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Technology and Global Change

Can We Really Control Giant Open Complex Systems?

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Human society and nature interact through complex interconnections and interdependencies. Using Chinese scientist Qian Xuesen's concept of Giant Open Complex Systems, this paper argues that if human beings are themselves such open complex systems, their interaction with other human beings and nature create co-relative, co-creative interactions that cannot be reduced to simple reductionist principles that enable prediction and control. We should therefore have few illusions that we can fully control human destinies under current theories and policies.

> "Both our present science and our present technology are so tinctured with orthodox Christian arrogance toward nature that no solution for our ecologic crisis can be expected from them alone. Since the roots of our trouble are so largely religious, the remedy must also be essentially religious, whether we call it that or not. We must rethink and re-feel our nature and destiny."
> —Lynn Townsend White (1967)

> "Humankind has not woven the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself."—Speech of Chief Seattle of the Suquamish tribe (1854)

INTRODUCTION

The purpose of this conference is to examine why most humans "perceive to be in control of the real world, but see only a reduced reality, that, in time, space and complexity, is only a minuscule part of an infinite world. That world is loaded with an immeasurable number of connected cause and effect relationships, that all, in some way, affect every individual on his planet" (Vasbinder 2023).

Humanity's perception of reality and control over its environment is an interrelationship between humans and living things with consciousness, on the one hand, and the physical world of matter, which may or may not have consciousness, on the other. This paper examines the assumptions behind the illusion of (human) control down to their fundamental levels and implications. The Chinese nuclear scientist Qian Xuesen (1911–2009) famously defined human beings as "Giant Open Complex Systems (GOCS)" (Xuesen, Jingyuan, and Ruwei 1992) since each brain has 10^{12} neurons, processing dynamically how a human being would act or react with other human beings and the environment around it. Thus, GOCS are interacting with GOCS, so that the overall system is increasingly complex, and growing. He observed that inanimate or closed systems obey the second law of thermodynamics, in which a state of equilibrium may be reached, whereas living systems are open, nonlinear, and far away from equilibrium. He concluded that the reductionism underlying exact science is not suitable for the study of GOCS, requiring a new synthesis of both quantitative and qualitative research. Qian's followers in China have drawn on traditional Chinese holistic thinking to build on the GOCS approach, evolving a "Wuli-Shili-Renli" approach (Gu and Zhu 2000), using a synthesis of *wuli* (knowing, studying, and measurement of objective existence), *shili* (subjective modeling), and *renli* (comparing and coordinating human relations) in their approach to systems engineering and management thinking. It is a pity that this approach was never adopted in an interpretation of how Chinese economic and social reforms were achieved in the last forty years.

Section 1 looks at how the recent emergence of systems thinking, the view that the major problems of our time are all interconnected and independent and must be examined from a system or holistic point of view (Capra and Luisi 2014), reveals new ways of thinking about how human society and ecology are evolving. Section 2 goes into why we need to apply transdisciplinary (on top of multi- and interdisciplinary) GOCS thinking to accept that we do indeed have an "illusion" of control over the whole system, whereas we may have only partial (and perhaps fleeting) control in a limited area (time and space). Section 3—"Think Systemically, Act Locally"—sums up what can be done in an era of emergence of acceleration of multiple

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trends, in which excessive human activity may be damaging the ecology such that the existence of humans and other living things is threatened (Age of Anthropocene). Section 4 concludes.

1. THE EMERGENCE OF SYSTEMS THINKING

In the era before science and technology, different civilizations thought about man, matter, and nature in eclectic ways, with deep religious perspectives and values, including attributing the what and why of factors affecting man and nature to god or gods. Egyptian physician and pyramid architect Imhotep (ca. 2700 BCE) clearly thought in terms of organic, physical, and religious systems in aligning human icons (pyramids) to power and their relation to gods and the afterlife. The early Greeks believed in many gods, but their philosophers tried to see the world beyond gods in terms of planetary order in which spherical bodies moved in circles around the earth (Aristotle and Plato, ca. third and fourth centuries BC). The atomists (Berryman 2022) (Leucippus, fifth century BCE; Democritus, fourth century BCE; and Lucretius, first century BCE) theorized that the natural world comprised basic particles, atoms, and void. Atoms move and combine in the void to form different things. Claudius Ptolemy (90–168 CE) introduced the idea of epicycles (circles within circles) that established a mathematical relationship between planets that had predictive power.

The evolution of Western systems thinking emerged from an atomist/reductionist frame of mind combined with linear deductive logic to produce scientific analysis and empirical verification. Whereas classical Chinese thinking was dialectic and holistic, recent Chinese systems thinking asserts that "the roadmap of Western systems thinking emerged from reductionism to holism, while the Chinese roadmap emerged from holism to reductionism to dialectic unity of the two" (Pan, Valerdi, and Kang 2013).

The systems thinker Donella Meadows (1941–2001) defined a system as "a set of things—people, cells, molecules or whatever—interconnected in such a way that they produce their own pattern of behaviour over time" (Meadows 2008). Russell Ackoff defines it as "a whole consisting of two or more parts (1) each of which can affect the performance or property of the whole, (2) none of which can have an independent effect on the whole, and (3) no subgroup of which can have an independent effect on the whole" (Ackoff 1994). In other words, a system is a whole that has parts that are not independent of the whole, yet the system may have properties that are not in the parts—the whole is more than the sum of its parts.

Meadows put her finger on the essential interconnection between the parts of a system—what she called "the basic operating unit of a system—the feedback loop" (2008, 5). Changing the system involves looking for "leverage points" that would create feedback loops that change the system.

Ackoff classified systems into physical, organismic, and social. Physical systems are inanimate, whereas organismic systems are living and may have consciousness. Social systems are human systems that interact with both physical and organismic systems to evolve a collective consciousness and behavior that has self-order. Environmentalist James Lovelock (1919–2022) conceived the idea of Gaia, which postulates that the earth is a self-regulating system (Lovelock 1995). Some consider that the earth may have a consciousness that is formed by the interaction between conscious beings that comprise the earth.

In *The System View of Life* (2014), Fritjof Capra and Pier Luigi Luisi sought to synthesize Western and Eastern thinking, including the latest insights from biology, into a unifying overview of how systems thinking should both permeate modern analytical thinking and provide new solutions to systemic problems.

The terms "illusions" and "control" imply that we are thinking of human consciousness (illusions or perceptions) and control (human agency that enables man to control physical, organismic, and human systems). Illusions are mental models of reality that are imperfect or incomplete descriptions of reality. Most theories or models may be inadequate and blinkered by vested interests of the theoreticians or because the model adopted narrow assumptions that excluded a systemic view of the whole.

For most of their existence, human beings struggled to survive, living by their wits and appearing defenseless against nature, weather, and predators. But the invention of tools, farming, and animal husbandry, and use of wood, water, and then fossil energy sources propelled humans to be able to control nature and other humens. Genesis 1:28 claimed that God made man in his image and gave him power to rule over other men and living things. This came to be known as the domination code (Newcomb 2018). Thus, it was no coincidence that the industrial and scientific age rose with the age of imperialism and colonialism, especially control over energy sources (largely fossil fuels). The Industrial Revolution coincided with not just physical technology (science) but also social technology (the power of institutions and modern management) and business models (profit-driven capitalism) (Beinhocker 2007).

As philosopher of science Stephen Toulmin (1922–2009) identified in *Cosmopolis* (Toulmin 1992), the arrival of printing in Europe, competitive nation-states, and commercialization created in the Renaissance era the conditions for new thinking. Then the discovery of America and the Cape of Good Hope route to Asia in the second half of the sixteenth century added fresh resources, land, slaves, food, and energy to previously poor European states. However, he dates the rise of Western modernity to the first three decades of the seventeenth century. Before that, philosophy was practical and steeped in the humanities. Indeed, sinologist Joseph Needham (1900–1995) thought that ancient Chinese thought was essentially organic materialism, which saw evolution through organic or biological corelative terms, rather than mechanical or physical interactions (Needham 1956). The Renaissance produced a rich study of humanism, but new ideas and perspectives from conquering new lands and cultures shifted a humanist, religious perspective toward a more secular, theoretical approach, paving the way for the emergence of hard science and technology.

Toulmin identified that after 1600, philosophy shifted toward abstract, universal theories, from the oral to the written, from the particular to the universal, from the local to the general, and from the timely to the timeless (1992, 33). Formal logic and quantitative measurement was in, and qualitative rhetoric, previously worshipped in classical humanism, was out. With the influence of Bacon (1561–1626), Descartes (1596–1650), Leibniz (1646–1716), Newton (1643–1727), and other scientists, there evolved scientific methodology that was essentially a mechanistic view of the world, subject to universal natural laws of physics and mathematics.

The rise of science created specialized disciplines, each evolving their own language and compartmentalized tools and processes—namely, thought systems. It propelled science forward, so much so that philosopher/author C. P. Snow (1905–1980) lamented the division between the two cultures, science and art (Snow 1959). As American historian Lynn Townsend White Jr. noted, the rise of science was associated with Christianity, with all its worldview of beginning (when God created the earth) and end (Judgment Day). The ideals of perfect knowledge (optimality), certainty, and one theory of everything were goals of classical science. The idealized view of the world sought optimization, zero transaction costs, and control. It ignored the dark side, uncertainty, and side effects, which were neither measured nor taken into consideration. Open systems do not have clear boundaries, and there may be no beginnings or endings, only continuum through space-time and different dimensions.

In the twentieth century, advances in biology led Austrian biologist Ludwig von Bertalanffy (1901–1972) to evolve his general systems theory of open systems thinking (von Bertalanffy 1972). At around the same time, Norbert Wiener (1894–1964), drawing upon his experience in working with different scientists and social scientists under the multidisciplinary Macy Conferences (Wikipedia contributors 2023b), evolved "cybernetics," defined as the "science of control and communication in the animal and the machine" (Wiener 1961). With the evolution of information theory by Alan Turing (1912–1954), Claude Shannon (1916–2001), and others, those who studied the brain, like Ross Ashby (1903–1972), began to fuse biology, mathematics, and engineering, which led to the creation of the computer model of mental activity. But it was from biology that the view of patterns, self-regulation, and self-organization came to shape systems thinking. The idea of patterns emerging out of chaos was first pointed out in the "butterfly effect" by meteorologist Edward Lorenz (1917–2008) (Wikipedia contributors 2023a), with added insights by mathematician Benoit Mandelbrot (1924–2010) on the fractal geometry of nature (Mandelbrot 1982).

Biology was where the boundary between life and matter became blurred. The cell, by and large one of the smallest living organisms, is an operationally closed system, but its interaction with other cells and inanimate material (chemicals) creates what South American biologists Maturana (1928–2021) and Varela (1924–2001) called "autopoiesis" (Maturana and Varela 1980)—the cell interacts with the environment in a cognitive interactive way in which the cell "creates" its environment and the environment helps the cell evolve. The ecosystem self-organizes.

The next stage of development was the application of the Santiago (Maturana and Varela 1980) theory of autopoiesis to the evolution of social systems. Human beings and their collectives are more complex than cells. Humans have concepts, ideas, symbols, and values that are associated with human thought, consciousness, language, and culture. German sociologist Niklas Luhmann (1989) saw communication as the basis for social system production and reproduction through networks (Luhmann 1989). Communication exists through multiple feedback loops that create shared systems of beliefs, explanations, and values that are reinforced through rituals, codes, rules, and law, as well as social hierarchy. This gives identity and meaning to individuals, members, and the group.

We thus come to the problems of the modern age, an age of polycrises from multiple factors, such as technology, demographics, climate change, geopolitics, and social injustice, that have interacted to form what some Europeans call "permacrises."[1]

The world is interconnected by trade, finance, information networks, and production/distribution supply chains. Disruption of one part has a huge impact on the other parts, some not immediately obvious, but lagged feedback effects accumulate to cause "Black Swan" shocks to the system.

Herein lies the dilemma of "Illusion of Control"—how do we solve our problems that are systemic in nature?

2. SOLVING SYSTEMIC PROBLEMS

The fifth-century Chinese philosopher Zhuangzi famously had a dream about a butterfly. When he woke up, he asked whether he was a butterfly dreaming that he was a man or the other way around. Human beings have constructs of reality through their sensory powers. The division of mind and body (matter) by Descartes was useful to force deeper thinking about the parts, but later scientists forgot to take a "crude look at the whole" (Miller 2016) to see how the parts are interacting with the whole and how the whole is changing. Zhuangzi was therefore one of the earlier philosophers to wonder about what is reality and what is illusion. The Dao Dejing (fourth century BCE) (Wikipedia contributors 2023d) evolved from the Yijing (1045 BCE) (Wikipedia contributors 2023e) and was clearly aware that the whole is

1 See https://www.etui.org/sites/default/files/2023-01/Social policy in the European Union-state of play 2022-Policy making in a permacrisis-2023.pdf.

changing and that we simply need to comprehend the Way (Dao) or "process of change" to learn how to act. You either go with the flow or go against the tide, whereas many would prefer to just not do anything.

Having identified that change (Yi) is the essence of life and that there are three essential elements of change—no change, constant change, and our perception of change (reductionist or expansionist/complexifying)—the Yi Jing and Dao Dejing form the basic foundations of the Chinese worldview. The Confucian synthesis of classical approaches of the Dao, Yijing, Legalist, and other schools became mainstream thinking in China after the Han Dynasty (202 BCE–220 CE) until the arrival of Buddhist thinking from India that flowered in the Tang Dynasty (618–907 CE). In the twentieth century, after a century of humiliation by unequal treaties, the fall of the Qing Dynasty (1636–1912) brought in two new schools of thinking—capitalism and communism. Both contended for power until the Chinese Revolution of 1949, when China became communist.

The success of the post-1978 reforms in China showed that the Chinese Communist Party had learned and adapted to realistic Chinese rural conditions and then opened up to Western science, technology, and capitalist markets in order to reform the domestic system systematically. The Chinese have yet to codify lessons from their system reform into something that would resemble a Washington Consensus, in which neoliberals in the Bretton Woods institutions (the World Bank and the International Monetary Fund) drew up a template of policies and market institutions by which emerging and developing economies (EMDEs) could advance into free market, advanced income, and developed economies (Wikipedia contributors 2023c). The Washington Consensus could not pass the Asian financial crisis test of 1997–98, and it was buried with the global financial crisis of 2007–8.

What are the lessons to be drawn from the inability of the existing economic orthodoxy of free markets and democratic ideals to predict political, economic, and financial crises? One possible explanation is that the basic principles and assumptions behind neoliberal economic theory were incomplete. Many EMDEs had neither the historical experience nor the human talent and institutions, laws, and market rules to enable them to climb out of their low-income or middle-income traps. We need to go back to the Polanyi critique of the Friedrich Hayek (1899–1992) / Milton Friedman (1912–2006) neoliberal market economic approach of the 1940s. In his classic *The Great Transformation* (1944), Karl Polanyi (1886–1944) saw that markets are part of the economic system, which is embedded in a larger social system, which then is embedded in a planetary system. For free markets to explain economy and social change, let alone the impact of ecology, would be too reductionist, simplistic, and incomplete.

Since the 2008 global financial crisis and the increasingly obvious effects of climate change, the world has struggled with how to overcome problems of increasing complexity, in which mainstream thinking appeared inadequate to explain or to offer change solutions. Since 2016, with the arrival of Brexit and the election of populist leaders such as Donald Trump, there has been awareness that the world is shifting out of the unipolar order to a multipolar world in which everything has become more complex. The outbreak of the COVID-19 pandemic in 2020 and the 2022 Ukraine war, plus increasing geopolitical tension between the great powers, showed that we need a systems thinking approach to how to deal with very complex system failures.

We can illustrate how a modern, advanced, and rich community, such as the European Union, is coping with such complex change. Historically, the European Union was a social institutional response to the tragic history of world wars fought largely in twentieth-century Europe. Western European nations sought to build an institutional framework for a rule-of-law-based security arrangement and democratic prosperity. Although Western Europe successfully developed manufacturing and also social democratic politics, gyrations in European currencies led these nations to create the euro and the eurozone to reinforce the Common Market, as well as common capital markets and legal institutions that would eventualize political integration. The weakness of the existing system was that defense and security were largely outsourced to the United States and the North Atlantic Treaty Organization (NATO). Although the Ukraine invasion by Russia created greater unity in response, the war disrupted many of Europe's social policies, which are still works in progress.

Europe and the world face multiple global-scale crises: pandemic, inflation, debt, climate warming with intensity of natural disasters, technology disruption, social inequities, and geopolitical tensions that erupted in war, all happening together or in rapid sequence. The Ukraine war will not end soon, while demands on the budget grow by the day. Even though Europe is a rich and advanced region with very sophisticated institutions, these are being strained by growing bureaucratization, pulls between national interests that conflict with European interests, and divisive plus fragmented politics that seem driven by extremist or fundamentalist factions.

The European Union's own evaluation of how the Ukraine war disrupted its social policy toward better integration showed that more of the same policies cannot work (Vanhercke, Sabato, and Spasova 2023). There is a pile of health, pension, social security, migrant, education, gender, and national security/defense issues, on top of aging demographics and very different interests pulling in different directions. Instead of reforms that appear "too little, too late," the European Union may be trying "too much, too soon," with results that are clearly getting negative or unsatisfactory outcomes. Complex problems may not be solved by adding more complexity.

The war in Ukraine has increased the urgency to reform the European Union, but from a systems thinking perspective, it would be difficult to reform piecemeal without making very fundamental structural reforms. If a rich and advanced region like Europe with the best and brightest of experts and mature rule-of-law institutions has difficulty solving its own problems (illusion of control), what hope is there for poorer and less advanced EMDEs?

Order of importance	Leverage Point	Comment
12	Numbers, constants, and parameters such as subsidies, taxes, standards	Changing parameters—e.g., increase taxes and cut spending—can address deficits
11	Buffers—the sizes of stabilizing stocks relative to their flows	Having buffers can cushion shocks
10	Stocks-and-flow structures—physical systems and their nodes of intersection	Proper design makes a difference
9	Delays—the lengths of time relative to the rates of system changes	Delays in feedback loops are critical determinants of system behavior
8	Balancing feedback loops—the strength of the feedbacks relative to the impacts they are trying to correct	Looking at information and controlling parts of system
7	Reinforcing feedback loops—the strength of the gain of driving loops	A balancing feedback loop is self-correcting; a reinforcing feedback loop is self-reinforcing
6	Information flows—the structure of who does and does not have access to information	Accountability
5	Rules—incentives, punishments, constraints	Power over rules is real power
4	Self-organization—the power to add, change, or evolve system structure	Empowering the system to reorganize itself to adapt or create
3	Goals—the purpose or function of the system	Changing the goals is a superior leverage point
2	Paradigms—the mindset out of which the system (its goals, structure, rules, delays, parameters) rises	The shared ideas of the minds of society
1	Transcending paradigms	Let go into enlightenment or the magic that transforms behavior

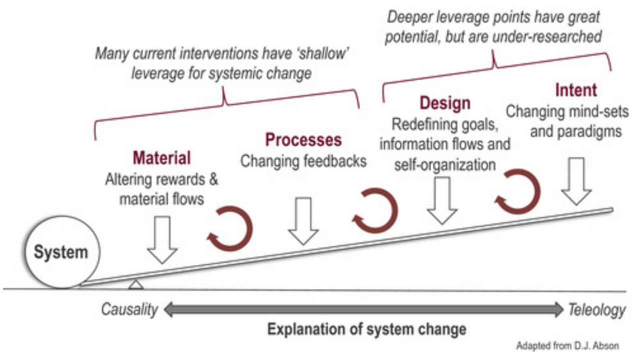

Figure 1.

Where do you begin reforms, and how do you know that such reforms would be effective? Donella Meadows famously identified what she called twelve leverage points, meaning places in the system where a small change could lead to a large shift in behavior. Leverage points were first identified by MIT systems dynamics professor Jay Forrester (1918–2016), Meadows's mentor. Meadows pointed out that although people intuitively identify leverage points, they often adopt policies that go in the wrong direction. For example, reformers often think that growth is the only solution, whereas fewer of something (e.g., cars) may turn out to be better for the system as a whole.

Recently, Abson et al. (2017) summarized these twelve leverage points into four categories of "shallow" leverage material and processes, as well as "deeper" leverage of design and intent (figure 1).

As Hayek (Bowles, Kirman, and Sethi 2017) observed astutely, market systems have self-order or self-organizing powers, adapting to the environment, that may be more efficient than state order, but he ignored the possibility that they may be prone to crashes. Hayek disliked state intervention, because that would give power eventually to totalitarianism. The interplay between markets and state power suggested to imperial historians that empires go through cycles of centralization of power (integration) and decentralization through collapse (disintegration). Out of the collapse of the Roman Empire came the rise of Christianity—a nonstate power, not necessarily another empire. Out of the centralization and unification of China came total collapse and yet another reunification, sometimes through foreign invasion. It was never possible to predict where the sources of change would come from.

System changes that come from feedback loops are essentially reflexive. When one feedback loop goes in one direction, and you identify that it may be the cause of excess or imbalance, then less rather than more may be the solution. In a situation of excessive order, disorder may win; in a situation of excessive disorder, order may win. We cannot generalize for all systems.

What lessons can we draw from Meadows's work? The answer is that there is no one-size-fits-all solution for every single complex system. The leverage points for individual GOCS are different for each and every one, which is exactly why Chinese traditional medicine treats patients based on their individual diagnosis (Kaptchuk 2000), differentiating between time and geography (location). Western medicine is applied generically, as prognosis in terms of medicine or surgery is uniform in approach as long as the diagnosis as to cause is identified.

3. THINK SYSTEMICALLY, ACT LOCALLY

The discussion so far seems to suggest that closed systems may be more amenable to control, whereas open systems are much more difficult to control. This implies that we always need a reflexive diagnosis of whatever system we are studying. The Chinese approach accepts self-reflection (know yourself before you know your enemy) as a first step toward diagnosis. The Dao approach looks for time, space, and human unity 【天时，地理，人和】 to decide what is the most appropriate way to act. The wise would seek to go with the flow or the flow of Dao, meaning that you rarely act against the forces of nature or human forces acting against you. The person who does that can achieve *wuwei*, the art of effortless action, or doing less to allow forces of nature to act for you. In complex situations where much is unknown, it is sometimes preferable to allow the situation to unfold by itself, rather than acting in haste. Yet, at the right time, when conditions seem to shift in a clear direction, intervention would achieve much with little effort—namely, hitting the right leverage point.

Self-reflection would enable the "actor" to determine his power reach—or his power network through which he can act on events. An individual can only influence at most his or her proximate network, such as family or colleagues. The president of the United States, however, is able to influence global events because of greater power, but this is mostly exercised indirectly through his command in the White House, and thus his action is limited to directing or influencing his circle of immediate subordinates or peers, through whom he can then influence areas beyond Washington, DC. Thus, "think systemically, act locally" means that with a holistic and system-wide perspective, human agency at the practical level should focus on "local" or proximate leverage points.

We can illustrate this point through examining human agency in climate change. Climate change involves massive systems change from individuals to communities and the planetary level. One of the frustrations with climate change is that individual and collective perceptions of the threat of climate change are uneven, since different people in different climates and geography will have different experiences of the level of threat. There is also a further feeling that individuals cannot do much and therefore we should leave complex decisions to governments to handle. Unfortunately, because of short-term electoral cycles, governments tend to avoid the tough action needed and to tackle those that give "easy wins," or low-hanging fruit.

Those who feel that markets or business should be involved are also disappointed because profit-driven interests prefer to maintain the status quo. Furthermore, there is increasing concentration of power and resources, especially in a situation whereby costs (and externalities) are not fully recognized in terms of pollution, loss of biodiversity, and loss of irreplaceable minerals, let alone impact on human health and livelihood.

Meadows was clear that the most powerful leverage points lie in changing the paradigm, but that changes very slowly. The world today is very different from the classical world. The Greek conqueror Alexander the Great made a huge impact in extending Greek influence as far away as India. At its height, the Roman Empire ruled over seventy million people but had a large ecological footprint because of massive deforestation for wood (firewood and shipbuilding) and mining for arms (Harper 2017). Today, the world has a population of eight billion, and the one billion in the rich West are struggling to persuade the seven billion in the rest of the world that we should work together on climate change.

We live in an illusion of control, because even small things, like cheap weather balloons, can be thought of as spy balloons, which then can escalate geopolitical tensions to the next nuclear war. Illusions of control and insecurity combined can lead to mutually assured destruction.

The rule of thumb "think systemically, act locally" is a practical way to let every individual, community, corporation, or state think and act where they can on their own identified leverage points. If living complex systems are self-regulating, then individual loss of control might not mean that the system will be totally out of control.

Dennis Meadows, when asked about the future of climate change, said he was optimistic about the planet, because it will go on for another billion years even if the human species or a large chunk of living species are wiped out (Rachel Carson Center 2013). Measured in decades, paradigms will disappear because they become obsolete, and if no transcendent paradigm appears to mobilize collective human action to avert climate disaster, then human beings may be reduced to just another animal competing for survival.

4. CONCLUSION

We should have few illusions about our illusions of control. We control properly neither our planetary or human systems nor our own illusions and delusions. Interconnected consciousness interacts with interconnected physical reality in ways we do not yet fully understand. Classical science gave man hope that he was destined to control his environment. Quantum science and the system view of life are not so sure. It is good to be in doubt, and through doubt and the search for truth, we may accept that we cannot control our fate fully, but we can share, care, and work toward, where we can, the betterment of the world we live in.

COMPETING INTERESTS

The author has nothing to declare.

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