ARE ECOSYSTEMS ALIVE?

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ABSTRACT

A system is a group of interacting components in which the nature of the interactions maintains the situation as an interactive group for some relevant amount of time. Organisms are living systems in which a complex of subsystems, biological cellular-maintenance metabolism, contained and protected by an outer membrane, continuously maintains the character and dynamic nature of the system. An ecosystem is a system composed of living organisms and their abiotic environment.

While it is observationally evident that the abiotic component of an ecosystem contains the biotic component, the question has been raised whether an ecosystem is also a living system, like unicellular and multicellular organisms. An accurate, rigorous answer requires a realist approach that is not based on subjectivity, postulate, hypothesis, or theory, but rather on consideration of the intrinsic qualities of (a) living systems and (b) systems with living systems as components. Because this is a question about the nature of these systems, this is a problem for general systems science.

Unicellular organisms, such as amoebas and paramecia, are living systems—they are alive. Using a single individual unicellular organism as a baseline example of a living system, the discussion follows a development of increasing complexity of relation and hierarchy from two such individuals in a simple group, through a few stages of system development to the level of an ecosystem. Along the way are noted the factors that prompt that development, and whether those factors or the emergent relations or hierarchic levels confer life on the successive situations. It is a series of stages of increasing complexity of systems with living systems as components. The idea, if ecosystems are alive as ecosystems, at the hierarchic level of ecosystem, then where do the factors that make them so come into play, somewhere in the development of systems leading up to the level of ecosystem, or only at the moment of emergence for an ecosystem?

With the results of this investigative process in hand, the discussion turns to questions concerning the origin of the idea that ecosystems are alive, that they are living systems. Here general systems theory comes into play. There are specific patterns of organization of material structure and process (system principles, isomorphies, etc.) that occur in diverse situations—such as at multiple levels of the hierarchic organization of material reality—where those patterns play specific roles in the intrinsic nature of those situations, roles that are consequences of the intrinsic nature of each pattern of organization. General systems studies these patterns of organization, discovering (1) which patterns play these general roles, (2) where they occur, (3) how they influence the nature of the situations in which they occur, and (4) how and why they differ from one situation to another. Once these general patterns of organization are recognized and understood, they can be used as intellectual tools to enhance the understanding of various situations. This is systems thinking, and it is necessary in order to achieve an understanding of whether an ecosystem is alive or not, and why.

Keywords: ecosystems; hierarchy; living systems; systems thinking; general systems

Are Ecosystems Alive?

INTRODUCTION

"What distinguishes an ecosystem from an organism?" "Are ecosystems 'alive' or do they just contain life?" These are two of the questions listed for the 2008 International Society for the Systems Sciences Annual Meeting. The answers to these questions are provided by realist philosophy and general systems science.

Realist philosophy has two roles. First it strives for accurate knowledge and understanding of the intrinsic nature of reality, of that which exists. Second, realist philosophy sets the rules for science. The purpose of science is to provide accurate knowledge about the intrinsic nature of reality. Realist philosophy figures out how to do that, and passes judgment on the results of science. For example it is realist philosophy that points out that it is observation, with all its various methodologies, that leads to accurate knowledge. Realist philosophy additionally points out the foundational and universal necessity of objectivity in the pursuit of accurate knowledge and understanding. Realist philosophy examines the procedures by which an item of proposed knowledge has been found, and compares that proposed knowledge with what is already known.

General systems science is a science of comparison. There are specific patterns of organization of material structure and process that occur in diverse situations—such as at multiple levels of the hierarchic organization of material reality—where those patterns play specific roles in the intrinsic nature of those situations, roles that are consequences of the intrinsic nature of each pattern of organization. General systems studies these patterns of organization, discovering 1) which patterns play these general roles, (2) where they occur, (3) how they influence the nature of the situations in which they occur, and (4) how and why they differ from one situation to another.

So, "Are ecosystems 'alive' or do they just contain life?" To distinguish living systems, such as unicellular and multicellular organisms, from systems that have living systems as components, such as ecosystems, it is necessary to compare the intrinsic patterns of organization of organisms and ecosystems to see in what way they are similar and in what way they are different. This is the work of general systems science.

Two things that influence the nature and the role of a pattern of organization in any particular situation are (a) factor development, and (b) the context the situation provides for the existence there of that pattern. A factor is something that exists in a situation and plays a role there. For example, any particular pattern of organization of material structure and process that occurs in a situation is a factor of that situation. Various situations provide different contexts for factors because (a) they can differ in what they are made of, and (b) they contain different mixes of additional factors. Because it is the intrinsic qualities of a component that determine the nature of the relations it can have with other components, what components occur in a situation determine what kinds of relations can occur there, and thus the manner in which a pattern can exist in that situation.

With factor development, a factor occurs in simple form and plays simple roles in simple situations where few other factors are also playing roles, but occurs in more complex form and can play more complex roles in situations where larger numbers of other factors are playing a greater diversity of roles. For example, when a particular pattern of organization occurs at two levels of a hierarchical situation, there will be fewer hierarchical levels that constitute the structure of the pattern of organization at the lower level and a greater number of levels constituting the structure of the pattern at the higher level. At the higher level there will be all the levels that constitute the lower level, plus all the intervening levels. Those intervening levels add complexity to the intrinsic nature of the higher level case of the pattern of organization. That factor, the pattern of organization, occurs there in a more complex, developed form.

A group of interrelating factors constitutes a situation, and situations develop in multiple ways. A pattern of relations of particular significance in situation development is that the nature of what goes before determines the nature of what follows. Following the development of a factor or of a situation provides understanding of how and why a factor or situation comes into existence, and why they have their specific intrinsic qualities. Living systems and systems with living systems as components are developmentally related. Organisms are components of ecosystems, ecosystems are hierarchically above organisms, and ecosystems are more complex than organisms. There are developmental relations of hierarchy and complexity. What distinguishes organisms from ecosystems are factors of development.

DEVELOPMENT OF LIVING SYSTEMS AND SYSTEMS WITH LIVING COMPONENTS

The developmental path that will be followed begins with a unicellular organism, a single free-living cell, and then looks at various stages leading up to the level of an ecosystem. The most obvious factor that will be found that distinguishes living systems from systems with living components is that living systems are coherent systems, systems in which the components are coherently attached to one another, while the other systems that will be looked at along the way are noncoherent systems, systems in which the components are not coherently attached. Less obvious will be the intrinsic nature of various factors that play roles in all theses stages, but that develop along the way, thereby playing their roles in different ways at various stages, and thus having different effects on the nature of the situations in which they occur at each of the successive stages.

All known living systems are extremely complex with diverse components and multiple subsystems. Life is a complex of structure and process which varies tremendously from the simplest forms of living beings to the most complex forms. It turns out that very few of these factors are required to be present in an individual living being all the time. Even fewer such factors universally distinguish something that is alive from something that is not alive. It appears that an exterior membrane containing a cell-system maintenance-metabolism continuing its diverse processes in a normal manner are the basic requirements that must be present for a system to be alive. If the cell maintenance processes stop, all other processes stop, and all levels of life die, from the cellular level to the organism level, with consequent virtually complete disorganization of the living system.

How these requirements occur in the stages from a unicellular organism to an ecosystem will be looked at in this sequence: (1) a single free-living cell (an amoeba), (2) a simple group of free-living cells, (3) a system with interacting free-living cells, (4) a system with interbreeding unicellular organisms (paramecia), (5) a system of interacting species, and (6) an ecosystem.

A Free-living Unicellular Organism

An amoeba, making its way across the field of view of the microscope, is alive. It is a living system, composed of diverse units and subsystems interrelating in complexly networked hierarchies and processes. Closer magnification reveals a flow within, a number of structures, organelles, being moved about. This one-celled creature's metabolism takes place in the fluid cytosol of that flow, and also on the surface of and inside those structures. There is also a cell membrane that keeps the contents of the cell together and prevents it from being lost to the surrounding medium. Thus, the amoeba has the basic requirements of a living system.

Now look at the creature more generally, as a whole. It is a single living cell. Its outer membrane confines all its components into a single unit. In order to do that, the molecules of the cell membrane must stick together. They must cohere with a bond of sufficient strength to maintain the integrity of the cell. Within the cell there are other such coherent relations between molecules, for example, those that maintain the structure of the various organelles. However, throughout the cell there are multitudes of components that are not coherently bonded, the molecules of the cytosol and all the items carried about by it, and many others within the organelles.

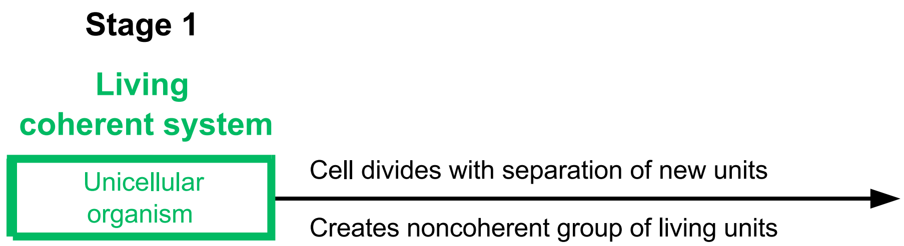

Figure 1. The amoeba, as a living system, as a contained compound system, is a coherent system.

When units of matter join together in a coherent manner they form a coherent system, such as a rock, a drop of water, or a seed—individual units. When units of matter interrelate without sticking together they form a noncoherent system such as the atmosphere, a flock of birds, or the cytosol and the items within it—groups of units. The amoeba is a compound system in that its components have both coherent and noncoherent relations, with the latter contained by the former. A coherently contained compound system, as a whole, exists in the form of an individual unit—a compound system occurring, overall, in the form of a coherent system, a developed form of coherent system. The amoeba is alive as a free-living unicellular organism, as a living system, as a contained compound system—as a coherent system (Figure 1).

Simple Group of Free-living Unicellular Organisms

When a cell divides there are then two cells together. This situation constitutes a simple group, wherein units occur in proximity to one another but do not interact—a noncoherent group (Figure 2). Because there is no interaction, a simple group is not a system. The situation is a noncoherent group composed of two coherent systems. The coherent systems are alive, but the situation at the level of the simple noncoherent group cannot be alive, cannot be a living system, because it is not a system at all. Even though at the hierarchic level of the components the units are individually alive, at the hierarchic level of the whole, it is no more than a nonliving group.

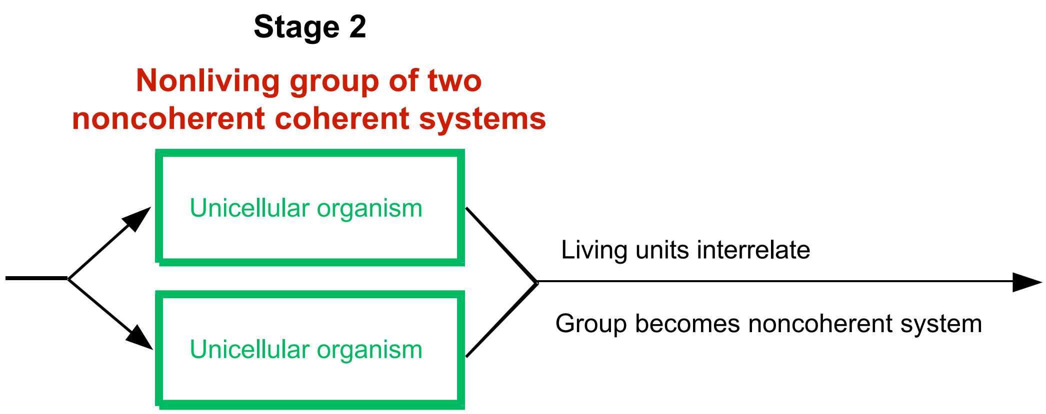

Figure 2. Two cells together constitute a simple group, wherein units occur in proximity to one another but do not interact. This is a noncoherent group composed of two coherent systems.

System of Interacting Free-Living Unicellular Organisms

When the cells of a simple group begin to interact, bumping into one another and competing for space and food, the situation becomes a simple system. Because it is composed of individual living organisms, it is a social system (Figure 3). A social system is a pattern of organization, and like virtually all factors, it develops, beginning here in simple form with simple organisms, and developing up to the stages and complexities of human societies, and then on to multispecies communities. A social system is a hierarchic level above an organism. Can that higher level be said to be alive? Is a social system a living system? Does the mere quality of being a system constitute the attainment of being alive?

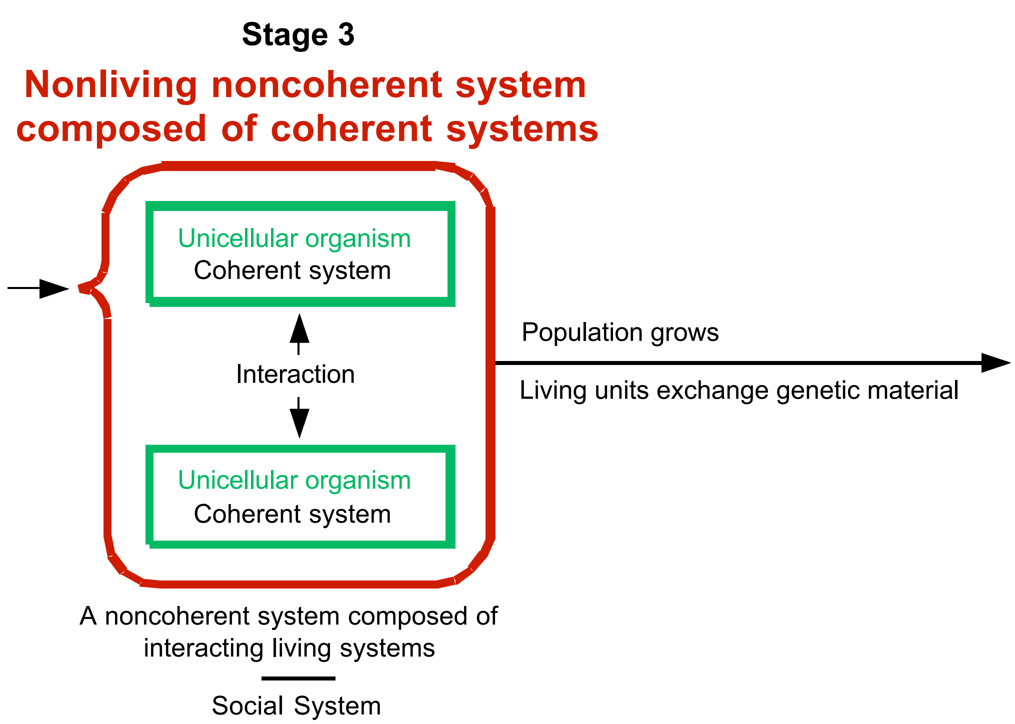

Figure 3. When the cells of a simple group begin to interact, bumping into one another and competing for space and food, the situation becomes a simple social system.

The situation is a noncoherent system composed of coherent systems. There is life at the hierarchic level of the components, the individual living cells. They have cell maintenance metabolism and a coherent membrane that keeps the parts together. However, the types of interactions that take place between the cells, at the system process level, do not constitute system maintenance relations. Collisions and competitions are more likely to disperse the members of the group and result in the disintegration of the system character of the situation. There is no membrane or any sort of intrinsic barrier to keep the parts together. The type of interactions and the qualities of the system at the level of the noncoherent relations between these cells are not the type of relations and qualities that together constitute a living system. The situation at the level of noncoherent system composed of simply-interacting living units is not alive. A social system at this stage of development is not a living system, but rather a system composed of living systems.

System of Interbreeding Unicellular Organisms

A system is a group of interacting components in which the nature of the interactions maintains the situation as an interactive group for some relevant amount of time. A social system is a system with living components, the behaviour of which maintains the situation as a system. At the previous stage, the interactive relations of competition for space and food established the situation as a social system in only a minimal sort of way. At this stage, the interbreeding relation is a mutually enhancing cooperative encounter that plays a distinct role in maintaining the situation as a system. As with the prior stage, the situation here is a noncoherent system composed of coherent systems (Figure 4).

Interbreeding involves an exchange of genetic material, and with unicellular organisms this occurs by way of processes collectively called conjugation. While both amoebas and paramecia reproduce by way of cell division, for transfer of genetic material it is necessary to switch attention away from the group of amoebas to a pair of nearby paramecia.

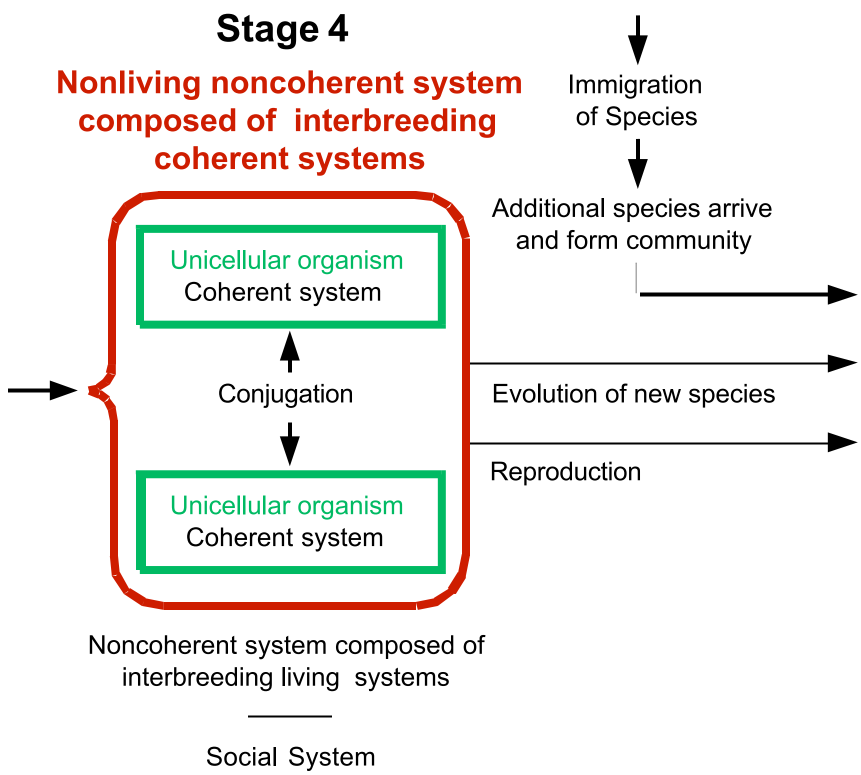

Figure 4. A noncoherent social system composed of interbreeding living units—an interbreeding population system.

Conjugation, in which the paramecia exchange DNA, is an encounter between two individuals, a minimal social event. Afterward they each go their own way, and the social situation would seem to disappear. However, over time and under appropriate circumstances, the two paramecia, and their progeny through division, conjugate with various other members of the local population. The result is the transfer and distribution of various genes through the population and the development of a gene pool. The group of individual paramecia and the set of genes they transfer through the population constitutes a social system, wherein the interactive behaviour of the component living subsystems maintains the nature of the larger system.

In cell maintenance metabolism, the component subsystems interact in a manner that maintains the cell system as a whole. Cell maintenance metabolism confers life on the cell. Does conjugation, the transfer of DNA among a group, which creates a dynamic gene pool, confer the quality of life on the social-system-level group of living components? A review of the relation of coherence and noncoherence in this sequence of stages can provide the answer.

In the first stage (a single unicellular organism) (Figure 1), noncoherence plays a required role in cell maintenance metabolism making it possible for the various components to move about and engage in sequences of reactions. Coherence plays a role in the structure of organelles and another role in the cell membrane in keeping all the components of the living system interactively together. The first stage is a compound system, which due to the coherent membrane occurs as a whole in the form of a single unit coherent system.

The second stage (Figure 2), a group of organisms, is a two level hierarchy. At the first level, that of the living system organism, the roles of noncoherence and coherence are as just described for the first stage. At the second level, that of the group, there is no role for coherence. It is a completely noncoherent situation in that there is no interaction at all, and thus no role for system, and no role for living systems relations at the second level. The second stage is a group of two noncoherent coherent systems.

The third stage (Figure 3), also a two level hierarchy, is a rudimentary system because there is interaction between the components. At the lower level are the coherent living systems components. At the upper level the components are noncoherent but have interactions. Because there is no outer membrane keeping the noncoherent components of the system together, those components can easily disperse, disintegrating the system and any possibility for there to be a living system. The third stage is a rudimentary system of two (or more) noncoherent coherent systems.

The fourth stage (Figure 4), again a two level hierarchy, has definite simple system interactions. There are the lower level coherent living system components. The upper level again consists of noncoherent components. While the interactions at the this level establish an ongoing system, the noncoherence of the components allows the frequency of the encounters to be so sporadic, so dispersed, that the situation is only barely an ongoing system, far too simple and inconsistent to confer a living system status for this case. The fourth stage is a simple system of noncoherent coherent systems.

So far, noncoherence without an associated role for coherence has precluded the possibility of there being a living system at the second hierarchic level, the level of the system as a whole.

System of Interacting Unicellular Species

The next stage is an ecological community system (Figure 5). Here the components of the system are the populations of the organisms, the species populations that interact with one another. The community within an ecosystem is composed of all the living organisms that are living there. The interactions that take place are numerous, diverse, and complex, such as competition between species for resources, ecological succession, predation, and mutualism. Community dynamics can follow trends of change or establish various homeostatic conditions. A great many general patterns of structure and process occur in community dynamics, making this situation the first in this sequence of stages to have sufficient complexity for a possible claim to actually be a living system.

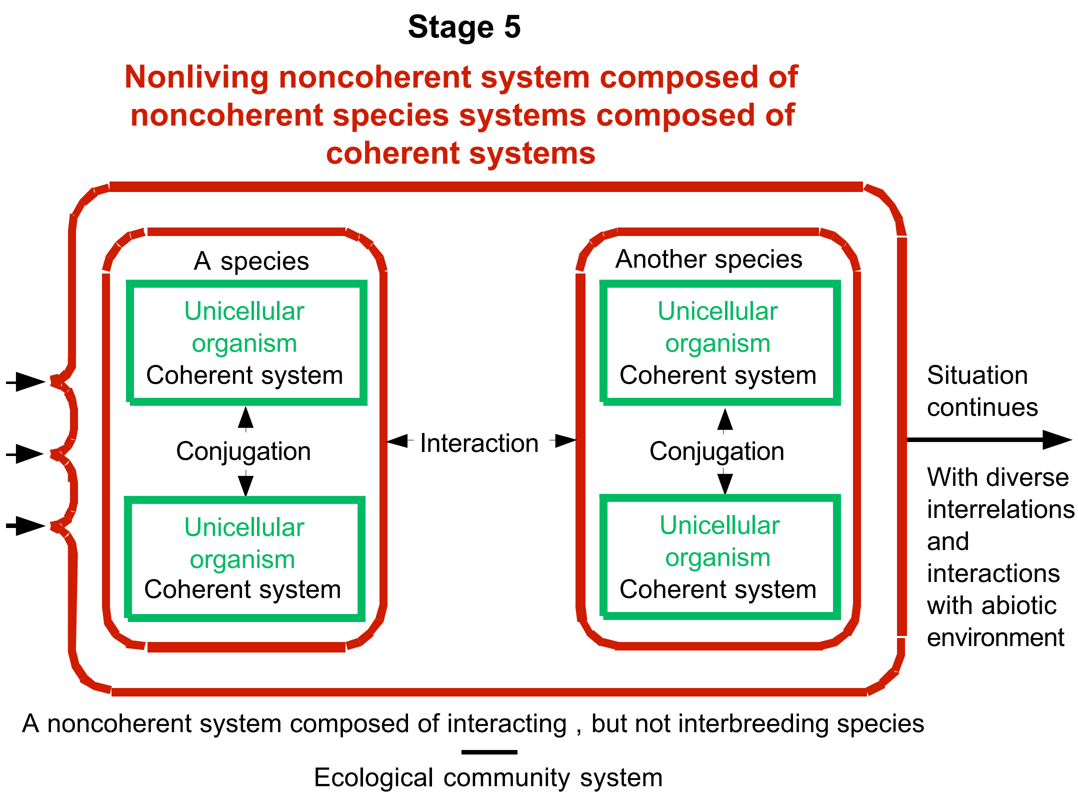

Figure 5. Nonliving noncoherent ecological community system composed of noncoherent nonliving interacting species population systems composed of coherent living interbreeding individual organisms.

The situation is now a three level hierarchy. The lowest level is composed of all the individual organisms of all the species populations—individual coherent living systems. At the second level are the interacting and interbreeding populations of each species—noncoherent systems of interacting coherent components that at the hierarchic level of the species do not constitute living systems. At the third level are the interrelations between species. Because species exist as the individuals of the species, the interactions of one species with another occur by way of interactions between individuals. The cumulative encounters establish the state of the group, the species population, in the local community of species. The situation is a noncoherent system (the community) composed of noncoherent systems (species populations) composed of coherent systems (individual creatures).

As with the previous noncoherent systems back to noncoherent group, there is no system outer barrier that keeps the interacting noncoherent subsystems together. It turns out, however, that established ecological communities tend to remain in place, despite what is probably a continuous dispersal of individuals from the periphery. The lack of a containing barrier in this case does not seem to completely preclude the possibility of this third level situation from being a living system.

As far as is known, life originated on earth only once. Since then, all life has been one, several billion year old, bifurcating cascade of reproductively linked organisms. Throughout all these unbroken diversifying chains of living beings, life has been based on the cellular pattern of organization, both with unicellular and multicellular organisms. As far as is known there has never been any other form of life than that based on the cell.

For the interactions between species at the community level to constitute a living system would be the equivalent of the re-emergence of life at a higher hierarchic level. It would be a new creation of life, a truly new creation of life because it would not be reproductively derived, not genetically derived—not a part of that great multibillion year old cascade of reproductively linked individuals. It would be creation of life by way of combinatorial enhancement, the emergence of a living system through the creation and combination of the particular set of general patterns of organization that together constitute a living system (what the artificial life researchers would like to achieve). While the emergence of life in cellular form has occurred only once, has anything like this combinatorial emergence ever happened before? Well, yes, it has, and this is why there has always been so much trouble with defining life—there are two distinct levels.

It appears that life probably originated at the cellular level, with a cell membrane there at the beginning to protect and contain the life processes. Thereafter, and on a number of different occasions, dividing cells did not separate and these situations eventually evolved into multicellular forms of life. Now, within a unicellular organism there are a variety of life processes and organelles that carry out those processes. There is a division of labor and cell machinery. The evolution of multicellular organisms is based in large part on the differentiation of the cells such that there occurs a division of labor, and the evolution of organs. Just as at the lower hierarchic level of individual cells there is cell maintenance metabolism, at the higher level there is multicellular organism maintenance physiology. Unicellular organisms are living systems, they are alive, and multicellular organisms are living systems, they also are alive. Because a multicellular organism is alive, as are the individual cells of which it is composed, there are two coexisting levels of living system, two levels of systems that are alive. Any definition of life must include both levels (there are differences).

If life can emerge at a higher level like this, can the level of ecological community achieve living system status? The answer requires a comparison of multicellular organism pattern of organization with that of ecological community. There are two outstanding features of distinction—system integration and the coherence/noncoherence aspect.

A remarkable feature of the complexity of cellular metabolism is the intricate integration of the subsystems. Of particular significance here are the roles of DNA and the subsystems that regulate gene expression, which constitute a cell system control subsystem. The physiology of a multicellular organism is also tightly integrated, and again there are system control subsystems, for example, the endocrine and nervous subsystems. In both the unicellular and multicellular cases it is system maintenance that is the primary role of the subsystems and their interactions.

Compare that with the aspects of system maintenance integration of an ecological community. Despite an impressive complexity of interactions among the components of an ecological community, the actual system maintenance integration interactions are in no way close to those of organisms. The interactions between the species components of an ecological community are, for the most part, encounters involving competition and consumption, rather than relations that enhance system maintenance integration. That ecological communities are loosely integrated compared to unicellular maintenance metabolism and multicellular maintenance physiology is made clear by the absence at the species community level of subsystems that are specifically system control subsystems. Ecological community systems do not require for the maintenance of their structure and processes the role of a system control subsystem. They do not require for their existence all the qualities that are required for a living system. The presence of system control subsystems in the organism cases and the absence of this type of subsystem in the community level case show that these are two distinct kinds of systems. An ecological community is not a living system—it is not alive.

An additional point to note here is that all the living components of ecological communities are coherent systems with outer boundaries such as cell membranes and skin and exist as individual units, while the system at the community level, lacking a barrier boundary, exists as a noncoherent system. So far, the living systems are coherent systems and the nonliving systems are noncoherent systems.

Ecosystem

An ecosystem is a system composed of living organisms and their abiotic environment (Figure 6). Under natural conditions an ecosystem is usually an ecological community and the various factors of the place where it exists, the bedrock or mineral substrate, the medium such as atmosphere or water, and the energy that passes through. The abiotic components include for example weather, topography, drainage, mineral leaching and deposit, seasons, day and night, erosion and sedimentation, and fire. The abiotic components basically set the stage for the ecosystem, and the biotic components live on or in, use, adapt to, and to various degrees, modify the abiotic components.

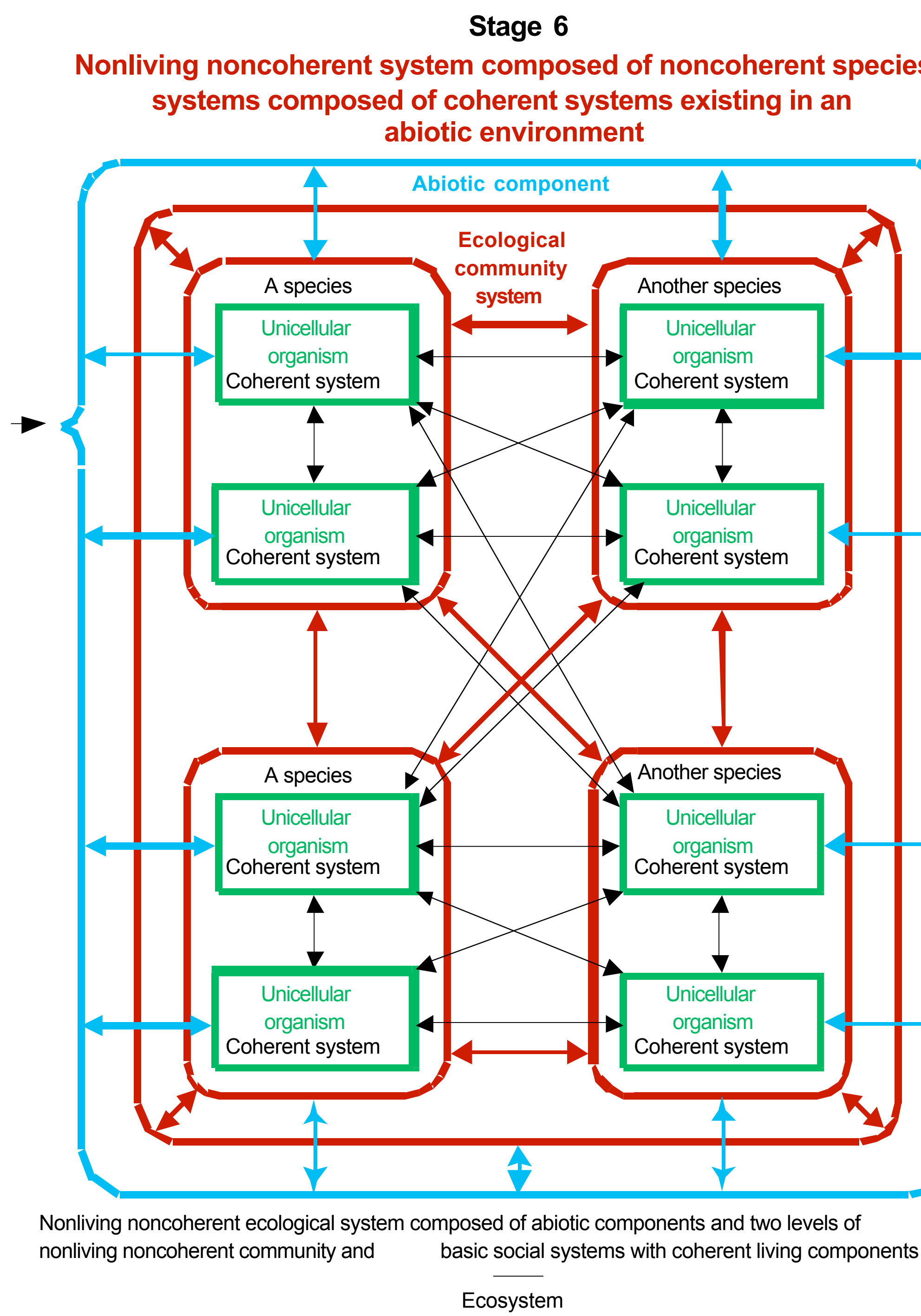

Figure 6. An ecosystem—a nonliving noncoherent ecological system with great quantity and diversity of biotic and abiotic components and their interrelations.

This discussion is considering the relations between living systems and a series of systems with living systems as components. First there are all the individual living organisms, the only actual living components of an ecosystem. Then there is the two level hierarchy of organisms interacting and constituting a system, wherein the organisms are alive but the situation at the level of simple system or social system is not alive. And there is the three level hierarchy of organisms, species, and ecological community, wherein the situation at the level of community is not alive. With an additional level, the abiotic environment, does an ecosystem—composed of living systems and a great variety of nonliving factors, components, and subsystems—constitute a living system? Is it alive?

Two critical factors distinguishing ecological community systems from living systems were the lack of a system control subsystem and the lower degree of integration in the ecological community. As it turns out, the abiotic factors of an ecosystem do not provide that system with a system control subsystem. Furthermore, the kinds of relations between the organisms and wind, leaching, and slope of the land are not the same kinds of relations between the subsystems of living systems. While there is a tremendous amount of complexity, there is not the equivalent degree of integration within that complexity. Ecosystems, like community systems, are not the same kind of system as are living systems, although they are like community systems in that they are also noncoherent systems. Ecosystems are not living systems—they are not alive.

WHY ASK THIS QUESTION?

Ecology is the interrelations of organisms and their environment, both the abiotic and the biotic aspects. The environment, the organisms, and the interrelations constitute an ecosystem. The organisms are alive. The abiotic factors of the environment, sand, the shape of a river channel, night, are not alive. The question suggests that there might be some way in which the combination of the two types of components could be alive.

Ecosystems do not look like organisms. Organisms are coherent systems, while ecosystems are noncoherent systems. The integration of ecosystems is not like the integration of organisms. Organisms have system control subsystems, while ecosystems have no role for such a subsystem. Where, then, does the idea come from that these two foundationally distinct kinds of systems could both be living systems? Two possibilities come to mind. First is the anthropomorphic projection of the living quality of organisms onto closely integrated groups of organisms, such as beehives, ant colonies, ecological communities, and ecosystems. And second, there is in the field of systems/complexity a widespread inadequacy in depth and breath of actual understanding of the nature and application of general systems thinking. The result is the misapplication of general patterns of organization, general systems principles, or isomorphies to situations where they do not occur, and the misunderstanding of the intrinsic nature of these factors and the roles they play in situations where they do occur.

Projecting the Life Quality of Organisms onto Systems Composed of Organisms

When spending a great deal of time closely observing colonies of ants and wasps, there develops a sense of the close ties between individual members of these colonies, and from that, and the diversity of their activities, there develops a sense of integrated social closeness. The colony is a unit, an active, busy whole going about its business within its environment of grasses, stones, shrubs, and trees. All the evident components, the organisms, are alive. It is natural to think of all of them together as a situation of aliveness, a living situation.

When observing an ecosystem, a forest or a grassland, what is evident is the plants and animals. The abiotic environment is there, in many ways it is visible, but it is the environment, the context. Unless there is something dynamic, grand, or particularly interesting about the abiotic factors, the mind tends to focus on plants and animals, on the ecological community aspect of the ecosystem. When observing such a community, seeing all the diverse interactions, and thinking about all that is going on there that is not immediately evident, there is again a sense of situation aliveness, the sense of a dynamic living situation.

An ant colony is a social system, a family level social system. In the organizational relation of components to the whole, it is a two level hierarchy, the living ant organisms, coherent systems, and the family social system, a noncoherent nonliving system. But there is more to insect colonies. There is almost always some artefact the insects have constructed—tunnels in the ground or in wood, nests made of various natural materials such as leaves sewn together with silk or the paper nests of hornets. These artefacts are components of the colony system, and when thinking about the colony as a living system these nonliving components are the context, the nest, or shelter of what is viewed as the living aspect of the situation. They get relegated to background, just as the abiotic aspects of the ecosystem. In both cases the mind gets distracted by the living components, and attributes to the group dynamic a feature, life, the required qualities of which do not actually exist there, at that hierarchic level of organization. The sense of situation aliveness, of a living situation, whether of a social system or an ecological community system dominating the view of an ecosystem, is a form of anthropomorphic projection. Anthropomorphism, in all its forms, is a nearly universal, subjective, human habit of mind, and a bane of accurate, objective observation and description.

Misunderstanding and Misapplication of General Patterns of Organization

From the beginning of general systems theory there has been the understanding that there are certain general patterns of organization that occur at various levels of the hierarchic organization of reality, and that additionally occur in diverse situations broadly across those levels. It was recognized that these generally occurring patterns of organization play roles in the situations in which they occur, and further, that they could be used to enhance understanding of those situations. To understand these general patterns in their diverse forms and roles, and to be able to use them as tools of analysis and further understanding is to think like a generalist.

From the beginning there was a problem. There were no generalists adept at finding these patterns, analysing, using, or teaching them. Everyone had been trained as specialists, worked within specialist paradigms, used specialist terminology to name and describe these general patterns—and the progress in general systems theory bogged down. Of the patterns that were identified, there occurred a failure to achieve deep understanding, and an equal failure to achieve the ability to traverse the breadth of modern knowledge, unifying that knowledge by using these patterns as a means of exploration and integration of understanding. The name general systems theory was abandoned by some, and the field was more fragmented—systems science, complexity science, chaos, fractals, and so on—than unified.

However, as the years went by there has always been a small core of people who would not let go of their understanding of the potential of general systems theory. Researchers recognizing the importance of systems understanding for the resolution of major world problems pushed forward the science of systems—analysing, diagramming, flow charting, simulating, and developing tools of analysis and of practical application.

Unfortunately, significant depth and breadth of understanding has seriously lagged behind. The result has been a widespread misunderstanding and misapplication of these general patterns of organization and the roles they play. And this is the other source of the question, “Are ecosystems alive?”

One major impetus for the misunderstandings behind this question was the misapplication of general patterns of organization in James Miller's living systems theory, where there are several noncoherent systems mislabelled as living systems (Miller, 1978). By mislabelling as living systems (a) the group, (b) the organization, (c) the society, and (d) the supranational system, the way was opened for researchers to wonder if there were other noncoherent systems with living systems as components that might also be considered as living systems. Once error is introduced it tends to lead to further error.

Scott Turner (2007) has analyzed processes that provide ventilation to the nest of the termite *Macrotermes michaelseni*. The above ground portion of the nest is an earthen mound with zones of porosity that allow a wind driven exchange of gases within the underground portion of the nest. The mound is a nonliving structural artefact that in physical interrelation with the wind establishes physical environmental conditions within the nest such that the termites can breathe.

Turner says, ". . . the mound's principal function as an organ of colonial physiology: it is a wind-driven lung to ventilate the underground nest." (2007, 134) This is anthropomorphism. Living lungs with their associated physiology as ventilation systems and nonliving artificial ventilation systems made of soil and driven by wind are different. Even though the factor, ventilation system, occurs in both cases, living organ and artificial soil mound, artificial ventilation systems are not lungs, they are not organs, and they do not have physiology. Both cases are ventilation systems, but of different kinds—different in what they are as ventilation systems.

The original anthropomorphism leads to further error. "One of life's most striking attributes is the tendency of living agents to assemble into what we might call 'organism-like' entities: cells into tissues, tissues into organs, organs into organisms, or organisms into superorganisms." (2007, 146) But there is no such thing as a noncoherent superorganism composed of organisms. Following the development of Turner's list of stages, the first three stages originate by way of development of coherent systems into more complex coherent systems. The last stage, however, originates by way of the development of a coherent system into a group of noncoherent individuals, a termite colony.

There are two primary problem areas where the approach to living systems theory was not adequate for a realistic theory. First, the theory did not incorporate sufficient understanding of factor development, and the consequences of that development for the roles of the factors in different situations. And second, there was not sufficient understanding of the significance of the difference between major developments and minor developments, that major developments should be expected to have major differences in consequences.

Anything that exists in a situation and plays a role there is a factor of that situation. When general patterns of organization occur in a situation and play roles there, they are factors of the situation. A fundamental and virtually universal characteristic of factors, including general patterns of organization, is that they develop, having simple form in simple situations and more complex form in more complex situations. A critically important point to understand about factor development is that as the factors occur in different form, so do their roles. Just because a factor occurs in two levels does not mean that it will occur in both places in the same manner or that its role will have the same effect on the nature of level—difference must be expected.

Here is an example using the general pattern of organization, cube. Eight small cubes can be combined to form a larger cube (Figure 7). The small cubes are components of the large cube, and there is then a hierarchic structure of two levels. The small cubes have coherent structure based on molecular bonds. They are robust and can take a hit without distortion.

The cube constructed of cubes has noncoherent structure held in place by gravity in relation to the shapes of smaller cubes. The large cube is not robust because the noncoherent relations between its components leaves it vulnerable to a blow, which would knock it apart. The higher level is different because the additional level adds a layer of complexity, allowing for a different kind of relation between components. The roles of the factor cube at the two levels are different. The lower level cubes can play roles that require robustness, and roles appropriate for cubes of their size. The higher level cube cannot play roles that require robustness, but it can play roles for a cube that is larger than a lower level cube.

There are a great many kinds of development. Development is the single most significant factor of general systems in that it is the only one that is completely universal, with all other factors of the infinite universe occurring within it. The transition from one part of space to another part is a form of development. The change that is time is another form, as is the change that is motion (Vesterby, 2008). Biological evolution, ontogeny, and ecological succession are developments. Learning, dancing, and making artefacts are all developmental processes. Plate tectonics, orogeny, erosion, and the deposition of an alluvial fan are developments, as are ocean currents and weather. The ongoing burning of a star, the ongoing orbiting of its planets, and the turning of a galaxy are cases of development. And the hierarchical organizations of material reality from elementary particles to galactic clusters are forms of development. There are a great many more. Clearly, understanding development does what general systems is supposed to do—it transports you across all the disciplines, across all reality.

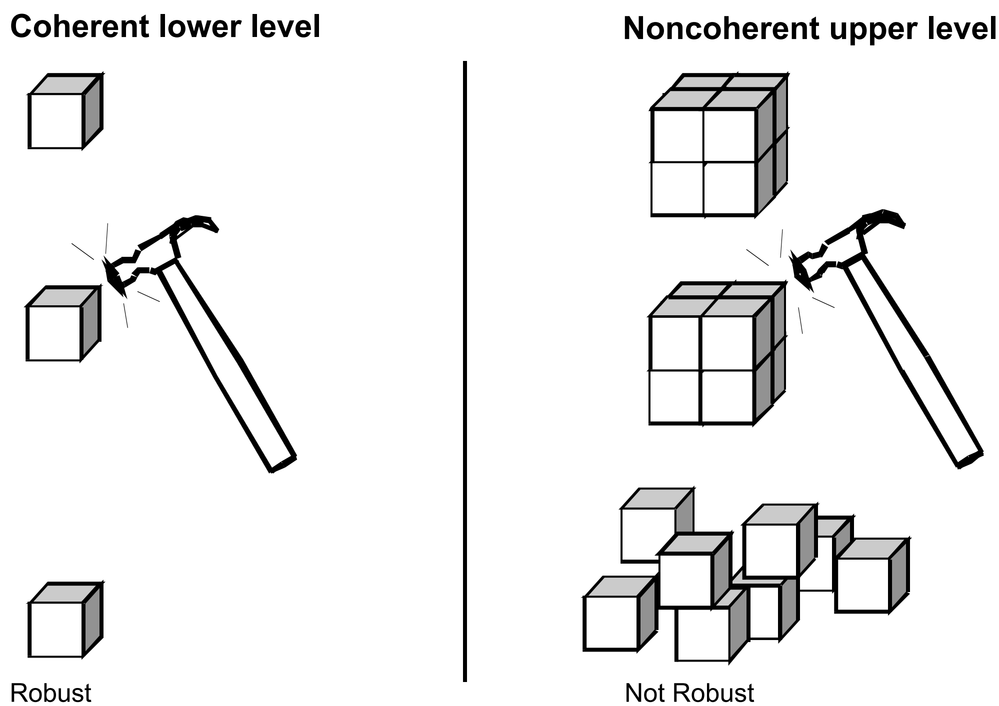

Figure 7. An extra hierarchic level provides a place for a different kind of relation between components.

To use development in that manner, as an intellectual tool of exploration and understanding, requires understanding the intrinsic nature of development as a general pattern of organization. The difference between major developments and minor developments is one of the more general and more important aspects of this factor that must be understood.

Here is a simple situation to demonstrate this difference. A drinking glass is in a sink under a tap, and a slow but even flow of water is filling the glass (Figure 8). There is a progressive change in the level of water in the glass. There is no other change in the ongoing development of this situation, and this is a case of minor development. The rim of the glass is a structural threshold of the situation over which the water eventually spills. This is an abrupt change with differences in what is happening. The level of the water in the glass is no longer changing, and the water is no longer contained by the glass. Soon the amount of water leaving the glass equals the amount entering the glass, and a steady state develops. Once more there is no other change in the ongoing development of this situation, and it is a case of minor development. There is again a progressive change, water entering and leaving the glass, but this steady state form of progressive change is entirely different from the progressive change of water slowly filling the glass. The development of the situation when the water reached the rim of the glass was a major development, and there were major differences in the nature of the situation thereafter.

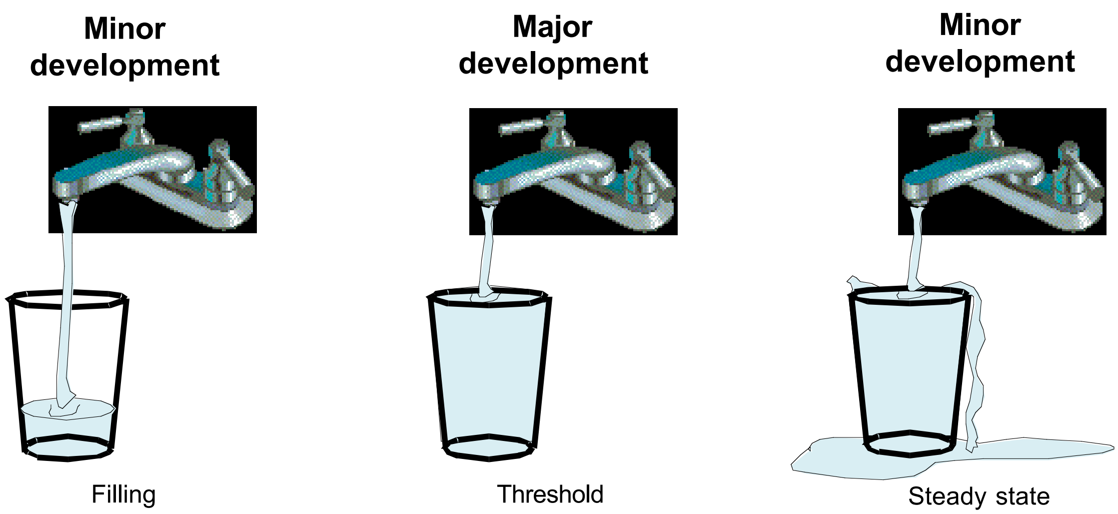

Figure 8. Threshold leads to change in the nature of what is happening.

The situation of ongoing minor changes, then a major change, then ongoing minor changes of a different sort, is itself a general pattern of organization, like threshold, steady state, emergence, or self-organization, that occurs again and again throughout the universe. An example is the steady development of the structure of the series of atoms by the progressive addition of elementary particles, then the major development of atoms combining with atoms, and the consequent progressive and diverse development of molecules and molecular complexity. Another example was all the abiotic chemistry that was taking place on earth before the origin of genetic mechanisms, that major biological development, and then the progressive and very different chemistry of life that has lasted without interruption these past few billion years. One more example—this one being the nature of evolution that took place by way of the cell division of unicellular organisms prior to the developments of multicellular organisms, then that set of major developments (fungi, plants, animals), and the consequent extraordinary kinds of evolutionary developments that then followed.

When unicellular organisms began dividing without separating and eventually evolved multicellularity, the consequence was the emergence of a new level of the general pattern of organization we call life. The new level of life started out like the prior level from which it developed—it existed in the form of coherent units. Many forms of this level have become even more like the prior level in that they have evolved to be compound systems contained by an outer barrier—a developed form of coherent unit.

Miller's living systems theory proposes a development of seven levels of living systems: cell, organ, organism, group, organization, society, and supranational organization (Miller, 1978, p. 1). The first three levels are coherent systems, while the last four are noncoherent systems. The transition from organism to group is a major development. The first three levels are unequivocally living systems. The last four levels are unequivocally systems with living systems as components. Miller proposes that the noncoherent systems are living systems, and it is this idea that can lead to the question about the living system status of ecosystems.

Miller is saying that just as a new level of living system emerged with the evolution of coherent multicellular organisms, a new level of living system emerges with the noncoherent interactive association of a group of organisms. This idea, however, does not take into account the significance of the differences that occur after a major development. The primary difference has to do with coherence and noncoherence. In the known cases where a second level of life developed, it always occurred by way of vegetative growth—cell division directly into coherent bonding, and a coherent second level. There is cell division, and association of cells, a coherent association. The case Miller proposed does not occur by way of vegetative growth. There is organism reproduction, and association, a noncoherent association. Miller is claiming the origin of a new level of living system by way of a process which is opposite from that by which all other developments of a second level of living system have occurred before. It should be noted that no evidence has ever been found that indicates that over the past several billion years a new level of what is obviously a living system has ever evolved or come into existence by way of noncoherent association of units. The transition from an organism to a group of organisms is a major development, and major differences in the consequences must be expected, not ignored.

Miller gave nineteen critical subsystems that he believed constitute a living system, and he believed that these subsystems occur in each of his proposed seven levels of living systems. "Together they make up a living system, . . ." (Miller, 1978, p. 1). The idea that this set of subsystems always constitutes a living system does not take into account the significance of the differences that occur with factor development. Factors occur in different forms in different situations because of differences of how many other factors are playing roles there, how many factors are playing roles in the intrinsic makeup of the factor itself, what the factor is made of, and the hierarchic depth of organization involved. The result is that different forms can have different roles, which can have different effects on the nature of the situation in which the factor occurs. The transition from one stage of the development of a factor to another stage usually involves differences in form, role, and the effect of the factor in the developed stage, which must be expected, and not ignored.

The nineteen critical subsystems are factors which develop through Miller's seven levels. He recognized factor development, for example the role of DNA in a cell and the role of a charter in an organization. But he did not account for the differences. There is a significant difference in the form of the reproducer subsystem at the lower three levels and at the upper four levels.

A unicellular organism reproduces by division into two cells. This process does not involve the creation of new life. There are now two cells, but the living processes of those cells are just the living processes of the prior cell divided into two parts. This is how it has been since the beginning of life. The ongoing chemistry of life has always been passed on uninterrupted in this manner. The reproducer subsystem of a unicellular organism confers life by passing on life itself. Both the organ level and the organism level are created in exactly this manner, by cell division, by life being passed on, cell division by cell division, through the process of growth. With the first three levels, the reproducer subsystem passes on life, life itself, uninterrupted.

At Miller's level of an organization the form of the reproducer subsystem is entirely different. Consider the difference in what molecules DNA is made of, and what molecules a paper and ink charter is made of. The processes by which each plays its roles are, again, different. The effects, then, can be quite different in that charters, in general, do not code for proteins. The reproduction subsystems are different in forms, specific roles, and specific effects. The one confers life by passing on life. The other confers life...........How? When an organization copies its charter, and sends off a team of its members with that copy to a new territory to establish a duplicate orgnization, there is a duplication of the charter and a division of the members of the prior group. Miller claimed that this is a living system reproducing and creating another living system. But where is the life? The actual life of the system still resides in the component organisms, the people.

The mere presence of a factor or a specific set of factors at two different levels does not render those levels the same. It does not make the systems at those levels the same kind of systems. The presence of forms of Miller's nineteen subsystems at the level of an organization does not make an organization a living system—it does not make the organization alive. Actually, the methodological expectation should be that the levels will be different, that the nature of the systems will be different. The difference in the forms is so great that rather than expecting a charter to contribute to its level being a living system, the expectation should be that that form of the factor would more likely prevent the level from being a living system.

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