Ecology, Community, and Agriculture

BY FRITJOF CAPRA

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I would like to speak about the interrelations between ecology, sustainability, and community, and I hope to show you why gardening and farming are ideal practices to explore and understand these interrelations.

I also want to show you that the theory of living systems, which is now emerging at the forefront of science, offers us an appropriate theoretical framework for the understanding of the links between ecology, sustainability, and community. Systems theory is not *needed* for this understanding. Indigenous cultures have had a systemic understanding of nature and of their place in it — an understanding in terms of relationships, connectedness, and context — throughout the ages without developing a scientific framework in our sense of the term. They have what Gregory Bateson called "systemic wisdom."

However, our context here is education within the framework of industrial society. In that framework, there is a lot of emphasis on critical thinking and on science; and therefore it will be very useful to show that the issues we are concerned about are supported by some of the latest developments in science.

The understanding of community is extremely important today, not only for our emotional and spiritual well-being, but also for the future of our children and, in fact, for the survival of humanity. The central challenge of our time is to create and maintain sustainable communities, i.e. social, cultural, and physical environments in which we can satisfy our needs and aspirations without diminishing the chances of future generations.

Since its introduction in the early 1980s, the concept of sustainability has often been distorted, co-opted, and even trivialized by being used without the ecological context that gives it its proper meaning. What is sustained in a sustainable community is not economic growth, development, market share, or competitive

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advantage, but the entire web of life on which our long-term survival depends. In other words, a sustainable community is designed in such a way that its ways of life, businesses, economy, physical structures, and technologies do not interfere with nature's inherent potential to sustain life.

In our attempts to build and nurture sustainable communities we can learn valuable lessons from nature, because nature's ecosystems *are* sustainable communities of plants, animals, and microorganisms. The members of these ecological communities have coevolved over billions of years so as to maximize their sustainability. So, what we need to understand are the basic principles of organization of these sustainable ecological communities. We need to become ecologically literate.

When we begin to understand the principles of ecology at a deep level, we see that they can also be understood as principles of community. Indeed, you could say that ecosystems are sustainable because they are living communities. So, community, sustainability, and ecology are inseparably connected.

ECOLOGY

The word "ecology," as you may know, comes from the Greek oikos ("household"). Ecology is the study of how the Earth Household works. More precisely, it is the study of the relationships that interlink all members of the Earth Household. As John Muir, our famous naturalist, put it at the turn of the century,

> *When we try to pick out anything by itself,*
> we find it hitched to everything else in the
> universe.

LIVING SYSTEMS

The most appropriate theoretical framework for ecology is the theory of living systems. This theory is only now fully emerging but has its roots in several scientific fields that were developed during the first half of the century — organismic biology, gestalt psychology, ecology, general system theory, and cybernetics.

In all these fields scientists explored living systems, which means integrated wholes whose properties cannot be reduced to those of smaller parts. Although we can distinguish parts in any living system, the nature of the whole is always different from the mere sum of its parts.

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Systems thinking was raised to a new level during the past twenty years with the development of a new science of complexity, including a whole new mathematical language and a new set of concepts to describe the complexity of living systems.

Examples of these systems abound in nature. Every organism — animal, plant, microorganism, or human being — is an integrated whole, a living system. Parts of organisms — e.g. leaves, or cells — are again living systems. Throughout the living world, we find systems nesting within other systems. And living systems also include communities of organisms. These may be social systems — a family, a school, a village — or ecosystems.

All these living systems are wholes whose specific structures arise from the interactions and interdependence of their parts. Systems theory tells us that all living systems share a set of common properties and principles of organization. This means that systems thinking can be applied to integrate academic disciplines and to discover similarities between phenomena at different levels of scale — the individual child, the classroom, the school, the district, and the surrounding human communities and ecosystems.

Now, of course, there are a lot of differences between ecosys-

tems and human communities. There is no culture in ecosystems, no consciousness, no justice, no equity. So we can't learn anything about these human values from ecosystems. But what we can learn and must learn is how to live sustainably. This wisdom of nature is the essence of ecoliteracy.

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THE WEB OF LIFE

So, how do ecosystems organize themselves? Well, the first thing we recognize when we observe an ecosystem is that it is not just a collection of species but a community, which means that its members all depend on one another. They are all interconnected in a vast network of relationships, the web of life.

Understanding ecosystems, then, leads us to understanding relationships. This is a key aspect of systems thinking. It implies a shift of focus from objects to relationships. A vibrant community is aware of the multiple relationships among its members. Nourishing the community means nourishing these relationships.

Now, understanding relationships is not easy for us, because it is something that goes counter to the traditional scientific enterprise in Western culture. In science, so we have been taught, we measure and weigh things. But relationships cannot be measured and weighed; relationships need to be mapped. You can draw a map of relationships, interconnecting different elements or different members of a community. When you do that, you will discover certain configurations of relationships that appear again and again. This is what we call patterns. The study of relationships leads you to the study of patterns.

MATTER AND FORM

And here we discover a tension that has been characteristic in Western science and philosophy throughout the ages. It is a

tension between two approaches to the understanding of nature, the study of matter and the study of form. These are two very different approaches. The study of matter begins with the question, "What is it made of?" This leads to the notions of fundamental elements, building blocks; to measuring and quantifying. The study of form asks, "What is the pattern?" And that leads to the notions of order, organization, relationships. Instead of quantity, it involves quality; instead of measuring, it involves mapping.

So, these are two very different lines of investigation that have been in competition with one another throughout our scientific and philosophical tradition. For most of the time, the study of matter — of quantities and constituents — has dominated. But in recent decades the rise of systems thinking has brought the study of form — of patterns and relationships — to the fore again. The main emphasis of chaos and complexity theory is on patterns. The strange attractors of chaos theory, the fractals of fractal geometry — all these are visual patterns. The whole new mathematics of complexity is essentially a mathematics of patterns.

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THE PRINCIPLES OF ECOLOGY

When systems thinking is applied to the study of the multiple relationships that interlink the members of the Earth Household, a few basic principles can be recognized. They may be called principles of ecology, principles of sustainability, or principles of community; or you might even call them the basic facts of life. We need a curriculum that teaches our children these fundamental facts of life —

- that an ecosystem generates no waste, one species' waste being another species' food;
- that matter cycles continually through the web of life;

There is a web of relationships among all the components of a living organism, just as there is a network of relationships among the plants, animals, and microorganisms in an ecosystem, or among people in a human community.

- that the energy driving these 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 cooperation, partnership, and networking.

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The central insight of the theory of living systems that is now emerging in science is the recognition that there is a basic pattern of life that is common to all living systems. That basic pattern is the network. There is a web of relationships among all the components of a living organism, just as there is a network of relationships among the plants, animals, and microorganisms in an ecosystem, or among people in a human community.

One of the key characteristics of these living networks is the fact that all their nutrients are passed along in cycles. In an ecosystem, energy flows through the network, while the water, oxygen, carbon, and all other nutrients move in these well-known ecological cycles. Similarly, the blood cycles through our body, and so does the air, the lymph fluid, and so on. Wherever we see life we see networks; and wherever we see living networks, we see cycles.

GARDENING AND FARMING IN SPIRITUAL TRADITIONS

These three insights — the network pattern, the flow of energy, and the nutrient cycles — are essential to the new scientific conception of life. Scientists have formulated them in complicated technical language. They speak of "autopoietic networks," "dissipative structures," and "catalytic cycles." But the basic phenomena described by those technical terms are the web of life, the flow of energy, and the

cycles of nature. And these are exactly the phenomena that are experienced, explored, and understood through gardening and farming.

The understanding of life in terms of networks, flows, and cycles is relatively new in science, but it is an essential part of the wisdom of spiritual traditions; and it is not a coincidence that gardening, farming, and the preparation of food have been integral parts of religious practice in many spiritual traditions, for example in the monastic traditions of Christianity and Buddhism.

So, the contemporary concept in ecology is that of the food web, a network of feeding relationships.

Gardening and cooking are examples of cyclical work — work that has to be done over and over again, work that does not leave any lasting traces. You cook a meal that is immediately eaten. You clean the dishes, but they will soon be dirty again. You plant, tend the garden, harvest, and then plant again. This work is part of monastic practice, because it helps us recognize the natural order of growth and decay, of birth and death, and thus makes us aware of how we are all embedded in those cycles of nature.

BECOMING ECOLOGICALLY LITERATE ON THE FARM

On the farm, we learn about food cycles, one of the earliest and most important ecological concepts. From the beginning of the science of ecology, ecologists have been studying feeding relationships. At first, they formulated the concept of the food chain, which we still use today — small creatures being eaten by bigger ones, which are eaten in turn by still bigger ones, and so on. Soon ecologists realized that all the big creatures are eaten by smaller ones when they die, by the so-called decomposer organisms. This led to the concept of food cycles. And finally, ecologists recognized that these food cycles are all interconnected, because most species feed on several other species, as we do, and thus the food cycles become part of one interconnected network. So, the contemporary concept

in ecology is that of the food web, a network of feeding relationships.

Through farming, we also become aware how we ourselves are part of the web of life.

On the farm, we learn that green plants play a vital role in the flow of energy through all ecological cycles. Their roots take in water and mineral salts from the earth, and the resulting juices rise up to the leaves, where they combine with carbon dioxide (CO_2) from the air to form sugars and other organic compounds. In this marvelous process, known as photosynthesis, solar energy is converted into chemical energy and bound in the organic substances, while oxygen is released into the air to be taken up again by other plants, and by animals, in the process of respiration.

By blending water and minerals from below with sunlight and CO_2 from above, green plants link the earth and the sky. We tend to believe that plants grow out of the soil, but in fact most of their substance comes from the air. The bulk of the cellulose and the other organic compounds produced through photosynthesis consists of heavy carbon and oxygen atoms, which plants take directly from the air in the form of CO_2. Thus the weight of a wooden log comes almost entirely from the air. When we burn a log in a fireplace, oxygen and carbon combine once more into CO_2, and in the light and heat of the fire we recover part of the solar energy that went into making the wood. All this we can learn from gardening and farming.

In a typical food cycle, the plants are eaten by animals, which in turn are eaten by other animals, and thus the plants' nutrients are passed on through the food web, while energy is dissipated as heat through respiration and as waste through excretion. The wastes, as well as dead animals and plants, are decomposed by insects and bacteria, the decomposer organisms, which break them down into basic nutrients, to be taken up once more by green plants.

In farming, we integrate the natural food cycles into our cycles of

planting, growing, harvesting, composting, and recycling. Through this practice, we also learn that the farm as a whole is embedded in larger systems that are again living networks with their own cycles. The food cycles intersect with these larger cycles — the water cycle, the cycle of the seasons, and so on, all of which are links in the planetary web of life.

Through farming, we also become aware how we ourselves are part of the web of life. To quote from the famous speech attributed to Chief Seattle, "We did not weave the web of life; we are merely a strand in it. Whatever we do to the web, we do to ourselves."

On the farm, we learn that a fertile soil is a living soil containing billions of living organisms in every cubic centimeter. These soil bacteria carry out various chemical transformations that are essential to sustain life on Earth. Because of the basic nature of the living soil, we need to preserve the integrity of the great ecological cycles in our practice of gardening and agriculture. This principle is embodied in traditional farming methods, which are based on a profound respect for life. Farmers used to plant different crops every year, rotating them so that the balance in the soil was preserved. No pesticides were needed, since insects attracted to one crop would disappear with the next. Instead of using chemical fertilizers, farmers would enrich their fields with manure, thus returning organic matter to the soil to reenter the ecological cycle.

About four decades ago, this age-old practice of organic farming changed drastically with the massive introduction of chemical fertilizers and pesticides. Chemical farming has seriously disrupted the balance of our soil, and this has had a severe impact on human health, because any imbalance in the soil affects the food that grows in it and thus the health of the people who eat the food. Fortunately, a growing number of farmers have now become aware of the hazards of chemical farming and are turning back to organic, eco-

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logical methods. Visits to these farms are ideal opportunities for teaching the merits of organic farming to our children.

Another type of cycle we encounter in the garden and on the farm is the life cycle of an organism — the cycle of birth, growth, maturation, decline, death, and new growth of the next generation. On the farm, we experience growth and development on a daily basis. We can follow the development of a plant from the seed to the first shoot, the growth of the stem and leaves, the buds, the flowers, and the fruits. And when we look into a fruit, we find that at its very core are the new seeds; and so the life cycle begins again.

Learning in the garden and on the farm is learning in the real world at its very best.

The understanding of growth and development, of course, is essential not only for gardening and farming, but also for education. While the children learn that their work in the school garden changes with the development and maturing of the plants, the teachers' methods of instruction and the entire discourse in the classroom changes with the development and maturing of the students. This is systems thinking in action — applying the same principle to different systems levels.

Since the pioneering work of Jean Piaget in the 1920s and 30s, a broad consensus has emerged among scientists and educators about the unfolding of cognitive functions in the growing child. Part of that consensus is the recognition that a rich, multi-sensory learning environment — the shapes and textures, the colors, smells, and sounds of the real world — is essential for the full cognitive and emotional development of the child. Learning in the garden and on the farm is learning in the real world at its very best. It is beneficial for the development of the individual student and the school community, and it is one of the best ways for children to become ecologically literate and thus able to contribute to building a sustainable future.