Ecology & Community
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The understanding of community is extremely important today, not only for our emotional and spiritual well-being, but for the future of our children and, in fact, for the survival of humanity.

As you well know, we are faced with a whole series of global environmental problems which are harming the biosphere and human life in alarming ways that may soon become irreversible. The great challenge of our time is to create sustainable communities; that is, social and cultural environments in which we can satisfy our needs without diminishing the chances of future generations.

In our attempts to build and nurture sustainable communities we can learn valuable lessons from ecosystems, which are sustainable communities of plants, animals, and microorganisms. In over four billion years of evolution, ecosystems have developed the most intricate and subtle ways of organizing themselves so as to maximize sustainability.

There are laws of sustainability which are natural laws, just as the law of gravity is a natural law. In our science in past centuries, we have learned a lot about the law of gravity and similar laws of physics, but we have not learned very much about the laws of sustainability. If you go up to a high cliff and step off it, disregarding the laws of gravity, you will surely die. If we live in a community, disregarding the laws of sustainability, as a community we will just as surely die in the long run. These laws are just as stringent as the laws of physics, but until recently they have not been studied.

The law of gravity, as you know, was formalized by Galileo and Newton, but people knew about stepping off cliffs long before Galileo and Newton. Similarly, people knew about the laws of sustainability long before ecologists in the twentieth century began to discover them. In fact, what I'm going to talk about today is nothing that a ten-year-old Navajo boy or Hopi girl who grew up in a traditional Native American community would not understand and know. In preparing this presentation, I discovered that if you really try to distill the essence of the laws of sustainability, it's very simple. The more you go to the essence, the simpler it is.

What I want you to understand is the essence of how ecosystems organize themselves. You can abstract certain principles of organization and call them the principles of ecology; but it is not a list of principles that I want you to learn. It's a pattern of organization I want you to understand. You will see that whenever you formalize it and say, "This is a key principle, and this is a key principle," you don't really know where to start, because they all hang together. You have to understand all of them at the same time. So, when you teach the principles of ecology in school, you can't say, "In third grade we do

interdependence and then in fourth grade we do diversity." One cannot be taught or practiced without the others. What I'm going to do, then, is describe how ecosystems organize themselves. I'll present to you the very essence of their principles of organization.

Relationships

When you look at an ecosystem — say at a meadow or a forest — and you try to understand what it is, the first thing you recognize is that there are many species there. There are many plants, many animals, many microorganisms.

And they're not just an assemblage or collection of species. They are a community, which means that they are interdependent; they depend on one another. They depend on one another in many ways, but the most important way in which they depend on one another is a very existential way — they eat one another. That's the most existential interdependence you can imagine.

Indeed, when ecology was developed in the 1920s, one of the first things people studied were feeding relationships. At first, ecologists formulated the concept of food chains. They studied big fish eating smaller fish, which eat still smaller fish, and so on. Soon these scientists discovered that these are not linear chains but cycles, because when the big animals die, they in turn are eaten by insects and bacteria. The concept shifted from food chains to food cycles.

And then they found that various food cycles are actually interlinked, so the focus again shifted, from food cycles to food webs or networks. In ecology, this is what people are now talking about. They're talking about food webs, networks of feeding relationships.

These are not the only examples of interdependence. The members of an ecological community, for example, also give shelter to one another. Birds nest in trees and fleas nest in dogs and bacteria attach themselves to the roots of plants. Shelter is another important kind of interdependent relationship.

To understand ecosystems, then, we need to understand relationships. That's a key aspect of the new thinking. Also, always keep in the back of your minds that when I talk about ecosystems I'm talking about communities. The reason we're studying ecosystems here is so that we can learn about building sustainable human communities.

So we need to understand relationships, and this is something that runs counter to the traditional scientific enterprise in Western culture. Traditionally in science, we have tried to measure and weigh things, but relationships cannot be measured and weighed. Relationships need to be mapped. You can draw a map of relationships that shows the connections between different elements or different members of the community.

When you do that, you discover that certain configurations of relationships appear again and again. These are what we call patterns. The study of relationships leads us to the study of patterns. A pattern is a configuration of relationships appearing repeatedly.

The study of form and pattern

So this study of ecosystems leads us to the study of relationships, which leads us to the notion of pattern. And here we discover a tension that has been characteristic in Western science and philosophy throughout the ages. It is a tension between the study of substance and the study of form. The study of substance starts with the question, What is it made of? The study of form starts with the question, What is its pattern? Those are two

very different approaches. Both of them have existed throughout our scientific and philosophical tradition. The study of pattern began with the Pythagoreans in Greek antiquity, and the study on substance began at the same time with Parmenides, Democritus, and with various philosophers who asked: What is matter made of? What is reality made of? What are its ultimate constituents? What is its essence?

In asking this question, the Greeks came up with the idea of four fundamental elements: earth, fire, air, and water. In modern times, these were recast into the chemical elements; many more than four, but still the basic elements of which all matter consists. In the nineteenth century, Dalton identified the chemical elements with atoms, and with the rise of atomic physics in our century the atoms were reduced to nuclei and electrons, and the nuclei to other subatomic particles.

Similarly, in biology the basic elements first were organisms, or species. In the eighteenth and nineteenth centuries there were very complex classification schemes of species. Then, with the discovery of cells as the common elements in all organisms, the focus shifted from organisms to cells. Cellular biology was at the forefront of biology. Then the cell was broken down into its macromolecules, into the enzymes and proteins and amino acids and so on, and molecular biology was the new frontier. In all of this endeavor, the question always was: What is it made of? What is its ultimate substance?

At the same time, throughout the same history of science, the study of pattern was always there, and at various times it came to the forefront, but most times it was neglected, suppressed, or sidelined by the study of substance. As I said, when you study pattern, you need to map the pattern, whereas the study of substance is the study of quantities that can be measured. The study of pattern, or of form, is the study of quality, which requires visualizing and mapping. Form and pattern must be visualized. This is a very important aspect of studying patterns, and it is the reason why, every time the study of pattern was in the forefront, artists contributed significantly to the advancement of science. Perhaps the two most famous examples are Leonardo da Vinci, whose scientific life was a study of pattern, and the German poet Goethe in the eighteenth century, who made significant contributions to biology through his study of pattern. This is very important to us as parents and educators, because the study of pattern comes naturally to children; to visualize pattern, to draw pattern, is natural. In traditional schooling this has not been encouraged.

Art has been sort of on the side. We can make this a central feature of ecoliteracy: the visualization and study of pattern through the arts. Now, recognizing that the study of pattern is central to ecology, we can then ask the crucial question: What is the pattern of life? At all levels of life — organisms, parts of organisms, and communities of organisms — we have patterns, and we can ask: What is the characteristic pattern of life? I’m actually working on a book now to answer this question, so I could give you a fairly technical description of the characteristics of the pattern of life; but here I want to concentrate on its very essence.

Networks

The first step in answering this question, and perhaps the most important step, is a very easy and obvious one: the pattern of life is a network pattern. Wherever you see the phenomenon of life, you observe networks. Again, this was brought into science with ecology in the 1920s when people studied food webs — networks of feeding relationships. They begin to concentrate on the network pattern. Later on, in mathematics, a whole set of tools was developed to study networks. Then scientists realized that the network pattern is not only characteristic of ecological communities as a whole, but of every

member of that community. Every organism is a network of organs, of cells, of various components; and every cell is a network of similar components. So what you have is networks within networks. Whenever you look at life you look at networks.

Then you can ask: What is a network and what can we say about networks? The first thing you see when you draw a network is that it is nonlinear; it goes in all directions. So the relationships in a network pattern are nonlinear relationships. Because of this nonlinearity, an influence or message may travel around a cyclical path and come back to its origin. In a network, you have cycles and you have closed loops; these loops are feedback loops. The important concept of feedback, which was discovered in the 1940s, in cybernetics, is intimately connected with the network pattern. Because you have feedback in networks, because an influence travels around a loop and comes back, you can have self-regulation; and not only self-regulation but self-organization. When you have a network — for instance, a community — it can regulate itself. The community can learn from its mistakes, because the mistakes travel and come back along these feedback loops. Then you can learn, and next time around you can do it differently. Then the effect will come back again and you can learn again, in steps.

So the community can organize itself and can learn. It does not need an outside authority to tell it "You guys did something wrong." A community has its own intelligence, its own learning capability. In fact, every living community is always a learning community. Development and learning are always part of the very essence of life because of this network pattern.

Self-organization

As soon as you understand that life is networks, you understand that the key characteristic of life is self-organization, so if somebody asks you, "What is the essence of life? What is a living organism all about?" you could say, "It is a network and because it is a network it can organize itself." This answer is simple, but it’s at the very forefront of science today. And it is not generally known. When you go around in academic departments, this is not the answer you will hear. What you will hear is "Amino Acids," "Enzymes," and things like that; very complex information, because that is the inquiry into substance: What is it made of?

It is important to understand that, in spite of the great triumphs of molecular biology, biologists still know very little about how we breathe or how a wound heals or how an embryo develops into an organism. All of the coordinating activities of life can only be grasped when life is understood as a self-organizing network. So self-organization is the very essence of life, and it’s connected with the network pattern.

When you look at the network of an ecosystem, at all these feedback loops, another way of seeing it, of course, is as recycling. Energy and matter are passed along in cyclical flows. The cyclical flows of energy and matter — that’s another principle of ecology. In fact, you can define an ecosystem as a community where there is no waste.

Of course, this is an extremely important lesson we must learn from nature. This is what I focus on when I talk to business people about introducing ecoliteracy into business. Our businesses are now designed in a linear way — to consume resources, produce goods, and throw them away. We need to redesign our businesses to imitate the cyclical processes of nature rather than to create waste. Paul Hawken has recently written about this very eloquently in his book The Ecology of Commerce.

So we have interdependence, network relationships, feedback loops; we have cyclical

flows; and we have many species in a community. All of this together implies cooperation and partnership. As various nutrients are passed along through the ecosystem, the relationships we observe are many forms of partnership, of cooperation. In the nineteenth century, the Darwinists and Social Darwinists talked about the competition in nature, the fight — "Nature, red in tooth and claw." In the twentieth century, ecologists have discovered that in the self-organization of ecosystems cooperation is actually much more important than competition. We constantly observe partnerships, linkages, associations, species living inside one another depending on one another for survival. Partnership is a key characteristic of life. Self-organization is a collective enterprise.

We see that these principles — interdependence, network patterns, feedback loops, the cyclical flows of energy and matter, recycling, cooperation, partnership — are all different aspects, different perspectives on one and the same phenomenon. This is how ecosystems organize themselves in a sustainable way.

Flexibility and diversity

Once you have established that, then you can ask more detailed questions, such as: what is the resilience of such an organization? How does it react to outside disturbances? In this way, you will discover two further principles that enable ecological communities to survive disturbances and to adapt to changing conditions. One is flexibility. Flexibility manifests itself in the network structure, because networks in ecosystems are not rigid; they fluctuate. Whenever you have feedback loops, if there is a deviation, the system brings itself back into balance. And since these disturbances happen all the time, because things in the environment change all the time, the net effect is a continual fluctuation.

Everything in an ecosystem fluctuates: population densities, supplies of nutrients, quantities of rainfall, and so on. And that is also true for an individual organism. Whatever we observe in our body — our temperature, our hormonal balance, our skin humidity, our brain waves, our breathing patterns — all fluctuates. This is how we can be flexible and adapt, because these fluctuations can be disturbed and then will come back again to a healthy fluctuating state. So flexibility through fluctuations is the way ecosystems remain resilient.

Of course, this does not always work, because there can be very severe disturbances that will actually kill a particular species, just wipe it out. What you have then is that one of the links in a network is destroyed. An ecosystem, or any kind of community, will be resilient when this destroyed link is not the only one of its kind; when there are other links, other connections. So when one link is wiped out, the other ones can at least partially fulfill its function. In other words, the more complex the network is and the more complex all these connecting links are, the more resilient it will be, because it can afford to lose some of its links. There will still be plenty there, fulfilling the same function.

This, my friends, translates into diversity. Diversity means many links, many different approaches to the same problem. So a diverse community is a resilient community. A diverse community is one that can adapt to changing situations, and therefore diversity is another very important principle of ecology.

Now, we have to be careful when we talk about diversity, because we all know it’s politically correct to celebrate diversity and to say it’s a great advantage. But it’s not always a great advantage, and this is what we can learn from ecosystems. Diversity is a strategic advantage for a community if, and only if, there is a vibrant network of relationships, if there is a free flow of information through all the links of the network. Then diversity is a tremendous strategic advantage. However, if there is fragmentation, if

there are subgroups in the network or individuals who are not really part of the network, then diversity can generate prejudice, it can generate friction, and as we know well from our inner cities, it can generate violence.

So diversity is great if the other principles of sustainable organization are fulfilled. If there are not, diversity is a hindrance. We need to see that very clearly. If we have a network structure with feedback loops, and if different kinds of people make different mistakes, and if information about these different kinds of mistakes is shared and travels through the network, then very quickly the community will figure out the smartest ways to solve certain problems or the smartest ways to adapt to changes. All the research about diverse learning styles and diverse intelligences will be extremely useful if — and only if — there is a vibrant community where you have interdependence, a vibrant network of relationships, and cyclical flows of energy and information. When the flows are restricted, you create suspicion and distrust, and diversity is a hindrance. But when the flows are open, diversity is a great advantage. In an ecosystem, of course, all doors are always open. Everything exchanges energy, matter, and information with everything else, so diversity is one of the key strategies of nature for survival and evolution.

So these are some of the basic principles of ecology — interdependence, recycling, partnership, flexibility, diversity, and as a consequence of all these, 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.