TOWARD A SCIENCE AND ART OF WHOLENESS

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We are held in the sweet embrace of a universe that is fundamentally alive, creative, and self-organizing. Wholeness, whether in science or art, begins with what is most salient in our creaturely experience: the emergence of coherent structure, rather than its dissipation into the featureless noise of thermal equilibrium. Further, this structure emerges effortlessly from a web of simple local relationships, self-organizing into exquisitely complex and beautiful types of dynamic, organic order. Wholeness is grounded in that which is fundamentally conducive to life. A science and art of wholeness therefore reconnects us with all that nurtures and sustains life; with the playful and creative dimensions of life; and with the cycles of growth and decay intrinsic to life.

The physicist Lee Smolin, in *The Life of the Cosmos*, presents the breathtaking hypothesis that the universe, from its earliest moments, has had the capacity for coherent self-organization at all levels of scale. From the beginning, the universe has systematically cascaded cycles of energy, matter, and information from its entire being down to its finest geometry, where space-time becomes a fluctuating web of quantum relationships. His definition of a *self-organized, non-equilibrium system* then becomes fundamental to understanding the structure, evolution, and dynamic wholeness of the universe:

1. A distinguishable collection (system) of matter with recognizable boundaries (e.g., cell);
2. That has a flow of energy and matter passing through it (e.g., nutrients in, wastes out);
3. Allowing it to hold a stable configuration over long time periods relative to its internal rhythms (e.g., a cellular lifespan of years versus metabolic processes measured in seconds);
4. Maintained by the action of cycles transporting matter and energy both within the system and between the system and its exterior (e.g., respiration);
5. And stabilized against small perturbations by the existence of feedback loops that regulate the cycles (e.g., metabolic response to heat or cold).[1]

In this view, self-organized, non-equilibrium systems—cells, organisms, the biosphere, stars, galaxies—are the fundamental patterns of a living universe rather than odd exceptions. The new science of complexity addresses such systems across disciplines and scales, foregrounding fractal geometries (with symmetries based on repeated features at multiple levels of scales); non-linear dynamics (unpredictable over long periods but richly patterned); emergent behavior (large-scale coherence from simple interactions); resilience (inherent ability to resist perturbation); networks (of relationships); and thresholds (dramatic transformations when perturbations are too large).

None of this contradicts the second law of thermodynamics, which can be understood to mean that the amount of *useful work* available in any *closed* system decreases over time, or equivalently that the *entropy* of the system must increase. Self-organized, non-equilibrium systems are inherently open systems, exchanging energy and matter to feed coherent structure even as the overall entropy of the open system plus its surroundings increases. If "there is no time at which the universe will come to equilibrium, then it might be useful to view it permanently as a self-organized non-equilibrium system. We might then want to say that … the universe, by being itself a non-equilibrium system, creates through its own processes of self-organization conditions that are hospitable to the evolution of life."[2] Self-organizing processes support cyclical flows of energy and matter that are constantly renewing and rebirthing, held within the nurturing context of cycles at a larger scale, and in turn nurturing myriad flows at a smaller scale.

What is a living system? We need to add two additional characteristics to self-organized, non-equilibrium systems: adaptive goal-seeking governed by a stable internal code (e.g., DNA) and the ability to reproduce. The biologist Mae-Wan Ho observes "ubiquitous cycling as the means for structuring at every level of living organization, and the coupling of all the cyclic

processes … from the ecological cycle of the biosphere to the biochemical metabolic cycles in organisms down to the whirring of molecular machines, all meticulously choreographed … to spin and turn at different rates, each in step with the whole."[3]

A science of wholeness attends to growth, adaptation, transformation, emergence, and evolution at all scales, in biological and human systems, but also more broadly in cosmology, physics, and chemistry. The mathematical theories of symmetry and symmetry breaking, of non-equilibrium systems, and of self-organization and emergence provide a broad framework for inquiry. Morphogenesis—the birth of new form and structure through a coherent process of growth—becomes the natural history of self-organizing processes.

According to the Santiago Theory of Cognition originated by Humberto Maturana and Francisco Varela, living systems are cognitive systems, and living is a process of cognition. Within a science of wholeness, life, cognition, and compassion are primary and emerge from a coherent story that ultimately connects the human to the other ten to fifty million species on the planet; the current "ecozoic" era to almost four billion years of evolution in the biosphere; Earth to the Milky Way galaxy; and our magnificent spiral galaxy to the earliest evolution of gravitational perturbations in the universe. This "Universe Story" has been beautifully told by the geologian Thomas Berry and the astrophysicist Brian Swimme, who turn the scientific story of the emergence and evolution of the universe into a dramatic epic within which our individual lives assume profound narrative roles: "The universe began in a concentration of energy and at each instant has re-created itself new. The seemingly infinite power for transfiguration in every region of the universe speaks of an inexhaustible fecundity at the root of reality. When we examine the entire display we find, pervasive with being, an insistence to create anew."[4]

Our task, according to the great poet of the Big Sur country in California, Robinson Jeffers, is to "fall in love outwards." Our cells tingle with the knowledge of this kinship with all life, and with knowledge of the greater circle of being, the nested self-organizing systems that ultimately nourish this life. This is the ground of a science that is conducive to life, not "neutral," and certainly not in the active service of the destruction of living systems.

A science and art of wholeness is inherently reverent, revelatory, and participatory, attuned to the subjectivity, interiority, spirit, and consciousness of every piece of space-time. If the universe is a recursion of networks of relations, there is no coherent place to cut the web and remove the observer. The ecophilosopher David Abram beautifully evokes this shared net of being: "Gradually then, our senses awake to the world. We become aware of the thoughts that are thinking all around us—in the bushes, under the tumbled stones. As we watch the crows, our own limbs begin to feel the intelligence of feathered muscles adjusting to the wind. Our toes listen to roots sending capillaries in search of water, and our skin replies to the lichens radiating in slow waves across the surface of the upthrust bones of the hill."[5]

This has important implications for the ethics of experimentation. Surely we cannot abstract living processes from their inherent habitats without doing violence to them and corroding the value of the knowledge so produced. A participatory science might draw its outlines from the profound empathy of Jane Goodall for the chimpanzees of Gombe, or from Goethe's precise phenomenological account of the origin of colors and "'the deeds and sufferings of light,' a poetic expression which is as precise in the science of quality as any mathematical expression in the science of quality."[6]

What is the research agenda for a science of wholeness? The biosphere, known as Gaia in its manifestation as a self-organizing system linking scales from cells to continents, is approaching catastrophic transformation. Greenhouse gas emissions are driving an increase in global mean temperature toward two degrees Celsius above its baseline level, at which point a highly destructive and difficult to predict climatic regime will emerge. Biodiversity is being lost at a devastating rate, and ecosystem health is in decline in most regions. Cultural and linguistic diversities are eroding, social inequity is increasing, and economic systems are relentlessly concentrating wealth and power.

We need to seek out what will truly sustain both human and more-than-human communities. A science *and* art of wholeness would address the fundamental preconditions for planetary health in a

way that could liberate the human capacity for beauty, joy, and compassion. It would anchor nested ecological design disciplines from the molecular to continental scales that could focus on ending net greenhouse gas emissions, eliminating toxicity, restoring biocultural diversity and ecosystem health, and enhancing social equity. For these ecological design disciplines, "nature is a matrix *within which* designs find an identity and a coherence that contribute to the health of the whole. Ecological designs are articulated within an ecosystem or bioregion in the way that veins are articulated within a leaf. They fill out an existing structure in a way that enhances the life, the flows, the processes within it."[7]

Things, buildings, or places that are conducive to life in the largest context should also make us feel more alive when we are around them, moved by their beauty and adaptation to the greater wholes they support. Otherwise, there is some danger that attempts merely to meet a list of technical constraints—ultimately doomed to failure—will be made mechanically, without the depth of feeling and simple sense of fitting life that ultimately sustain our spirits.

Now imagine the process of morphogenesis—the exquisite development of the human embryo; the delicate gravitational choreography of a spiral galaxy; the undifferentiated *meristem* cells at the tip of a plant, bursting into new growth in the spring sunshine—at play in all that we build and make. Imagine a home—or a city, or a bioregion—healing itself, growing more alive and beautiful, adapting, fitting itself more gracefully with its surroundings, and weaving itself back into ecosystems. This is the vision of Christopher Alexander, one of the foremost architectural theorists and designers of recent decades. In order to achieve this,

> *we must explicitly embrace a way of thinking of the world of as a fountain of rebirth in which atoms, molecules, trees and hedges, living creatures, we ourselves … are continuously reborn in new form, but also a fountain in which the stream of birth and growth, vital in its health, is never-ending. And what is this fountain? It is morphogenesis. It is the process which again and again takes the structure that exists, and turns it, in the very next moment, into a deeper structure which preserves the deep whole that exists. This continuous renewal and above all the morphogenesis itself, reflects and IS the source of the renewal and sustenance.*[8]

The universe is filled with nested domains of dynamic wholeness that are continuously generated and renewed by coherent morphogenetic processes. The Hai Shan Clinic was designed as a residence and clinic for Dr. Heiner Fruehauf, a gifted scholar and practitioner of both traditional Chinese medicine and naturopathy, using these processes. The building was designed by architect David Yarbrough working in collaboration with ecological designer Kathryn Langstaff. The structure sought to capture sacred geometry and harmony with living systems by employing non-toxic, local, and energy-efficient materials and systems including *leichtlehmbau* (a mixture of clay and natural fibers), traditional plasters, and timber frame construction. The fiber and clay walls are living walls, maintaining comfortable humidity and temperature levels while sequestering toxins.

Architects are now designing "Living Buildings" able to harvest their own energy and water and treat their own wastes; planners are designing cities with no greenhouse gas impacts; green chemists are designing out toxicity; and industrial designers are using "biomimicry" to emulate the extraordinary properties of spiders' silk, mussels' glue, and plants' photosynthetic components. All of this points to a vast process of repair and regeneration, linking scales and cultures, ensuring the possibility of graceful reinhabitation.

Artists are also finding meaningful ways to engage living systems. The site artist Andy Goldsworthy works with the materials he finds in fields, forests, rivers, ice fields, and many other habitats, sculpting gorgeous ephemeral works. He states, "When I'm working with material, it's not just the leaf or the stone … I'm trying to understand, not a single isolated object, but nature as a whole—how the leaf has grown, how it has changed, how it has decayed, how the weather's affected it. By working with a leaf in its place I begin to understand these processes."[9] This reflects a nuanced understanding of dynamic wholeness.

Artists are now collaborating with ecologists, landscape architects, planners, and many others to help generate a sense of place, cultural connectivity, and wholeness. Betsy Damon runs Keepers of the Water, a non-profit organization geared to water-oriented collaborations between

artists, scientists, and communities. She designed *The Living Water Garden* in Chengdu, China, a six-acre multipurpose park that purifies river water, provides recreation, and interprets local ecosystems. Patricia Johanson creates site installations that restore habitat while providing intimate access to ecosystems. Her piece *Endangered Garden* provides a half-mile-long bay walk anchoring butterfly habitats, bird baths, tide pools, and marshes within one of San Francisco's wastewater treatment facilities.

A science and art of wholeness must ultimately be enabled by a practical economics of wholeness based on living systems and the integrity of each person, family, community, and ecosystem rather than on thermodynamics, distant markets, and abstract agents. In December 2008, I had the opportunity to visit Christopher Alexander. At that time, shortly after the collapse of storied investment bank Lehman Brothers, global capital had suddenly stopped moving. There was a strange stillness, eerie and terrifying in some ways. Some of us began to imagine a world where capital as we know it didn't exist. Sitting at the kitchen table as dawn broke in the deep old county of Sussex, surrounded by ancient lanes and hedgerows, Alexander reminded me that "you can't create wholeness unless it's the sole aim." Wholeness can't be a minor outcome of a fundamentally disassociative, speculative economic process. It must be the goal, driving all the practical aspects of creating a building or place.

There are many promising directions for the reinvention of economics, which is halfway between a science and an art. Social scientist Riane Eisler offers a "caring economics" grounded in nurturing and partnership; Richard Norgaard a "coevolutionary economics" tied to complex evolutionary dynamics; Robert Costanza an "ecological economics" aligned with ecological restoration; and Mark Anielski an "economics of happiness."[10] Economic theories devoted to the restoration and renewal of wholeness would build on this work and provide a viable pathway for transforming dead capital tied to the destruction of communities and ecosystems into *living capital* supportive of living systems. They could make technical corrections that properly value the work of family members, communities, and ecosystems (human capital, social capital, natural capital); put a price on externalities (damages to the commons); place limitations on financial speculation; and rebuild non-monetary spaces for exchanges that are cornerstones of economic democracy.

The physicist and activist Vandanda Shiva suggests that "We consider the evolutionary potential of all life on earth and re-embed human welfare in our home, our community, and the earth family. Ecological security is our most basic security; ecological identities are our most fundamental identity. We are the food we eat, the water we drink, the air we breathe."[11] In this time of darkness, as we lose species and languages daily, as we teeter on the edge of climatic collapse, we must remember that our very human capacity for beauty and wholeness remains intact and binds us to the most fundamental processes of the universe. Let us find the courage to renew and restore that which is most precious. □

NOTES

1. Lee Smolin, *The Life of the Cosmos* (Oxford: Oxford University Press, 1997), 155.
2. Ibid., 157.
3. Mae-Wan Ho, *The Rainbow and the Worm*, 2nd ed. (Singapore: World Scientific Publishing, 1998), 52.
4. Thomas Berry and Brian Swimme, *The Universe Story: From the Primordial Flaring Forth to the Ecozoic Era—A Celebration of the Unfolding of the Cosmos* (New York: HarperCollins, 1992), 74.
5. David Abram, *The Spell of the Sensuous: Perception and Language in a More-Than-Human World* (New York: Pantheon Books, 1996), 274.
6. Henri Bortoft, *The Wholeness of Nature: Goethe's Way toward a Science of Conscious Participation in Nature* (New York: Lindisfarne Press, 1996), 46.
7. Sim Van der Ryn and Stuart Cowan, *Ecological Design: Tenth Anniversary Edition* (Washington, DC: Island Press, 2007), 127.
8. Christopher Alexander, "Sustainability and Morphogenesis: The Rebirth of a Living World." *The Structurist* No 47/48 (2007/2008): 19.
9. Andy Goldsworthy, quoted in Suzi Gablik, *The Reenchantment of Art* (New York: Thames and Hudson, 1991), 91.
10. Riane Eisler, *The Real Wealth of Nations: Creating a Caring Economics* (San Francisco: Berrett-Koehler, 2007). Richard Norgaard, *Development Betrayed: The End of Progress and a Co-Evolutionary Revisioning of the Future* (London: Routledge, 1994). Robert Costanza, *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1992). Mark Anielski, *The Economics of Happiness: Building Genuine Wealth* (Gabriola Island, BC: New Society Publishers, 2007).
11. Vandana Shiva, *Earth Democracy: Justice, Sustainability, and Peace* (Cambridge, MA: South End Press, 2005), 5.