Evolutionary Processes in Living Systems

Lane Tracy

Ohio University
106 Talon Drive
Cary, NC, USA
koorbats@yahoo.com

Abstract

Living systems encompass both biological and social systems. The genius of living systems theory lies in finding common structures and processes at work at such diverse levels as cells, organs, organisms, groups, organizations, communities, societies, and supranational systems. Living systems theory postulates that the commonalities result from a process by which each level evolves--"frays out"--from a lower level.

Evolutionary processes in biological systems are well known and thoroughly documented. In this paper I propose to examine whether the same processes operate in social systems. Evidence of evolution will be examined at the level of groups, organizations, communities, and societies. Particular attention will be paid to the means by which evolutionary changes are preserved and transmitted to future generations.

Keywords: evolution, living systems, group, organization, community, society

Introduction

James G. Miller (1978) proposed that the basic characteristics of life, as manifested at the cellular level, were carried to living systems at each higher level by what he called a "fray-out" process. Thus, organs and organisms did not need to reinvent the wheel in order to become living systems. The genetic information contained in the cells of each newly evolved organ, suitably modified, provides patterns for the essential subsystems and processes of life at the higher level of the organ. Similarly, evolving organisms build upon the foundation of genetic information provided by cells and organs. Organisms are able to evolve as living systems by using the DNA in their component cells to create the critical subsystems and processes that are necessary to life.

When Miller proposed this theory of a genetic process of fray-out from one level of living systems to another the evidence for it was rudimentary. However, recent advances in the study of DNA and of the genomes of ancient and modern species have broadened our understanding of genetic fray-out. Studies of the genomes of single-celled and multicellular life forms, and of the development of complex organs such as eyes and ears, have provided confirmation of fray-out from cells to organs to organisms. Indeed, a form of fray-out occurred even in the initial creation of the cellular level. Eukaryotic cells, the nucleated cells of which we are composed, are now known to have evolved from a combination of several different varieties of bacteria. Thus the development of life on earth appears to be based on a continuous process of information sharing both within and between levels of living systems.

Evolutionary processes in biological systems are well known and thoroughly documented. The fray-out process by which the necessary patterns of life were transferred from organs to groups, and thence to higher levels of (social) living systems, is less clear. The genetic information used for constructing subsystems and processes in biological systems is alpha-coded in molecules. Social systems, on the other hand, rely primarily on beta- and gamma-coded information (i.e., behavior and language) to guide the formation of the critical subsystems and processes. How can evolution account for this change? What evolutionary processes are involved?

Part of the answer lies in the fact that the switch from biological to social systems is not abrupt. It has been found that at least some of the behavior exhibited by groups and communities is governed by genetic information. In other words, Darwinian evolution certainly accounts for some of the observed social behavior of living systems. The transition from evolution based on genes to evolution based on memes is gradual.

Thanks to the popular books of authors such as Richard Dawkins (2004) and Stephen Jay Gould (1980) the world of sociobiology is no longer a secret known only to a few scientists. We have been made aware of hundreds of examples of social behavior governed in whole or in part by heredity. Yet we can easily construct many more examples of social behavior that seems to have little or no genetic component, behavior that is carefully learned. It would seem that, if we are to talk about the evolution of such behavior, we must accept Spencer's "social Darwinism" and the Lamarckian view of evolution as the inheritance of acquired characteristics, as well as the Darwinian view (*Darwin, 1859; Spencer, 1896*). Is social evolution the same process that Darwin described, a process of natural selection from randomly produced variation? That is the question that I will explore in this paper.

Evolution in Groups

Groups constitute the cellular level of social systems. The simplest group consists of two organisms linked together by common purposes and goals. The most basic reason to form a group of two organisms is to procreate. Such a group may be temporary or lasting. In animal and plant species in which the sperm or seed is broadcast, the reproductive group may consist of more than two individuals.

Because the organisms would likely not exist if their parents had not previously formed a reproductive group, evolution favors organisms that are genetically programmed for such grouping tendencies. Thus the formation of groups is a heritable tendency and the group level of living systems has a genetic basis, even though the actual genes are dispersed to the level of the component organisms.

As fertilization of an egg or seed is the most basic act of a group, Simms (1999) defined a basic unit of group work based on the energy required for this act. Definition of this unit puts the study of group processes on the same scientific footing as the processes of cells and organisms.

Family Groups

In what sense, and by what processes, do groups evolve from this most basic, generic state? One step in evolution appears to have been the formation of the family, whereby the temporary sexual partners remain together for such purposes as nurturance of the offspring, continued mating, mutual protection, or hunting for sustenance. The fertilization process does not require that the group remain intact, but once the group was formed various organisms seem to have found survival value in extending the duration and functions of the group.

The most primitive groups do not continue to exist beyond copulation, and the offspring resulting from fertilization are left to fend for themselves. At some point in history, or perhaps at many different points, by accident or circumstance a basic mating group discovered that it was worthwhile—energy efficient—to include the offspring in the group and protect them. Thus the nuclear family group was born. To the degree that the group then made the individual members less vulnerable to predators or climate changes, or facilitated the survival of the offspring to maturity, the retention of any genetic tendency to form a nuclear family would be favored.

Another evolving group form was the single parent with offspring. In many species this is a common form of group, but it was not always or necessarily so. Such groupings evolved along with the species, perhaps because the offspring were more likely to survive and to procreate themselves if they were protected in infancy. In each species considerable testing and adjustment may have occurred, and may be continuing to occur, with respect to such variables as duration of the group, number of generations included, protection or abandonment of weak members, inclusion of adopted members, building of a residence, definition of territory, and so forth. During each of these steps the evolutionary process of selection from unprogrammed variation was at work.

Symbiosis

Symbiosis is another common source of group formation, wherein the group is composed of individuals from different species. A common example would be the connection formed between certain birds and large mammals. The mammals allow the birds to perch on their backs and remove annoying insects, while the birds obtain regular sustenance from this arrangement.

Symbiosis is also a common source of grouping in plants. A good example would be aerobic plants that thrive by growing on branches or trunks of trees in the upper levels of forests. The difference between plants and animals poses no barrier to symbiosis. Many animals, such as bees, depend on certain plants for food and help those plants to propagate. The grouping of these plants and animals may be temporary or seasonal, but the groups are recognized as such.

Descending to the microscopic level, we find symbiotic relationships everywhere, such as the presence of bacteria in the digestive tracts of all sorts of animals. Dawkins (1996) cites the example of the fig which forms an "inclosed garden" pollinated by tiny wasps that live in a community within the fig. The wasps in turn harbor a community of bacteria that aid them in processing the fruit for energy.

Culture and Language

Up to this point we have not required a new mechanism for transmission and perpetuation of evolutionary changes. The various group processes discussed above can easily be encoded in the genetic profile of the species and preserved through procreation. At some time, however, group processes arose that were learned and transmitted by culture, either through imitation or by the use of language.

Culture and language provide new means for augmenting the genetic template of the group. New purposes and goals can be recorded in the hierarchy of values that govern group decision making. Innovations can be memorized and incorporated into the set of behavioral options. When innovations can be taught and learned through imitation or explanation, the group no longer has to wait for several generationsof natural selection to incorporate new behavior into the inheritance of its members. Natural selection can favor groups that are able to share innovations most efficiently and effectively.

For example, a recent book by Carel van Schaik (2006) documents the transmission of technological innovation in a large orang utan group on the island of Sumatra. In this group the use of a variety of tools was found and it was observed that the use of these tools was closely watched and copied by other individuals, even though such social behavior is not common among orang utans in general. Other nearby groups lacked both the tools and the social behavior of the tool-using group. Thus, van Schaik concluded that the evolution of tool using in the studied group was a cultural phenomenon, culture being the means by which advantageous innovations were preserved in the group.

Van Schaik is not arguing that the non-tool-using groups of orang utan are genetically inferior or lacking in intelligence. There is plenty of evidence that captive orang utans are able to learn to use a variety of tools. Van Schaik assumes that the groups on Sumatra that do not use tools have the intelligence to do so. What they lack is a culture that encourages imitation. It is the combination of genetically-based intelligence and communication-based culture that allows one group to obtain advantage from technological innovation.

Many species can be seen to lead their offspring by example. Ducklings and goslings seem to have a genetic predisposition to imprint on the first object they encounter, which would ordinarily be their mother. They then follow and copy everything the mother does, learning by example. The genes they inherit do not have to specify this learned behavior. Only the tendency to imprint must be inherited. And part of what they learn is to stick together as a group.

Much of human behavior is transmitted not only by genes and culture but also by language. Both culture and language augment genes as means of preserving and passing on advantageous innovations in a family group. But how are technological innovations generated and what is the means by which they are retained in future generations?

Some innovations occur by chance, just as genetic mutations do. A chimpanzee happens to poke a stick into a hole and observes that it comes out covered with delicious ants. The chimpanzee has the intelligence to realize that this is an act worth repeating. Other chimpanzees in the group observe the process and copy it. The group fares better than other groups that have not developed the same technique. In this instance technological innovation spread by culture still seems to follow the rules of Darwinian evolution.

When an innovation is planned and designed by engineers, however, it becomes more difficult to argue that we are capitalizing on chance variation. Yet even with the advantage of widespread education and communication each innovation seems to await discovery by a particular individual or group. The chance aspect of the process lies in who makes the discovery first, and perhaps in having the resources necessary to make the best use of the discovery. Being the first with an innovation offers a potential advantage to the discoverer.

For social learning at the group level it is reasonable to assert that Darwinian evolution still dominates but that Spencerian or Lamarckian evolution is also present. "Survival of the fittest" means not only being able to capitalize on chance variation but also being able to foresee what might be an advantageous innovation. The ability to plan and foresee and propagate an innovation is a combination of genetics and culture, and the actual creation of the innovation is partly by chance. Yet there is also a sense in which the adoption of an innovation by a group precedes its inclusion in the charter that defines the group. In extending the concept of evolution to groups and higher levels of living systems we are blending the ideas of chance variation and deliberate adoption and practice of new behavior as the source of change in the template of the system. Whatever the source of change, however, survival-of-the-fittest remains as the mechanism by which it is carried into the future.

Evolution in Organizations, Communities and Societies

Miller (1978) specified three levels of living systems above the group level: organizations, societies, and supranational systems (such as the United Nations). Communities were discussed as a possible additional level, but were not fully recognized until later (Miller & Miller, 1990). All of these levels were discussed with reference to humans but not other species. Thus any "evolution" perceived in organizations, communities and societies would clearly be based at least partly on language as the medium of communication and storage of new social structures and patterns of behavior.

We discussed the role of culture and language as well as genes in the evolution of groups. Like groups, the higher levels of living systems are composed of organisms, and thus there is always a genetic component to the structures and patterns of behavior found in organizations, communities and societies. But as we ascend the hierarchy of living systems, culture and language assume ever greater importance in the evolution of new forms.

Species of Organizations

Organizations are defined as "systems with multiechelon deciders whose components and subsystems may be subsidiary organizations, groups, and (uncommonly) single persons" (*Miller, 1978, 595*). Organizations tend to be highly artificial systems built upon a foundation of vision, mission, policies and procedures, often stated in written form in a charter. The charter is to the organization what a set of genes is to the cell or organism, i.e. basic instructions by which the system is built and operated. Yet the charter is augmented by the genes of the members of the organization and by less formal instructions such as norms and customs.

There are many distinct types of organizations, akin to the species of organisms. Organizations may be for-profit or non-profit, public or private, providing products or services, ranging in size from local to national to multinational. Their productive processes may be small batch, large batch or continuous. They may be real or virtual. Although organizations may be capable of changing from one type to another, such a species change is unusual.

When a new type of organization is created, it is often a new organization that does it. The new type may be created in response to new opportunities, development of a new technology, or loss of an old niche. For example, the development of the telegraph enabled railways to emerge as a new style of geographically extended organization. Radio did the same for steamships and airlines. The internet allowed the rapid development of a whole new species of virtual organizations, most of whose members may never meet each other in person.

Technological innovation seems to favor ever-larger organizations. Many types of smaller organizations have found it difficult to compete for resources as conglomerates and megastores dominate the stage. Organizationally, we appear to be in an age that favors large systems rather than small ones. If the smaller species of organization are to survive, they may need to grow larger, smaller, or form symbiotic relationships with the larger species. Indeed the symbiotic role for smaller organizations may be happening, as large organizations disperse functions such as research and service in order to focus on core competencies like production and marketing.

Modification of the structure and/or behavior of an organization may be initiated by any of the elements noted above. For instance, the top echelon of the decider--the executive committee, perhaps--may decide to revise the charter to take advantage of new opportunities, such as the development of a new product. This may involve building new structures such as a subsidiary or a joint venture. More gradual change may be initiated by the replacement of key members of the organization and a consequent shift in its culture. Growth in the size of an organization may introduce new difficulties in communication that require a new structure or adoption of a new technology.

Institutionalization of Organizational Change

The question for this paper is not how organizations change, but how change is institutionalized and passed on to later generations. In particular we are concerned here with large-scale change or the development of new species of organizations.

When a new type of organization or a major revision of an existing type occurs, it is typically done on an ad hoc and trial basis. There may be no elaborate plan or charter because no one really knows what to expect. Instead, the plan may be to play-it-by-ear and adjust the organization as necessary.

The top echelon of the decider subsystem may deliberately try to prevent premature solidification of a new type of organization structure, until the difficulties and opportunities are more fully known. That was the strategy used by Dee Hock (2005) in the creation of Visa International, a new type of organization built to take advantage of new technology and a business climate that favored a global network for credit card transactions.

If a new style of organization succeeds, word quickly spreads. The organization may look for other applications of its structure and may spawn subsidiaries or franchises in its own image. Other organizations and entrepreneurs will look at the new model to see if it fits their situation as a whole or parts of it might be useful. Obviously, learning is part of the process by which a new species spreads. But its success in establishing a new species depends on other factors as well.

Is the new style easily adopted by other individuals in other cultures, or under different leadership? Does it continue to flourish when competitors adopt a similar style? Is it readily adaptable as the environment continues to change? In other words, some of the same "selection" occurs with respect to learned aspects of structure and behavior that occurs in Darwinian evolution. Furthermore, the genetic makeup of the organic components continues to be a limiting factor in adaptability and in ability to maintain a new organizational structure.

Evolution in organizations differs from organic evolution with respect to how change is generated more than it differs in how new forms are spread. Organizational change can, of course, occur by chance. Organizations do sometimes capitalize on accidental discoveries. But organizations also try new structures and procedures deliberately, often with the specific intention of morphing into a new form if fortune favors the change. Organizations often invest in research on new technology, thereby helping to create the very conditions that will force them to change.

Evolving Communities

Miller (1978) originally considered communities to be organizations, but later acknowledged their status as a distinct level of living systems, placing communities above organizations even though many organizations are larger than most communities. Communities have evolved from small villages, often pulling up stakes and moving periodically, to market centers seated at the crossroads of trade routes, to city-states and capitol cities, to metropolises and suburbs. They have developed many different forms of governance, means of transport and communication, ways of competing for population, and methods of coping with waste products and pollution.

A community can be virtually synonymous with an organization or a society. Hershey, Pennsylvania was created by the Hershey organization for its workers, as were many other company towns. Cities such as Paris, Mecca, and Tokyo have come to symbolize whole societies, even though they do not contain all of the population of those societies.

Communities also exist in non-human species. Dawkins provides a marvelous description of an ant "town" in "The Leaf Cutter's Tale" (*Dawkins, 2004, 395-397*). A nest of leaf cutter ants can have the population of a large city, an elaborate infrastructure of tunnels and chambers, a well-defined economy based on leaves and fungi, a clear division of labor and the domestication of fungi. Many kinds of bees and termites build similarly large and elaborate communities.

The primary difference between human communities and insect communities is the means by which they are generated. The instructions for the building of an ant community reside in the genes of the ants. Although human communities may build to some extent on the genetic instructions for family preservation, the details of construction have obviously evolved well beyond any original genetic base. As with organizations, the charters of human communities contain many elements that have been deliberately crafted and then have stood the test of competition.

Our history records the failure and disappearance of other species of human community, such as city-states, walled towns, and villages built into the face of a cliff or on top of a mountain. Obviously, change in organizations is subject to the test of survival. To the extent that the change is deliberate, however, it is not pure Darwinian evolution.

Societal Evolution

Human societies are composed primarily of communities, but organizations such as government bureaus and political parties often have a strong role in the decision making processes of the society. Furthermore, major change in a society is often initiated by groups of people who have hitherto been excluded from decisions or suppressed as members of the society. Individual voters also play a role in many societies. Disaffected voters may opt for change even when the nature of the change is not at all clear. Thus, change in societies is initiated at many levels and with varying degrees of predictability.

Competition with other societies is only one of the factors determining the success and continued viability of societal change. Innovations may be tested by the availability of resources, changes in climate, reinterpretation of the charter or of fundamental beliefs, unpredictable changes in leadership, new technology, immigration and influence from other cultures, and a variety of other factors.

Innovation in societies is probably less a matter of planning and more subject to chance than in more tightly-knit organizations and communities. Thus, Darwinian evolution may account well for most change in societies, even though culture and language are the primary means for the transmission of such change.

Summary

Miller (1978) adopted evolution as the process by which living systems developed from cells to organs to organisms to groups to organizations to societies to supranational systems. In doing so he extended Darwinian evolution, based on natural selection from random variation, into the social realm in which Spencer (1896) saw natural selection--survival of the fittest--from more deliberate and planned change.

Recent research in genetics and sociobioloty has confirmed the importance of Darwinian evolution in the realm of cells, organs, and organisms and to some extent in groups. It has also confirmed the role of evolution in the progression from one level to the next. It is less clear, however, how fully Darwinian evolution can account for evolution within and between the levels organizations, communities, and societies. In particular, the variations at these levels are often the result of planning, not chance.

Natural selection still seems to account for the success of some changes and failure of others, but at the levels of social systems there is also planned selection with respect to what changes are tried. Furthermore, the means of retention of change shifts from genes to culture and language, which are more readily controlled and manipulated toward planned ends. These factors blur the distinction between Darwinian and Spencerian (or Lamarckian) evolution.

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