SYMBIOSIS AS A METAPHOR FOR SUSTAINABILITY PRACTICE IN HUMAN AFFAIRS

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ABSTRACT

This concept paper is an exploration of various symbiotic relationships and their potential relevance for the organization and conduct of human affairs. Many types of symbiosis exist: between plants, between plant and animal life and between different animals. They contribute to protection and defense, cleaning, reproduction, nutrition, transportation and illumination. Some symbiots are so tightly coupled that they are not able to exist, or exist in the same form, separately. Others can exist separately but they are less viable alone than together. Still others benefit from but do not depend upon the relationship. All seem to provide complementary features and strengths that either enhance the success and well being of both or impose a bearable burden on the non-advantaged partner.

We are seeking, and none too soon, new ways to make a difference in the achievement of sustainable relationships in human society and organizations and between human activity and the natural environment. A broader and deeper appreciation of symbiosis in the general public and among researchers in different disciplines may make a contribution to both innovation and a more effective application of existing knowledge and tools.

*Keywords***:** symbiosis, yoyo model

INTRODUCTION

Metaphors and analogies from the natural world are a rich source of ideas for both the systems field and its ability to contribute to finding answers to social and organizational problems. Sometimes these ideas are based on or backed up by laboratory or field research; sometimes they simply offer potential insight. Seemingly simple situations may be revealed in all their complexity as in Maturana's biology of cognition. Complex situations may be simplified by using simpler analogies, such as when the US Department of Transportation analyzed traffic flow as if it were a hydraulic system using Prigogine's ideas.

Stafford Beer found these possibilities useful in his work in British steel long before the publication of the Viable System Model and Team Syntegrity process. In Decision and Control (Beer, 1966), he introduced what he referred to as 'the yoyo model'. It tracks the process of moving from an insight, expressed as metaphor, between a managerial

situation and a scientific one. By selecting relevant factors, the model may be conceptualized and tested according to logic. If it meets that test a more rigorous formulation may be made that produces an isomorphism between the managerial and scientific situations. Finally, a scientific model, probably expressed in mathematics, may be proposed which applies to both. He gave an example of using a well-studied experiment in animal psychology – namely the learning curve of a rat learning to run a maze – to predict the 'learning curve' of a new factory as it reaches its output potential.

In this paper, it is my intention to consider examples of symbiosis as metaphors for designing and utilizing new or more wholistic ways to integrate current disparate activities and point the way toward an increasing appreciation of our interdependence within the natural world. Sustainability, in the long run, requires human life to re-conceptualize itself as part of nature, subject to its constraints and its opportunities. Symbiosis well illustrates these opportunities (Margulis, L. 1998) (Perry, N. 1983). From the bacteria in our digestive tracts to our place as part of the earth's animal and plant kingdoms, we are symbiots embedded in a web of interconnections. We could not live without these relationships, whether or not we are aware of them. Awareness could, however, spur adaptation, innovation and a certain humility that would help us avoid more damage our planet and ourselves.

SYMBIOSIS

The notion of symbiosis appears to offer a particularly rich source of metaphors and analogies. It means, quite literally, living together. There are three main types of relation:

Mutualism – where both parties benefit, although not always equally or simultaneously

Commensuralism – where one party benefits and the other suffers no ill effects, and

Parasitism – where one lives off the other although if the parasite gets too greedy, both it and the host will die.

Its examples range from the general phenomenon of plant and animal life exchanging carbon dioxide and oxygen to the very specific that become essentially a new species. The most common example of this is when particular types of fungi and algae (some of which are no longer found in a free state) come together to form lichen. The strength of the relationships varies from obligate or 'crucial to their survival' to 'beneficial but not necessary'. Many relationships fall between these two extremes.

Human beings have been learning, sometimes to their cost, about the ways in which they are connected within the web of life. Given the increasing impact of human activities on the natural world, learning more about these connections has become a matter of survival. Humans need to both become more aware of the risks being run and the measures needed to reduce or counteract them. Learning how symbiosis works can provide both specific ways to improve survival or quality of life and a general appreciation of the range and strength of interconnections and relationships. In common with other organisms, human

beings are required to adapt to changes in their environment and often to find new ways to survive. Like many living things, these adaptations include responding not only to absolute criteria but also to gradations in carrying capacity and time frames.

Organisms living in symbiosis perform a number of different, and sometimes multiple services for one another. A favourite and colourful example of multiple services is the relationship between the clownfish and the anemone. The anemone is stationary, and feeds by attracting and stinging prey. The clownfish is a mobile and attractive meal for many predators. But, the clownfish is able to form a relationship with an anemone that gradually allows it to build up resistance to the anemone's sting and enables it to live without harm in close association with the anemone. When this relationship has formed, the clownfish attracts predators who are then stung by the anemone. The clownfish shares the anemone's meal and, through its motions, keeps the water circulating and the anemone's immediate area clean. Protection is provided by the anemone, cleaning by the clownfish, and nutrition by collaboration between them.

Let's look at more examples of these services and where there might be analogies to human and social systems.

DEFENSE AND PROTECTION

In nature, organisms help each other avoid predators in several ways. The blind pistol shrimp and the goby fish divide responsibilities to mutual benefit. The goby fish can see and the shrimp can burrow or dig a tunnel that both it and the goby can use for shelter. The shrimp maintains contact by touch with the goby fish while both feed. The goby fish wiggles its tail when a dangerous predator is approaching. When the shrimp gets the signal it burrows and both take cover.

Hiding in plain sight characterizes the relationship between the sponge crab and red sponge. The crab breaks of a piece of sponge and hooks it to its shell. The sponge grows over and covers the crab's shell providing camouflage. The advantage to the sponge is that it, as a filter feeder, it benefits from the constant change of water as the crab moves. It also gets extra nutrients from the crab's leavings.

Anemones and different kinds of crabs collaborate in similar ways to that of the anemone and clownfish with the difference that the anemones live on the crab shells and the crab carries them from place to place and increases the anemone's nutritional variety.

Mammals also engage in mutual protection. In Africa, the herds of impala antelope and baboons collaborate at water holes. The impala has sharper senses and can give warning when predators approach. The aggressive and territorial baboons will protect both their own groups and the impala.

This is comparable to the relationships that grew up between early humans and dogs. The dog has much more sensitive hearing and smell than the human and is much more difficult for a predator to sneak up on. The humans shared food and shelter with the dogs

and joined them in repelling attackers. This relationship changed over time and dog/human interactions evolved to take advantage of different circumstances. Herding dogs enabled people to graze sheep among hills not conducive to farming. They protected the sheep from predators and were able to keep them from wandering off and getting lost. Sled dogs extended the range of the Inuit into terrain where they could not otherwise have survived. In the present time that relationship has become both more general (many dogs are predominantly companions) and more specific (such as when the dog's superior sense of smell is trained to enable it to perform search and rescue operations or sniff for explosives). The evolution of human/dog mutualism can serve as an example of the potential for refining and extending comparable interactions.

When we come to look at purely human analogies, we see some comparisons to symbiosis in nature. The Cold War between the United States and the former Soviet Union provided one. The United States and other western nuclear powers extended a 'nuclear umbrella' over NATO countries as well as South Korea and Japan. The mutual defense pact provided that the United States would regard an attack on one of these as an attack on itself and in return it received permission to operate military bases in these countries or receive other types of cooperation such as the Distant Early Warning or DEW line of radar stations in Canada, Greenland and Iceland. This type of collaboration, like that between the Impala and baboon is effective against a formidable and well-organized adversary. It is worth asking if such arrangements become counter-productive when the potential adversary is a small state with an unrepresentative or ineffective government or not a state at all. The possibility exists that the 'umbrella' strategy might now amplify rather than attenuate threats and increase the possibility for error.

Less problematically, collaboration among countries with respect to warning against natural disasters is effective. Weather satellites track hurricanes and cyclones and warn those in the path of disaster. Seismometers, supplemented by sensors on the sea floor attached to buoys give the alarm that a tsunami may be coming. Of course, messages must be received and acted upon to be effective. The current humanitarian crisis in Burma seems to have been exacerbated by the their government's failure to communicate the warnings it received to its population, as well as its reluctance to open its borders to international relief agencies to assist once the storm had run its course.

CLEANING AND WASTE DISPOSAL

It seems that little or nothing is wasted in nature. What is surplus or bad for one organism often becomes another's food directly or indirectly. While we are most familiar with bacteria breaking down dead plant and animal matter to enrich the soil, some of these relations are between organisms that actively seek each other out for cleaning.

Fish constitute the most numerous instances of cleaning. Since it is difficult if not impossible for many fish to remove their own parasites and necrotic flesh, a number of fish have evolved into roles of cleaners and clients. Even aggressive fish welcome smaller cleaner fish and allow them access to their skin and even their mouths and gills. Some fish even come to 'cleaning stations' and wait their turn with the cleaner fish. The

senorita fish and cleaner wrasse are able to service hundreds of fish in a day. This helps the client fish stay healthy and provides a substantial portion of the diet of the cleaners.

On land, some species of birds form relationships with herbivores, eating insect's disturbed by the movement of the larger animals, as well as parasites from their hosts. With the cattle egret and the oxpecker the herbivores benefit both from parasite removal and from the bird flapping its wings and drumming on its head when predators appear.

Formal and informal re-cycling provide actual and potential examples of 'cleaning' in human societies. Edward Burtynsky documented ship breaking in Bangladesh and the extraction of metals from e-waste in China. (Baichwal, J., 2006). As dangerous as these occupations are, they provide livelihoods for many. But, it is not only the scavenger occupations that provide opportunities for re-cycling and re-use. Second hand stores, swap meets, on-line exchanges like E-Bay and Craig's list and, at a less ambitious scale, garage sales are venues for mutually beneficial exchanges. One person's junk is indeed another's treasure and both parties are usually satisfied with the exchange.

The 'cleaning' function is one of the most promising pathways to promote sustainability. Just about any industry's waste product can be turned into a different product or into energy. The challenge is to find ways of doing this that are economical and that do not add further to environmental problems. This is an obvious source of green technologies and the jobs that would accompany them.

We may also look at symbiotic plants to compensate for human folly. One risk to people in former war zones is that spent shells that used depleted uranium to increase their penetration capacity remain on site and are a threat to the well being of plants and animals, including human beings. Dundee University researchers (Formina, F., Gadd, G. et al, 2008) have found promising evidence that free-living and symbiotic plant fungi can coat the depleted uranium surfaces and change it to a mineral form that is more stable and less likely to spread and be ingested. The potential for these fungi to perform a similar function in other soil polluted by metals is also a promising avenue of research.

POLLINATION AND PLANT REPRODUCTION

Pollination, performed mostly although not entirely by insects, transfers pollen from the male to the female plant. Insects visit the flowers for nectar and carry the pollen from one plant to the next. The symbiotic relationship between bees and the many flowers they pollinate has been receiving a great deal of attention these days because of the honeybee Colony Collapse Disorder that researchers are still trying to understand. A virus, pesticides and malnutrition (from a monoculture diet) and/or some combination of these have been suggested as culprits. What is clear is that a good proportion of the human diet depends on plants that bees pollinate. While it is possible for people to duplicate the bees' function with small brushes as they are trying in China, it is far from a general solution. While it is by no means certain that unintended effects of human activity are responsible, the problem of colony collapse is a wake-up call that we cannot take insect pollination for granted and must take steps to protect this relationship.

Seed distribution is a related activity. Birds and animals that eat fruit and its seeds are mobile and carry the seeds away from the plant where they have a better opportunity to grow. As long as the seeds can survive the trip through the digestive tract, they may land on fertile ground.

Burdock and other thistles (some of which are actually called 'hitchhikers') are distributed by fastening themselves on to passing animals to drop or get pulled off in a new site. While the arrangement is of benefit only to the plant, most animals do not suffer ill effects.

In human society, pollination and seed distribution may also transmit ideas, sometimes by accident. Burdock, with it's hook and loop characteristics, was the inspiration for the invention of Velcro. Many other innovations in human artifacts have been inspired by the close observation of nature. Among them are aerodynamic designs for planes and other vehicles, water and dirt repellant surfaces, building infrastructure and tools (Bluchel, K.G. and Malik, F. Eds., 2008).

A social equivalent of pollination and distribution is provided by venues for communication and the exchange of ideas in person, in print or face-to-face. Valuable innovations have often emerged when it has been possible to look at things from another angle or discuss a situation with people having different perspectives. Conferences, trade shows, business and student exchange programs and seminars where people have the opportunity to talk informally often lead to innovations. Businesses that depend on innovation often provide such opportunities from informal coffee hours to structured internal meetings. The observation that the conversations 'later in the bar' at conferences were often more valuable than the formal papers was one of the elements in Stafford Beer's design of the Team Syntegrity process (Beer, 1994). Harrison Owen (Owen, 1997) who developed Open Space Technology wrote about a similar insight.

NUTRITION AND DIGESTION

In general, life is dependent upon on acquiring enough nutrients to survive and reproduce. Animals depend directly (as in herbivores) and indirectly (as in carnivores) on plant life. Different types of homeostasis keep things in balance. One is the (simplified) example of homeostasis between predators and prey. Predators need prey to survive but if they take too many, there are not enough prey to go around and the population of predators declines. With fewer predators, the population of prey rebounds and the cycle starts again. Prey, at the population level, benefit from predators because they take the weak and the sick and keep them from depleting their food supply and suffering population collapse.

The general symbiosis between plant and animal life can become quite specific. The green hydra, for example, ingests algae that migrate to a position under the hydra's translucent outer skin. The algae are plants and produce oxygen and nutrients through photosynthesis. This provides the hydra with an additional food source when prey is

scarce. Hydra can exist without algae but are more vulnerable to variations in food supply without the added contribution of the algae's products of photosynthesis.

Cattle and other herbivores and their gut bacteria represent another type of symbiosis. They eat grass and other forms of cellulose, which they cannot break down themselves. Bacteria in the digestive tract that ferment the cellulose so that it can be digested perform that function as well as providing a source of protein for the cow. This fermentation process is what produces the methane gas that cattle expel. Although the details are less clear, human beings and their gut bacteria also seem to live in symbiosis.

In the plant world, bacteria enable legumes to convert the nitrogen in the soil to a form that plants can absorb. Crop rotation utilizing this nitrogen-fixing characteristic of legumes fertilizes the soil without the need for environmentally risky commercial fertilizers. Fungi attach themselves to the root system of trees, sharing in the nutrients produced by the tree and extending the tree's root system to enable it to absorb more water and nutrients from the soil. This relationship is especially important in dense forests where there is strong competition among trees for root space. Without the added absorption power of the fungi, many fewer trees would survive.

Human beings have learned some painful lessons from interfering in the natural balance. Creating situations with numerous prey but few or no predators and over-fishing are just two examples. Generally, species that live close together have evolved in concert and neither overwhelms the others. Introduction, by accident or on purpose, of 'exotic' species such as rabbits, zebra mussels, ice plant and Asian bark beetles has had serious consequences for local species and the balance that existed among them and often for the human activities as well.

Monoculture food crops, growing food with chemical fertilizers and pesticides, using energy to transport crops that can be grown locally over long distances, over-packaging, growing corn and soy for fuel and driving up prices all contribute to increasing our ecological footprint in unnecessary ways and place additional burdens on the less advantaged. Substantial latent potential exists in current agriculture and aquaculture to identify and build upon symbiotic relationships.

Human beings need nourishment for their minds and hearts as well as their bodies. Too often, organizational practice emphasizes internal competition rather than collaboration and inhibits rather than enhances the sharing of information and the building of trust and cooperation. Other than creating a less than pleasant atmosphere, such practices may keep people from discovering opportunities for better products and services and closer relations with customers and suppliers.

ILLUMINATION

Luminescent bacteria may form symbiotic relationships with fish and squid. The fish live and receive nourishment inside their hosts. The hosts benefit because the light emitted by

the bacteria attracts prey and enable them to see at depths where sunlight doesn't penetrate.

In social systems, we may find an analogy to this type of symbiosis in that societies all over the world have been willing to support artists who create beauty, storytellers and philosophers. This is sometimes a tangible and sometimes an intangible form of illumination. People thrive with stimulation and opportunities for new learning. Exchanges among people and cultures has often stimulated both artistic and scientific advance. One may think of ancient Greece or of Italy at the time of the Renaissance. The insights and aesthetics that emerged in those times are still informing human society today.

CONCLUSION

Thinking again of Beer's yoyo model, we can see that there are many comparisons that can be made between various types of symbiosis and ways forward that might reveal insights of help us to see ways of being that would leave smaller ecological and social footprints. With a more and more connected world, we see that actions lead to consequences that are sometimes far removed from the source. Many of these comparisons are at the level of metaphor and predominantly contribute new insights. Progress on others, especially in the field of bionics, may be more rigorous and proceed to the level of analogy or even a many-to-one mapping.

Although human beings can choose different ways consciously without waiting for good fits to arise through the slow process of evolution, we can appreciate what has been achieved in nature in all its complexity and try, with humility, to find comparable answers and adapt to our changing environments with a minimum of dislocation.

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