Cosmos and History: The Journal of Natural and Social Philosophy, vol. 11, no. 2, 2015

THE SYSTEMS VIEW OF LIFE
A UNIFYING CONCEPTION OF MIND, MATTER, AND LIFE

Fritjof Capra

ABSTRACT: Over the last thirty years, a new systemic understanding of life has emerged at the forefront of science. It integrates four dimensions of life: the biological, the cognitive, the social, and the ecological dimension. At the core of this new understanding we find a fundamental change of metaphors: from seeing the world as a machine to understanding it as a network. One of the most radical philosophical implications of the systems view of life is a new conception of mind and consciousness which, for the first time, overcomes the Cartesian division between mind and matter.

KEYWORDS: Systems view of life; Systemic thinking; Living networks; Autopoiesis; Cognition; Santiago theory; Consciousness; Prebiotic evolution

I was trained as a physicist and spent twenty years doing research in theoretical high-energy physics. I left physics in the mid-eighties and turned toward the life sciences, where a new conception of life has emerged during the last thirty years. It represents a change of paradigms from the mechanistic to the systemic view of life. This is what I'd like to talk about today.

A NEW CONCEPTION OF LIFE

At the very heart of this change we find a fundamental change of metaphors: from seeing the world as a machine to understanding it as a network. The entire material world, ultimately, is a network of inseparable patterns of relationships. We have also discovered that the planet as a whole is a living, self-regulating system. The view of the human body as a machine and of the mind as a separate entity is being replaced by one that sees not only the brain, but also the immune system, the bodily organs, and even each cell as a living, cognitive system. Evolution is no longer seen as a competitive struggle for existence, but rather as a cooperative dance in which creativity and the constant emergence of novelty are the driving forces. And with the new emphasis on complexity, nonlinearity, and patterns of organization, a new science of qualities is slowly emerging.

The strong interest in nonlinear phenomena generated a whole series of new and powerful theories that have dramatically increased our understanding of many key characteristics of life. During the last thirty years, I have been working on a synthesis of these theories; and to do so, I developed a conceptual framework that integrates four dimensions of life: the biological, the cognitive, the social, and the ecological dimension. I presented summaries of this framework, as it evolved, in two books: *The Web of Life* (1996) and *The Hidden Connections* (2002).

My final synthesis was published last year in a textbook by Cambridge University Press, titled *The Systems View of Life* and coauthored by Pier Luigi Luisi, professor of biochemistry in Rome. I call my synthesis "the systems view of life" because it requires systemic thinking — thinking in terms of relationships, patterns, and context.

NETWORKS AND FLOWS

To summarize the new systemic understanding of life, let me begin with biology and ask the age-old question: what is life? In other words, what is the essential difference between, say, a rock and a plant? When you ask biologists that question, they might say: a plant is made of cells, but there are no cells in a rock; or they might just zero in on DNA and say: a living organism is a biochemical system that contains DNA. It sounds simple: if it contains DNA it's alive, if it doesn't contain DNA, it's not alive.

But there is a catch: dead organisms also contain DNA, because the DNA does not disappear when an organism dies. So, to understand the essential nature of life, it is not enough to understand molecular structures. The difference between a living and a dead organism lies in the basic process of life — in what sages and poets throughout the ages have called the "breath of life." In modern scientific language, this process of life is called "metabolism." It is the ceaseless flow of energy and matter through a network of chemical reactions, which enables a living organism to continually generate, repair, and perpetuate itself.

The understanding of metabolism includes two basic aspects. One is the continuous flow of energy and matter. All living systems need energy and food to sustain themselves; and all living systems produce waste. That's part of metabolism. But life has evolved in such a way that organisms form communities, the ecosystems, in which the waste of one species is food for the next, so that matter cycles continually through the ecosystem.

The second aspect of metabolism is the network of chemical reactions that processes the food, and forms the biochemical basis of all biological structures, functions, and behavior. The emphasis here is on "network." One of the most important insights of the systems view of life is the recognition that networks are the basic pattern of organization of all living systems. Ecosystems are understood in terms of food webs (i.e., networks of organisms); organism are networks of cells; cells are networks of molecules; and then social networks are networks of communications. The network is a pattern that is common to all life. Wherever we see life, we see networks.

So, we have these two levels of description: the description in terms of networks and the description in terms of flows. They involve different languages. Flows are described in the language of physics and chemistry, networks in the language of topology. My synthesis, essentially, is a synthesis between these two perspectives: networks and flows. Let me begin with networks.

LIVING NETWORKS

Detailed examination of these living networks has shown that their key characteristic is that they are *self-generating*. Technically, this is known as the theory of autopoiesis, developed in the 1970s and 1980s by Humberto Maturana and Francisco Varela. *Autopoiesis* means "self-making." In a cell, for example, all the biological structures — the proteins, the DNA, the cell membrane, etc. — are continually produced, repaired, and regenerated by the cellular network. Similarly, at the level of a multicellular organism, the bodily cells are continually regenerated and recycled by the organism's metabolic network. Living networks continually create, or recreate themselves by transforming or replacing their components. In this way they undergo continual structural changes while preserving their web-like patterns of organization.

This coexistence of stability and change is indeed one of the key characteristics of life.

THE NATURE OF MIND

I want to emphasize that the theory of autopoiesis defines biological life as a particular pattern of organization — a self-generating network within a boundary of its own making. It does not specify the physical structures in which the network is embodied. When we study these structures, e.g. in a cell, we notice that they are continually being produced and regenerated, as I have mentioned. In other words, the embodiment of the pattern of organization in particular structures is a continual process of embodiment.

This is the key of my synthesis. I define the perspectives of pattern, structure, and process as three fundamental perspectives on biological life. And the process perspective leads to what is perhaps the most important philosophical implication of the systems view of life. The process of life — i.e. the dynamics of the self-generation and self-perpetuation of living networks — is identified with cognition, or with mind.

This is a radically new conception of mind, which finally overcomes the Cartesian division between mind and matter. In the seventeenth century, René Descartes based his view of nature on the fundamental division between two independent and separate realms — that of mind, the "thinking thing" (*res cogitans*), and that of matter, the "extended thing" (*res extensa*).

Following Descartes, scientists and philosophers continued to think of the mind as an intangible entity and were unable to imagine how this "thinking thing" is related to the body. The decisive advance of the systems view of life has been to abandon the Cartesian view of mind as a thing, and to realize that mind is not a thing but a process.

This novel concept of mind was developed during the 1960s by Gregory Bateson, and independently by Humberto Maturana, and then by Maturana and Francisco Varela. It is known today as the Santiago theory of cognition. During the past three decades, the study of mind from this systemic perspective has blossomed into a rich interdisciplinary field, known as cognitive science, which transcends the traditional frameworks of biology, psychology, and epistemology.

The central insight of the Santiago theory is the identification of cognition, the process of knowing, with the process of life. The interactions of a living organism — plant, animal, or human — with its environment are cognitive interactions. Thus life and cognition are inseparably connected. Mind — or, more accurately, mental activity — is immanent in matter at all levels of life.

This is a radical expansion of the concept of cognition and, implicitly, the concept of mind. In this new view, cognition involves the entire process of life — including perception, emotion, and behavior — and does not even necessarily require a brain and a nervous system.

The conceptual advance of the Santiago theory is best appreciated by revisiting the thorny question of the relationship between mind and brain. In the Santiago theory, this relationship is simple and clear. Mind is not a thing but a process — the process of cognition, which is identified with the process of life. The brain is a specific structure through which this process operates. The relationship between mind and brain, therefore, is one between process and structure. Moreover, the brain is not the only structure through which the process of cognition operates. The entire structure of the organism participates in the process of cognition, whether or not the organism has a brain and a higher nervous system.

The Santiago theory of cognition, in my view, is the first scientific theory that overcomes the Cartesian division of mind and matter. Mind and matter no longer appear to belong to two separate categories, but can be seen as representing two complementary aspects of the phenomenon of life — process and structure. At all levels of life, mind and matter, process and structure, are inseparably connected.

CONSCIOUSNESS

Now let me say a few words about consciousness. Cognition, as understood in the Santiago theory, is associated with all levels of life and is thus a much broader phenomenon than consciousness. Consciousness — that is, conscious, lived experience — unfolds at certain levels of cognitive complexity that require a brain and a higher nervous system. In other words, consciousness is a special kind of cognitive process that emerges when cognition reaches a certain level of complexity. The central characteristic of this special cognitive process is self-awareness — to be aware not only of one's environment but also of oneself.

In our book, we review several recent theories of consciousness in some detail, including those of Gerald Edelman, Giulio Tononi, Francisco Varela, and Antonio Damasio. None of them really solves the so-called "hard problem" of consciousness studies — how does conscious experience emerge from neurophysiology? — but together they have taken some important steps toward a true science of consciousness.

THE SYSTEMS VIEW OF EVOLUTION

Let me now move on to what is one of the most rewarding features of the systems view of life — a new systemic understanding of evolution. Rather than seeing evolution as the result of only random mutations and natural selection, we are beginning to recognize the creative unfolding of life in forms of ever-increasing diversity and complexity as an inherent characteristic of all living systems. Although mutation and natural selection are still acknowledged as important aspects of biological evolution, the central focus is on creativity, on life's constant reaching out into novelty.

We dedicate three chapters of our book to the systems view of evolution, and we begin with an homage to Charles Darwin. At the center of Darwinian thought stands the insight that all living organisms are related by common ancestry. With this realization Darwin's conception of life was utterly holistic and systemic: a vast planetary network of living beings interlinked in space and time.

The systems view of evolution includes the Darwinian notions of chance variations and natural selection, but it also recognizes that evolution did not begin with the first living cell but millions of years earlier with a process known as molecular, or "prebiotic" evolution. The detailed ideas about this prebiotic evolution are still very speculative, but most biologists and biochemists do not doubt that the origin of life on Earth was the result of a sequence of chemical events, subject to the laws of physics and chemistry and to the nonlinear dynamics of complex systems. My coauthor, Pier Luigi Luisi is one of the leaders in this research on the origin of life, and in our book he wrote a very detailed chapter on this new and intriguing field of science.

As far as biological evolution is concerned, the classical view maintains that all evolutionary variation results from random mutations, followed by natural selection. The systems view, by contrast, recognizes three avenues of evolution: random mutations of genes, horizontal genetic transfers among bacteria (also known as "gene trading"), and finally the creation of new forms of life through acquisition of entire genomes in a process known as symbiogenesis.

All these processes are subject to the physical and chemical constraints of the organism's environment. When new genetic patterns are created, they need to be integrated into their cellular environment. This involves a complex dynamic of an entire network of chemical reactions, in which only a limited number of new forms and functions are possible — a limited number of attractors in the language of complexity theory. The entire process is far from random. Although there are random elements in the generation of new genetic patterns, from then on the process is highly ordered and complex.

According to the systems view, the expression of life's creativity in the process of evolution must be seen as an aspect of the much broader process of life, and since this process of life is closely associated with cognition, evolution is a process that is complex, highly ordered, and ultimately cognitive. It is an integral part of life's self-organization.

SOCIAL NETWORKS

So far, I have been talking about the biological and the cognitive dimensions of life. In my synthesis, I also extend the systems view of life to social systems. The key concept, once again, is the network. According to the theory of "social autopoiesis" developed by the sociologist Niklas Luhmann, living networks in human society are networks of communications. Like biological networks, they are self-generating, but what they generate is mostly nonmaterial. Each communication creates thoughts and meaning, which give rise to further communications, and thus the entire network generates itself.

As communications continue in a social network, they form multiple feedback loops which, eventually, produce a shared system of beliefs, explanations, and values — a common context of meaning, also known as culture, which is continually sustained by further communications. Through this culture individuals acquire identities as members of the social network, and in this way the network generates its own boundary.

I have found it very instructive to juxtapose biological and social networks. Biological networks operate in the realm of matter; social networks operate in the realm of meaning. Both produce material structures, and social networks also produce the nonmaterial characteristics of culture — values, rules of behavior, beliefs, knowledge, etc.

Biological systems exchange molecules in their networks of chemical reactions; social systems exchange information and ideas in their networks of communications.

Biological networks produce and sustain a material boundary, which imposes constraints on the chemistry that takes place inside it. Social networks produce and sustain a nonmaterial, cultural boundary, which imposes constraints on the behavior of its members.

SYSTEMIC PROBLEMS — SYSTEMIC SOLUTIONS

In the fourth and last part of our book, titled "Sustaining the Web of Life," we discuss the ecological dimension of life and the critical importance of the systems view for dealing with the problems of our multi-faceted global crisis. It is now becoming more and more evident that the major problems of our time — energy, environment, climate change, poverty, and so on — cannot be understood in isolation. They are systemic problems, which means that they are all interconnected and interdependent.

As Pope Francis puts it in his remarkable encyclical *Laudato Sì*:

> Our common home is falling into serious disrepair… [This is] evident in large-scale natural disasters as well as social and even financial crises, for the world's problems cannot be analyzed or explained in isolation... It cannot be emphasized enough how everything is interconnected.

Unfortunately, this realization has not yet dawned on most of our political and corporate leaders who are unable to "connect the dots," to use a popular phrase. Instead of taking into account the interconnectedness of our major problems, their so-called "solutions" tend to focus on a single issue, thereby simply shifting the problem to another part of the system — for example, by producing more energy at the expense of biodiversity, public health, or climate stability.

Moreover, our leaders refuse to recognize how their piecemeal solutions affect future generations. What we need is solutions that are systemic and sustainable. A systemic solution does not solve any problem in isolation but deals with it within the context of other related problems. In other words, while systemic problems have harmful consequences in several different areas, systemic solutions solve problems in several of those areas.

Over the last few decades, the research institutes and centers of learning of the global civil society have developed and proposed hundreds of such systemic solutions all over the world. In our textbook, we dedicate about 60 pages to detailed discussions of the most effective of these solutions. They include proposals to reshape economic globalization and restructure corporations; new forms of ownership that are not extractive but generative; a wide variety of systemic solutions to the interlinked problems of energy, food, poverty, and climate change; and finally the large number of systemic design solutions known collectively as ecodesign, which embody the basic principles of ecology.

Together these systemic solutions present compelling evidence that the systemic understanding of life has given us the knowledge and the technologies to build a sustainable future. What we need is political will and leadership.

Fritjof Capra, Ph.D., physicist and systems theorist, is a founding director of the Center for Ecoliteracy in Berkeley. Capra is the author of several international bestsellers, including *The Tao of Physics* (1975), *The Web of Life* (1996), *The Hidden Connections* (2002), *The Science of Leonardo* (2007), and *Learning from Leonardo* (2013). He is coauthor, with Pier Luigi Luisi, of the multidisciplinary textbook, *The Systems View of Life: A Unifying Vision* (Cambridge University Press, 2014).

www.fritjofcapra.net