VIEWPOINT

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THE NEW FACTS OF LIFE: CONNECTING THE DOTS ON FOOD, HEALTH, AND THE ENVIRONMENT

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This essay is adapted from a speech Fritjof Capra delivered at a professional development institute, "Linking Food, Health, and the Environment," hosted by the Center for Ecoliteracy and Teachers College Columbia University in the summer of 2008.

A discussion of the interrelations between food, health, and the environment is extremely topical today. Rising food prices together with the price of oil and a series of so-called "natural" catastrophes dominate the news every day. At the same time, there is a lot of confusion. Why are world food prices increasing so quickly and dramatically? Why is world hunger rising again after a long steady decline? What do food prices have to do with the price of oil? Why is it so important to grow food locally and organically? In this brief talk, I shall try to show that a full understanding of these issues requires a new ecological understanding of life (a new "ecological literacy") as well as a new kind of "systemic" thinking—thinking in terms of relationships, patterns, and context.

Indeed, over the last 25 years, such a new understanding of life has emerged at the forefront of science. I want to illustrate this new understanding by asking the age-old question, what is life? What's the difference between a rock and a plant, animal, or microorganism? To understand the nature of life, it is not enough to understand DNA, proteins, and the other molecular structures that are the building blocks of living organisms, because these structures also exist in dead organisms, for example, in a dead piece of wood or bone.

The difference between a living organism 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. In other words, metabolism involves the intake, digestion, and transformation of food.

Metabolism is the central characteristic of biological life. But understanding metabolism is not enough to understand life. When we study the structures, metabolic processes, and evolution of the myriads of species on the planet, we notice that the outstanding characteristic of our biosphere is that it has sustained life for billions of years. How does the Earth do that? How does nature sustain life?

Ecological Literacy

To understand how nature sustains life, we need to move from biology to ecology, because sustained life is a property of an ecosystem rather than a single organism or species. Over billions of years of evolution, the Earth's ecosystems have evolved certain principles of organization to sustain the web of life. Knowledge of these principles of organization, or principles of ecology, is what we mean by "ecological literacy."

In the coming decades, the survival of humanity will depend on our ecological literacy—our ability to understand the basic principles of ecology and to live accordingly. This means that ecoliteracy must become a critical skill for politicians, business leaders, and professionals in all spheres, and should be the most important part of education at all levels—from primary and secondary schools to colleges, universities, and the continuing education and training of professionals.

We need to teach our children, our students, and our corporate and political leaders the fundamental facts of life—that one species' waste is another species' food; that matter cycles continually through the web of life; that the energy driving the ecological cycles flows from the sun; that diversity assures resilience; that life, from its beginning more than three billion years ago, did not take over the planet by combat but by networking.

All these principles of ecology are closely interrelated. They are just different aspects of a single fundamental pattern of organization that has enabled nature to sustain life for billions of years. In a nutshell: Nature sustains life by creating and nurturing communities. No individual organism can exist in isolation. Animals depend on the photosynthesis of plants for their energy needs; plants depend on the carbon dioxide produced by animals, as well as on the nitrogen fixed by bacteria at their roots; and together plants, animals, and microorganisms regulate the entire biosphere and maintain the conditions conducive to life.

Sustainability, then, is not an individual property but a property of an

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Once we understand the principles of living systems, we can design processes of organizational change accordingly and create human organizations that mirror life's adaptability, diversity, and creativity.

entire web of relationships. It always involves a whole community. This is the profound lesson we need to learn from nature. The way to sustain life is to build and nurture community. A sustainable human community interacts with other communities—human and nonhuman—in ways that enable them to live and develop according to their nature. Sustainability does not mean that things do not change. It is a dynamic process of co-evolution rather than a static state.

Systems Thinking

The fact that ecological sustainability is a property of a web of relationships means that in order to understand it properly, in order to become ecologically literate, we need to learn how to think in terms of relationships, in terms of interconnections, patterns, context. In science, this type of thinking is known as systemic thinking or "systems thinking." It is crucial for understanding ecology, because ecology—derived from the Greek word *oikos* ("household")—is the science of relationships among the various members of the Earth Household.

Systems thinking emerged from a series of interdisciplinary dialogues among biologists, psychologists, and ecologists, in the 1920s and '30s. In all these fields, scientists realized that a living system—organism, ecosystem, or social system—is an integrated whole whose properties cannot be reduced to those of smaller parts. The "systemic" properties are properties of the whole, which none of its parts have. So, systems thinking involves a shift of perspective from the parts to the whole. The early systems thinkers coined the phrase, "The whole is more than the sum of its parts."

What exactly does this mean? In what sense is the whole more than the sum of its parts? The answer is: relationships. All the essential properties of a living system depend on the relationships among the system's components. Systems thinking means thinking in terms of relationships. Understanding life requires a shift of focus from objects to relationships.

For example, each species in an ecosystem helps to sustain the entire food web. If one species is decimated by some natural catastrophe, the ecosystem will still be resilient if there are other species that can fulfill similar functions. In other words, the stability of an ecosystem depends on its biodiversity, on the complexity of its network of relationships. This is how we can understand stability and resilience by understanding the relationships within the ecosystem.

In science, we have been told, things need to be measured and weighed. But relationships cannot be measured and weighed; relationships need to be mapped.

Understanding relationships is not easy for us, because it is something that goes counter to the traditional scientific enterprise in Western culture. In science, we have been told, things need to be measured and weighed. But relationships cannot be measured and weighed; relationships need to be mapped. So there is another shift: from measuring to mapping.

In biology, a recent dramatic example of this shift happened in the Human Genome Project. Scientists became acutely aware that, in order to understand the functioning of genes, it is not enough to know their sequence on the DNA; we need to be able to also map their mutual relationships and interactions.

Now, when you map relationships, you will find certain configurations that occur repeatedly. This is what we call a pattern. Networks, cycles, feedback loops are examples of patterns of organization that are characteristic of life. Systems thinking involves a shift of perspective from contents to patterns.

I also want to emphasize that mapping relationships and studying patterns is not a quantitative but a qualitative approach. Systems thinking implies a shift from quantity to quality. A pattern is not a list of numbers but a visual image.

The study of relationships concerns not only the relationships among the system's components, but also those between the system as a whole and surrounding larger systems. Those relationships between the system and its environment are what we mean by context.

For example, the shape of a plant, or the colors of a bird, depend on their environment—on the vegetation, climate, etc.—and also on the evolutionary history of the species, on the historical context. Systems thinking is always contextual thinking. It implies a shift from objective knowledge to contextual knowledge.

Finally, we need to understand that living form is more than a shape, more than a static configuration of components in a whole. There is a continual flow of matter through a living system, while its form is maintained; there is development, and there is evolution. The understanding of living structure is inextricably linked to the understanding of metabolic and developmental processes. So, systems thinking includes a shift of emphasis from structure to process.

All these shifts of emphasis are really just different ways of saying the same thing. Systems thinking means a shift of perception from material objects and structures to the nonmaterial processes and patterns of organization that represent the very essence of life.

Current World Problems

Once we become ecologically literate, once we understand the processes and patterns of relationships that enable ecosystems to sustain life, we will also understand the many ways in which our human civilization, especially since the Industrial Revolution, has ignored these ecological patterns and processes and has interfered with them. And we will realize that these interferences are the fundamental causes of many of our current world problems.

It is now becoming more and more evident that the major problems of our time cannot be understood in isolation. They are systemic problems, which means that they are all interconnected and interdependent. One of the most detailed and masterful documentations of the fundamental interconnectedness of world problems is the new book by Lester Brown, *Plan B*

(Norton, 2008). Brown, founder of the Worldwatch Institute, demonstrates in this book with impeccable clarity how the vicious circle of demographic pressure and poverty leads to the depletion of resources—falling water tables, wells going dry, shrinking forests, collapsing fisheries, eroding soils, grasslands turning into desert, and so on—and how this resource depletion, exacerbated by climate change, produces failing states whose governments can no longer provide security for their citizens, some of whom in sheer desperation turn to terrorism.

When you read this book, you will understand how virtually all our environmental problems are threats to our food security—falling water tables; increasing conversion of cropland to non-farm uses; more extreme climate events, such as heat waves, droughts, and floods; and, most recently, increasing diversion of grains to biofuel.

A critical factor in all this is the fact that world oil production is reaching its peak. This means that, from now on, oil production will begin to decrease worldwide, extraction of the remaining oil will be more and more costly, and hence the price of oil will continue to rise. Most affected will be the oil-intensive segments of the global economy, in particular the automobile, food, and airline industries.

The search for alternative energy sources has recently led to increased production of ethanol and other biofuels, especially in the United States, Brazil, and China. And since the fuel-value of grain is higher on the markets than its food-value, more and more grain is diverted from food to producing fuels. At the same time, the price of grain is moving up toward the oil-equivalent value. This is one of the main reasons for the recent sharp rise of food prices. Another reason, of course, is that a petrochemical, mechanized, and centralized system of agriculture is highly dependent on oil and will produce more expensive food as the price of oil increases. Indeed, industrial farming uses 10 times more energy than sustainable, organic farming.

The fact that the price of grain is now keyed to the price of oil is only possible because our global economic system has no ethical dimension. In such a system, the question, "Shall we use grain to fuel cars or to feed people?" has a clear answer. The market says, "Let's fuel the cars."

This is even more perverse in view of the fact that 20 percent of our grain harvest will supply less than 4 percent of automotive fuel. Indeed, the entire ethanol production in this country could easily be replaced by raising average fuel efficiency by 20 percent (i.e. from 21 mpg to 25 mpg), which is nothing, given the technologies available today.

The recent sharp increase in grain prices has wreaked havoc in the world's grain markets, and world hunger is now on the rise again after a long steady decline. In addition, increased fuel consumption accelerates global warming, which results in crop losses in heat waves that make crops wither, and from the loss of glaciers that feed rivers essential to irrigation. When we think systemically and understand how all these processes are interrelated, we realize that the vehicles we drive, and other consumer choices we make, have a major impact on the food supply to large populations in Asia and Africa.

All these problems, ultimately, must be seen as just different facets of one single crisis, which is largely a crisis of perception. It derives from the fact that most people in our society, and especially our political and corporate leaders, subscribe to the concepts of an outdated worldview, a perception of reality inadequate for dealing with our overpopulated, globally interconnected world.

The main message of Lester Brown's *Plan B*, is that there are solutions to the major problems of our time; some of them even simple. But they require a radical shift in our perceptions, our thinking, our values. And, indeed, we are now at the beginning of such a fundamental change of worldview, a change of paradigms as radical as the Copernican Revolution. Systems thinking and ecological literacy are two key elements of the new paradigm, and very helpful for understanding the interconnections between food, health, and the environment, but also for understanding the profound transformation that is needed globally for humanity to survive. ◘

Capra offers four lessons for the management of human organizations, based on the principles of living systems:

Lesson #1 A living social system is a self-generating network of communications. The aliveness of an organization resides in its informal networks, or communities of practice. Bringing life into human organizations means empowering their communities of practice.

Lesson #2 You can never direct a social system; you can only disturb it. A living network chooses which disturbances to notice and how to respond. A message will get through to people in a community of practice when it is meaningful to them.

Lesson #3 The creativity and adaptability of life expresses itself through the spontaneous emergence of novelty at critical points of instability. Every human organization contains both designed and emergent structures. The challenge is to find the right balance between the creativity of emergence and the stability of design.

Lesson #4 In addition to holding a clear vision, leadership involves facilitating the emergence of novelty by building and nurturing networks of communications; creating a learning culture in which questioning is encouraged and innovation is rewarded; creating a climate of trust and mutual support; and recognizing viable novelty when it emerges, while allowing the freedom to make mistakes.

Fritjof Capra is the bestselling author of *The Tao of Physics*, *The Web of Life*, and other books. A physicist best known for his work in systems thinking, Capra is also cofounder and chair of the board of the Center for Ecoliteracy.