



# From *The Web of Life*

Fritjof Capra

In the epilogue to *The Web of Life*, Fritjof Capra brings together a range of scientific theories to help readers develop a better understanding of ecological thinking. Capra defines the concept of ecological literacy and the ways in which human societies must become more ecologically literate to survive. As you read this selection, think not only about the dynamics between human society and ecosystems that Capra sets up, but consider also the language he uses to describe these uniquely linked systems.

## JOURNAL ASSIGNMENT

Before reading Capra's essay here, take a few minutes to write in your journal what you believe *ecological literacy* to be. How does one become ecologically literate? What does the term mean? Are you ecologically literate, and if so, in what ways?



Reconnecting with the web of life means building and nurturing sustainable communities in which we can satisfy our needs and aspirations without diminishing the chances of future generations. For this task we can learn valuable lessons from the study of ecosystems, which are sustainable communities of plants, animals, and microorganisms. To understand these lessons, we need to learn the basic principles of ecology. We need to become, as it were, ecologically literate. Being ecologically literate, or "ecoliterate," means understanding the principles of organization of ecological communities (ecosystems) and using those principles for creating sustainable human communities. We need to revitalize our communities—including our educational communities, business communities, and political communities—so that the principles of ecology become manifest in them as principles of education, management, and politics.

The theory of living systems discussed in *The Web of Life* provides a conceptual framework for the link between ecological communities and human

What?  
?

communities. Both are living systems that exhibit the same basic principles of organization. They are networks that are organizationally closed, but open to the flows of energy and resources; their structures are determined by their histories of structural changes; they are intelligent because of the cognitive dimensions inherent in the processes of life.

Of course, there are many differences between ecosystems and human communities. There is no self-awareness in ecosystems, no language, no consciousness, and no culture; and therefore no justice or democracy; but also no greed or dishonesty. We cannot learn anything about those human values and shortcomings from ecosystems. But what we can learn and must learn from them is how to live sustainably. During more than three billion years of evolution the planet's ecosystems have organized themselves in subtle and complex ways so as to maximize sustainability. This wisdom of nature is the essence of ecoliteracy.

Based on the understanding of ecosystems as autopoietic networks and dissipative structures, we can formulate a set of principles of organization that may be identified as the basic principles of ecology and use them as guidelines to build sustainable human communities.

The first of those principles is interdependence. All members of an ecological community are interconnected in a vast and intricate network of relationships, the web of life. They derive their essential properties and, in fact, their very existence from their relationships to other things. Interdependence—the mutual dependence of all life processes on one another—is the nature of all ecological relationships. The behavior of every living member of the ecosystem depends on the behavior of many others. The success of the whole community depends on the success of its individual members, while the success of each member depends on the success of the community as a whole.

Understanding ecological interdependence means understanding relationships. It requires the shifts of perception that are characteristic of systems thinking—from the parts to the whole, from objects to relationships, from contents to patterns. A sustainable human community is aware of the multiple relationships among its members. Nourishing the community means nourishing those relationships.

The fact that the basic pattern of life is a network pattern means that the relationships among the members of an ecological community are nonlinear, involving multiple feedback loops. Linear chains of cause and effect exist very rarely in ecosystems. Thus a disturbance will not be limited to a single effect but is likely to spread out in ever-widening patterns. It may even be amplified by interdependent feedback loops, which may completely obscure the original source of the disturbance.

The cyclical nature of ecological processes is an important principle of ecology. The ecosystem's feedback loops are the pathways along which nutrients are continually recycled. Being open systems, all organisms in an ecosystem produce wastes, but what is waste for one species is food for another, so that

what we  
can  
learn

learning  
(out of  
the system)

self-sustaining

non-linear

the ecosystem as a whole remains without waste. Communities of organisms have evolved in this way over billions of years, continually using and recycling the same molecules of minerals, water, and air.

The lesson for human communities here is obvious. A major clash between economics and ecology derives from the fact that nature is cyclical, whereas our industrial systems are linear. Our businesses take resources, transform them into products plus waste, and sell the products to consumers, who discard more waste when they have consumed the products. Sustainable patterns of production and consumption need to be cyclical, imitating the cyclical processes in nature. To achieve such cyclical patterns we need to fundamentally redesign our businesses and our economy.

clash

Ecosystems differ from individual organisms in that they are largely (but not completely) closed systems with respect to the flow of matter, while being open with respect to the flow of energy. The primary source of that flow of energy is the sun. Solar energy, transformed into chemical energy by the photosynthesis of green plants, drives most ecological cycles.

The implications for maintaining sustainable human communities are again obvious. Solar energy in its many forms—sunlight for solar heating and photovoltaic electricity, wind and hydro-power, biomass, and so on—is the only kind of energy that is renewable, economically efficient, and environmentally benign. By disregarding this ecological fact, our political and corporate leaders again and again endanger the health and well-being of millions around the world. The 1991 war in the Persian Gulf, for example, which killed hundreds of thousands, impoverished millions, and caused unprecedented environmental disasters, had its roots to a large extent in the misguided energy policies of the Reagan and Bush administrations.

sustainable energy

consequences!

To describe solar energy as economically efficient assumes that the costs of energy production are counted honestly. This is not the case in most of today's market economies. The so-called free market does not provide consumers with proper information, because the social and environmental costs of production are not part of current economic models. These costs are labeled "external" variables by corporate and government economists, because they do not fit into their theoretical framework.

Corporate economists treat as free commodities not only the air, water, and soil, but also the delicate web of social relations, which is severely affected by continuing economic expansion. Private profits are being made at public costs in the deterioration of the environment and the general quality of life, and at the expense of future generations. The marketplace simply gives us the wrong information. There is a lack of feedback, and basic ecological literacy tells us that such a system is not sustainable.

One of the most effective ways to change the situation would be an ecological tax reform. Such a tax reform would be strictly revenue neutral, shifting the tax burden from income taxes to "eco-taxes." This means that taxes would

14

be added to existing products, forms of energy, services, and materials, so that prices would better reflect the true costs. In order to be successful, an ecological tax reform needs to be a slow and long-term process to give new technologies and consumption patterns sufficient time to adapt, and the eco-taxes need to be applied predictably to encourage industrial innovation.

15 Such a long-term and slow ecological tax reform would gradually drive wasteful and harmful technologies and consumption patterns out of the market. As energy prices go up, with corresponding income tax reductions to offset the increase, people will increasingly switch from cars to bicycles, use public transportation, and carpool on their way to work. As taxes on petrochemicals and fuel go up, again with offsetting reductions in income taxes, organic farming will become not only the healthiest but also the cheapest means of producing food.

16 Eco-taxes are now under serious discussion in several European countries and are likely to be introduced in all countries sooner or later. To remain competitive under such a new system, managers and entrepreneurs will need to become ecologically literate. In particular, detailed knowledge of the flow of energy and matter through a company will be essential, and this is why the newly developed practice of "eco-auditing" will be of paramount importance. An eco-audit is concerned with the environmental consequences of the flows of material, energy, and people through a company and therefore with the true costs of production.

17 Partnership is an essential characteristic of sustainable communities. The cyclical exchanges of energy and resources in an ecosystem are sustained by pervasive cooperation. Indeed, we have seen that since the creation of the first nucleated cells over two billion years ago, life on Earth has proceeded through ever more intricate arrangements of cooperation and coevolution. Partnership—the tendency to associate, establish links, live inside one another, and cooperate—is one of the hallmarks of life.

18 In human communities partnership means democracy and personal empowerment, because each member of the community plays an important role. Combining the principle of partnership with the dynamic of change and development, we may also use the term "coevolution" metaphorically in human communities. As a partnership proceeds, each partner better understands the needs of the other. In a true, committed partnership both partners learn and change—they coevolve. Here again we notice the basic tension between the challenge of ecological sustainability and the way in which our present societies are structured, between economics and ecology. Economics emphasizes competition, expansion, and domination; ecology emphasizes cooperation, conservation, and partnership.

19 The principle of ecology mentioned so far—interdependence, the cyclical flow of resources, cooperation, and partnership—are all different aspects of the same pattern of organization. This is how ecosystems organize themselves to maximize sustainability. Once we have understood this pattern, we can ask more detailed questions. For example, what is the resilience of these ecological

communities? How do they react to outside disturbances? These questions lead us to further principles of ecology—flexibility and diversity—that enable ecosystems to survive disturbances and adapt to changing conditions.

The flexibility of an ecosystem is a consequence of its multiple feedback loops, which tend to bring the system back into balance whenever there is a deviation from the norm, due to changing environmental conditions. For example, if an unusually warm summer results in increased growth of algae in a lake, some species of fish feeding on the algae may flourish and breed more, so that their numbers increase and they begin to deplete the algae. Once their major source of food is reduced, the fish will begin to die out. As the fish population drops, the algae will recover and expand again. In this way the original disturbance generates a fluctuation around a feedback loop, which eventually brings the fish/algae system back into balance.

Disturbances of that kind happen all the time, because things in the environment change all the time, and thus the net effect is continual fluctuation. All the variables we can observe in an ecosystem—population densities, availability of nutrients, weather patterns, and so forth—always fluctuate. This is how ecosystems maintain themselves in a flexible state, ready to adapt to changing conditions. The web of life is a flexible, ever-fluctuating network. The more variables are kept fluctuating, the more dynamic is the system; the greater is its flexibility; and the greater is its ability to adapt to changing conditions.

All ecological fluctuations take place between tolerance limits. There is always the danger that the whole system will collapse when a fluctuation goes beyond those limits and the system can no longer compensate for it. The same is true of human communities. Lack of flexibility manifests itself as stress. In particular, stress will occur when one or more variables of the system are pushed to their extreme values, which induces increased rigidity throughout the system. Temporary stress is an essential aspect of life, but prolonged stress is harmful and destructive to the system. These considerations lead to the important realization that managing a social system—a company, a city, or an economy—means finding the *optimal* values for the system's variables. If one tries to maximize any single variable instead of optimizing it, this will invariably lead to the destruction of the system as a whole.

The principle of flexibility also suggests a corresponding strategy of conflict resolution. In every community there will invariably be contradictions and conflicts, which cannot be resolved in favor of one or the other side. For example, the community will need stability *and* change, order *and* freedom, tradition *and* innovation. Rather than by rigid decisions, these unavoidable conflicts are much better resolved by establishing a dynamic balance. Ecological literacy includes the knowledge that both sides of a conflict can be important, depending on the context, and that the contradictions within a community are signs of its diversity and vitality and thus contribute to the system's viability.

In ecosystems the role of diversity is closely connected with the system's network structure. A diverse ecosystem will also be resilient, because it contains

many species with overlapping ecological functions that can partially replace one another. When a particular species is destroyed by a severe disturbance so that a link in the network is broken, a diverse community will be able to survive and reorganize itself, because other links in the network can at least partially fulfill the function of the destroyed species. In other words, the more complex the network is, the more complex its pattern of interconnections, the more resilient it will be.

25 // \* In ecosystems the complexity of the network is a consequence of its biodiversity, and thus a diverse ecological community is a resilient community. In human communities ethnic and cultural diversity may play the same role. Diversity means many different relationships, many different approaches to the same problem. A diverse community is a resilient community, capable of adapting to changing situations.

26 However, diversity is a strategic advantage only if there is a truly vibrant community, sustained by a web of relationships. If the community is fragmented into isolated groups and individuals, diversity can easily become a source of prejudice and friction. But if the community is aware of the interdependence of all its members, diversity will enrich all the relationships and thus enrich the community as a whole, as well as each individual member. In such a community information and ideas flow freely through the entire network, and the diversity of interpretations and learning styles—even the diversity of mistakes—will enrich the entire community.

27 These, then, are some of the basic principles of ecology—interdependence, recycling, partnership, flexibility, diversity, and, as a consequence of all those, sustainability. As our century comes to a close and we go toward the beginning of a new millennium, the survival of humanity will depend on our ecological literacy, on our ability to understand these principles of ecology and live accordingly.