into waste, Figure 7. SCI helps communities shift to dealing with all key local resources – energy, water, food, materials, etc. – as closed-loop, metabolic, and regenerative flows of resources and co-adapted whole-system complexity.

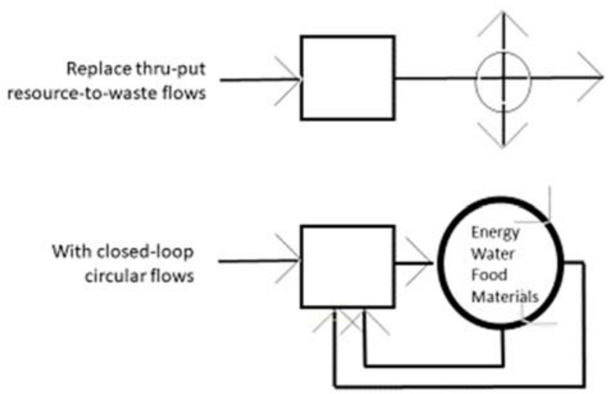

Figure 7. Re-empower metabolic system dynamics

8. SHIFTING FROM INTER-DISCIPLINARY CONSCIOUSNESS TO CO-DESIGN

I remain surprised, even at this 8th International Multi-Conference on Complexity, Informatics and Cybernetics: IMCIC 2017, that conversations continue to take an interdisciplinary rather than diverse intelligence co-design approach. I contend that when we talk about collaboration and building a broader vision, but frame the conversation as interdisciplinary, we tend to see through disciplinary lenses. I would prefer a whole-system approach that shifts visioning from disciplinary to whole-system perspectives. While I appreciate, for example, the vision of reality provided by science and western approaches to education, I feel they devalue other essential knowledge systems including indigenous and vernacular knowledge systems. While academicians are good dealing with things in a theoretical sense, they are not nearly so good operationalizing theories in the messy world and working through the wicked problems that emerge with failure to integrate with system complexity. Operationalizing sustainable solutions would benefit CAS by bringing the full range of intelligences into the conversation.

Figure 8. Integrate full spectrum of intelligences

9. LEVELS OF HUMAN SUPPORTS

Operationalizing sustainable community solutions in complex adaptive systems and avoiding the wicked problems that emerge with failure to integrate with system complexity also benefit from interconnecting three levels of human supports. These include ecological systems as primary support system upon which we rely for survival. It also includes infrastructural systems (energy, water, food, materials technology, etc.) as secondary supports through which we provision the complex system to address human needs. It also includes the built-environments (smart cities, living buildings, etc.) that collaborate in regenerating resources and the complex adaptive system.

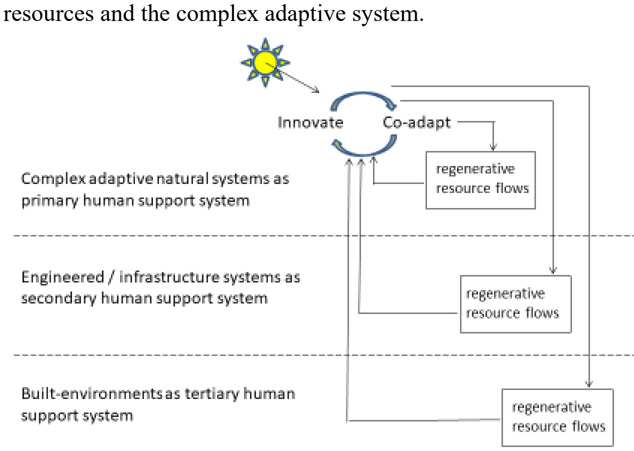

Figure 9. Integrate circular flows among 3 levels

10. EMERGING CONSCIOUSNESS AS CO-ADAPTED HUMAN AND ARTIFICIAL INTELLIGENCES

IMCIC 2017 conversations helped evolve my thinking about co-adapted human and artificial intelligence. They enhanced my understanding of how rapidly the two are co-adapting, and how new thinking models, types of intelligences, types of decisions, changes in design processes, changing performance measures and co-adaptation of HI-AI are empowering what I have coined complex system co-design.

	HUMAN INTELLIGENCE +	ARTIFICIAL INTELLIGENCE
THINKING MODEL:	Analogical	Logical
TYPE OF INTELLIGENCE:	Multiple/diverse intelligences	Mathematical
DECISIONS INFORMED BY:	Whole-system understanding	Immense processing
COLLECTIVE DECISIONS	Innovation-Intervention	Swarm behavior
PERFORMANCE RECORD	Reputation / trust	Block Chains
CO-ADAPTED INTELLIGENCE	Complex System Co-design	Smart Systems & Tech.

Figure 10. Consciousness as co-adapted HI + AI

Thinking Model
For several decades, advances in digital technologies have rapidly increased the power of logical thinking, which is allowing the mind to co-adapt at an accelerating pace. However, while artificial technology has been rapidly increasing the power of logical thinking, advances in analogical thinking have not been not keeping pace [7].

Types of Intelligences
Over these same decades, accelerating negative feedback from complex adaptive systems [13] has been elevating the need to enhance understanding of digital and cognitive thinking as profoundly different types of intelligences. There is also growing concern that while digital technology has rapidly increased the ability of the mind to co-adapt with these technologies to think mathematically and logically; advances in analogical thinking have not been keeping pace [7].

Effect on decisions
This is a major concern, since analogical thinking provides cross-system insights into complex adaptive systems and the co-adapted inter-connectivity within these systems. It provides this whole-system understanding by integrating emotional thinking, rational thinking, spiritual thinking and many other diverse intelligences. Analogical thinking also allows the mind to build new intelligence through the integration of these diverse intelligences. On the other hand, digital technology-enhanced rational and mathematical thinking tends to produce decisions overly determined by rational thinking.

Emerging consciousness through co-adapted HI + AI
The contention herein is that digital technology-enhanced rational and mathematical thinking also opens new opportunities for cognitive co-adaptation. The contention is that by accelerating human ability to think analogically, we can bring the power of the full diversity of knowledge systems to enhance human appreciation of, and sustainable engagement with, complex adaptive systems. The contention herein is finally that integrating this full diversity of knowledge systems to co-adapt consciousness can further empower humanity to behave appreciatively in the complex adaptive system, and thereby unlock and re-empower complexity.

Co-adapted HI + AI
About 25 years ago, I had the great learning experience of engaging in professional environmental planning and design grounded in whole-systems decisions informed through dialogue among diverse intelligences, in an environment of respect that appreciated diversity and did not allow focused expertise to pre-empt whole-system discussion [14]. I concurrently pursued a phd grounded in innovation/intervention processes [15] that pursued these same principles. From an evolved appreciation of logical and analogical thinking, I now see these innovation-intervention physical planning and design processes as the HI corollary of current swarm behaviors in IT, where large numbers of intelligent agents, each coming at an issue from a slightly different intelligence, enhance innovation and co-adaptation to produce decisions grounded in a diversity of intelligences.

Performance Measures
This raises the question then of how might performance measures change, e.g., how might people assess decisions so as to optimize the building of trust among diverse participants as the metric of performance? Along these lines, much current work focuses on optimizing the ability of block-chain technologies to inform decisions based on the history of the relative whole-system value of past decisions of specific participants. There is also excitement over the growing ability of computers to assess performance using information provided by a swarm of agents of diverse intelligences and use these assessments and analogical thinking to inform whole-system optimizing decisions [16].

Appreciative intelligence
So this is a truly exciting time of cognitive co-adaptation where human intelligence can contribute the richness and complexity of analogical thinking and the artificial intelligence of digital technology can provide the power of rational and mathematical thinking . . . to empower consciousness to grow at an unprecedented and accelerated rate. The excitement lies in the potential of emergence and co-adaptation of human intelligence to transform physical planning and design into "complex system co-design" and transform dumb technologies into "smart technologies".

11. COMPLEX SYSTEM CO-DESIGN

I have previously talked about five generations of design process [12]. I spoke of state-of-the-art 4th generation co-design processes that include users in the process but continue to be anthropocentric. I introduced Complex System Co-Design (CSCD) as seminal fifth-generation design process that includes people and the complex adaptive system upon which they depend as co-participants in the design process; and embraces process-level biomimicry and design processes grounded in the innovation–coadaptation cycles of complex adaptive systems. I contended that CSCD helps people co-adapt with the complex adaptive system of which they are intimately connected and to make solutions co-adapted with human needs and needs of the complex adaptive system. I also contended that CSCD helps communities change from human-focused, human-serving behaviors; and to make complexity-centric decisions that appreciate all living systems and serve the complex adaptive system as well as human needs.

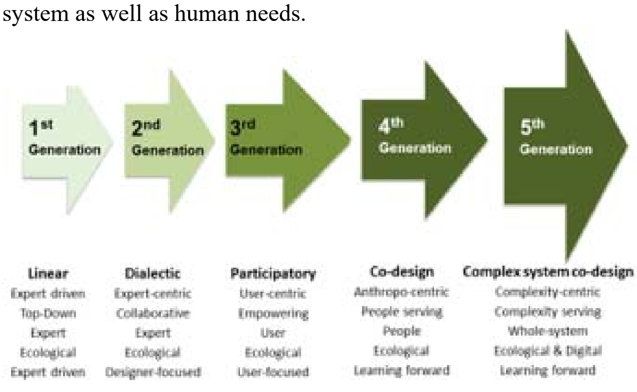

Figure 11. Complex system co-design
Adapted from [12]

CSCD integrates complexity science and design science. It is grounded in a complexity science appreciation of complexity emerging from cycles of innovation and co-adaptation. The CSCD designer applies this appreciation by innovating into complexity, appreciating CSCD whole-system functionality, and co-adapting with feedback from the complex adaptive system. Over time the designer, using this co-adaptive approach learns forward how to design better into complexity, how to get better feedback from complexity, and how to co-adapt better with this enhance complex adaptive system feedback.

CSCD also involves appreciating -- whether one is in design, informatics or cybernetics -- the imperative of a sustainable future; and many people say that we have about 30 years to get to this future. The contention herein is that arriving at this future will require the synergy of complexity science and design science to integrate the full diversity of thinking in such a way that the complex adaptive system is re-empowered to build complexity, Figure 12.

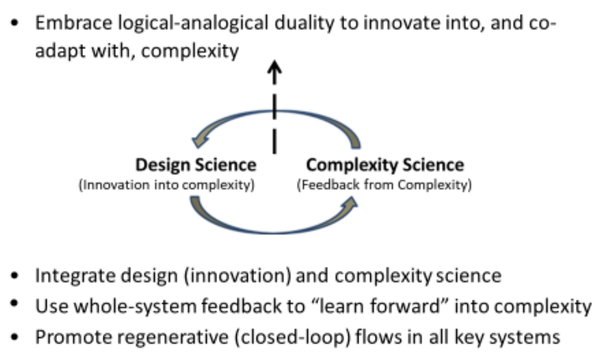

Figure 12. Optimize potential of logical-analogical duality

12. BIG HISTORY VIEW OF CYBERNETICS

While acknowledging that others have talked about third-generation cybernetics in a very different way, I herein propose a big history view of cybernetics. I see first-order cybernetics having emerged when complex adaptive systems figured out how to self-organize, self-manage and regenerate physical complexity. I see second-order cybernetics having emerged when living systems figured out how to self-organize, self-manage and regenerate biological complexity. I see third-order cybernetics emerging as consciousness learns to integrate all complex adaptive system intelligences (ecological, artificial, etc.) to become complex and deep enough in interconnected behavior to fully-sustain and regenerate complexity of the complex adapted system.

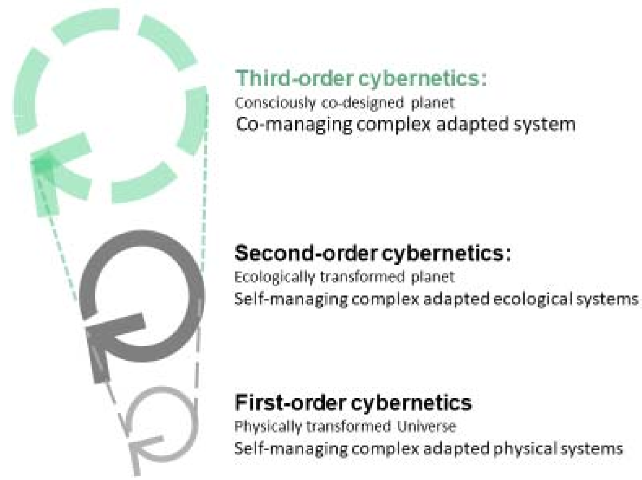

Figure 13. Big History view of cybernetics

Musings about a big history view of third-order cybernetics
This IMCIC 2017 conference has provided a fertile context for musing about big history and third-order cybernetics. The following are not yet predictions or even speculations but rather untested thoughts allowed to incubate. This includes musing about the nature of cybernetics from a big history perspective.

From a big history perspective, what is the emergent third-order paradigm of cybernetics and informatics? Is it one of complex system co-design, co-organization of complexity or co-management of complexity? What is the role of cybernetics in this big history emergence of consciousness as an appreciative system? What is the role of third-order cybernetics in the on-going integration of the Internet of Things, smart assets, self-organizing software and the circular economy [17]? How to co-manage actions to optimize, sustain and regenerate the health and productivity within the energy-water-food Nexus as the interconnected primary resource? Finally, and incorporating all of the above, what is the third-order role of cybernetics and informatics in empowering the unlocking of complexity as humanity's primary 21st century challenge [18]?

The contention herein is that as cybernetics and informatics transition to this third-order paradigm, they will do so with an appreciation of their need to co-adapt with today's rapidly changing context. This includes a contextual change in:

- *societal paradigm* from directed control to integration with diverse intelligences
- *definition of wealth* from financial capital accumulation to whole-system capacity building
- *systems engagement* from extractive-consumptive to regenerative-balanced
- *economy* from resource-to-waste to metabolic-circular
- *transactions* from "fees for services" to collaborating with complexity
- *production goal* from extracting short-term profits to sustaining whole-system productivity
- *performance metric* from financial gain to building trust/empathy/happiness
- *loci of focus* from global entities to local networks
- *perceived human role* from laborers to analogical thinkers

- *perceived human value* from Consumer to Maker (consumer-producer)

13. NETWORK CONVERSATION AROUND BIG HISTORY AND THIRD-ORDER CYBERNETICS

Building from Wahl's call for a methods shift from identifying best answers to asking the best questions [19] the final contention herein is that third-order cybernetics will be less about providing solutions and more about building understanding about core questions. This paper closes with a call to build this big history knowledge around core questions; starting with network conversation around two questions.

1. What is humanity's role in helping sustain the deep interconnectivity, intense networked conversation, and highly coordinated action among massive numbers of diverse agents needed for complex adaptive systems (CAS) to fully-function and positively regenerate

2. What is the role of complexity, informatics and cybernetics in helping humanity re-empower CAS as highly productive regenerative systems.

14. REFERENCES

[1] E. Jantsch, **Design for Evolution: Self-Organization and Planning in the Life of Human Systems**, New York, George Braziller, 1975.

[2] G. Wald, "From Big Bang to Big Bucks", lecture at the University of Pennsylvania, 1976

[3] B.T. Swimme & M.E. Tucker, **Journey of the Universe**, Yale University Press, 2011

[4] D. Christian, "The History of the World in 18 Minutes". www.ted.com/talks/david_christian_big_history accessed 9/7/2017.

[5] A.H. Maslow, & R. Lowery, (Ed.). **Toward a psychology of being** (3rd ed.), New York: Wiley & Sons, 1998

[6] D. Beck, & C.C. Cowan. **Spiral dynamics: Mastering values, leadership, and change : exploring the new science of memetics.** Cambridge, MA: Blackwell Business, 1996

[7] N. Callaos. "Analogical Thinking, Inter-Disciplinary Communication … ", Participative talk at IMCIC 2017.

[8] Raworth, K., "Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist", 2017

[9] J. C. Ramo, **The Age of the Unthinkable: Why the New World Disorder Constantly Surprises Us and What We Can Do About It**, Little, Brown and Company Pub., 2009

[10] F. Capra., **The Turning Point: Science, Society, and the Rising Culture**. New York: Simon and Schuster, 1982.

[11] D. Armistead, D. Thriving Community Solutions, Next System Conference, Ball State University, Mar. 2016

[12] D. Ruskoff, **Throwing Rocks at the Google Bus: How Growth Became the Enemy of Prosperity**, Penguin, New York, NY, 2016

[13] J. Motloch, "Complex System Co-Design: Pathway to becoming an appreciative system", **International Multi-conference on Complexity, Informatics and Cybernetics** IMCIC, 2017.

[14] C. Mulder. **Thesen Island Development Framework**, 1991.

[15] A. Hatchuel, P. Agrell, and J.P. van Gigch. "Innovation as system intervention", **Systems Research: The Official Journal of the International Federation for Systems Research**, Vol. 4 #1., 1987

[16] Rzevski, G. Harnessing the Power of Self-organization, Complex Systems 2016, New Forest, UK, 6/2016

[17] Ellen McArthur Foundation. Intelligent Assets: Unlocking the circular economy potential, 2016

[18] Motloch, J. Unlocking Complexity: Big Science Project and Research Agenda, *International Journal of Science and Nature and Ecodynamics,* Volume 11, Number 4, 2016

[19] Wahl, D.C., *Designing Regenerative Cultures*, Triarchy Press, 2016