Energy, Complexity and Strategies of Evolution

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Introduction

Cultural evolution has long been among the themes of anthropology but it has never ranked high. It is left mainly to archaeologists because they have to make sense of how society works and survives through time–a concern that has pretty much been abandoned by many cultural anthropologists. Anthropologists today seem little motivated to find out how society works, but rather to make the world a better place to live in for a particular population. The challenges of atmospheric change, nuclear proliferation, environmental degradation and resource exhaustion, the emergence of life threatening species–these challenges of contemporary evolution have awakened less interest in anthropology. The concern with cultural evolution seems to be of greater interest to non-anthropologists, such as in the work of Jarrod Diamond (2005), a biologist, and the genre that as emerged as Big History, with the works of David Christian (2005) and others. Among the few contemporary anthropologists who have sought the dynamics of cultural evolution, the work of Joseph Tainter (1996) stands out.

A scholar who has addressed these problems, but from a vaster perspective, is the astrophysicist, Eric Chaisson (2001). He proposes that both cultural and biological evolution must be seen as charged by the same dynamics that have been responsible for the evolution of the entire universe–namely, the energy initiated with the Big Bang and that has since been responsible for the emergence of galaxies, stars, planets, and in turn, life and culture. While this may appear to be an exotic claim, Chaisson effectively places human society within the larger context of the dynamics and processes of cosmic evolution.

Here we will first look at these dynamics and then turn to some aspects of contemporary society. My own bias has for many years been to use energy as a tool to

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understand how society works. Energy is still the only variable I know that provides a common measure that allows us to compare values within and between societies. More immediately, it is the relationship between energy and complexity that provides an analytical tool for examining contemporary developments.

Cosmic Evolution

Chaisson proposes that the density of free energy flow is a measure for quantifying complexity of matter with which the energy is engaged. So far as I know, no social scientists have addressed this proposition. Anthropologists interested in these models will recall the classic measure used in their field was that proposed by Leslie White, *energy per capita.* The significant improvement of this measure over that of *energy per capita* is that the latter did not include the changes in complexity that result from addition of energy to the mass of the system. It was concerned with the increase of non-human energy made available to human beings, but rather with increase with respect to all the matter in the system. The significance of Chaisson's proposition was recognized by a group of historians who have expanded their view of history to include the universe. This "Big History" takes history from the beginning of the universe –the Big Bang– down through the emergence of planetary systems, the appearance of life, and then human society and modern life[1]. It incorporates all eras that have been the subject of evolutionary studies–the evolution of the cosmos, the evolution of life, the evolution of civilization. The work of Big History is instructive in that it accepts dynamics for evolution that do not depend on contemporary social values. Since they do not resort to the usual reasons given to explain human history–motivation, technology, dialectic materialism, or God –to explain cosmic or biological evolution, they are free to seek other dynamics in the human process.

The measure proposed by Chaisson is the *free energy rate density* (Φ_m, erg s^{-1} g^{-1}), quantifying the energy that flows in a system per unit mass and unit time. For him the evolution of complexity begins with the Big Bang, with matter appearing some 12 billion years ago. Thence, he traces a slowly accelerating curve of Φ_m that shows an increasing rapid rise down to the present. In this model life emerges some 3.5 billion years ago as "islands of complexity" that today number in the hundreds of thousands of

[1] See, Christian, David. (ídid). Spier, F (1996)

different kinds of organic molecules and millions of living species. (Chaisson, 2002:11-12).

If we leave this cosmic picture and focus on evolution of life and human society over the more recent eras, additional processes become evident. While the curve traced by cosmic evolution shows a gradual increase in the rate of the density of energy flow, the emergence of life accelerates this rate so that a second distinctive phase become evident–besides the continuing horizontal increase, there is the appearance of more sharply increasing phases of energy density use. This gradual increase and then the transitions to a more vertical phase allow us see how change in energy density flow provides a common measure connecting cosmic evolution with that of life and human society. Chaisson expressed succinctly:

> "Energy –especially energy flow– is a more useful metric for quantifying complexity on all scales. From galaxies to stars to planets to life, the rise of complexity over the course of all time can be reasonably quantified by the normalized flow of energy. Physical systems are well modeled by their energy budgets; but so are biological systems, now that science has gone beyond the *élan vital* or peculiar "life force" that once plagued biology; cultural systems, too, can be so modeled, for machines, cities, economies and the like are uniformly described, at least in part, by energy flow.
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> "All complex structures are subject to the rules of thermodynamics. Not the kind of equilibrium thermostatics governing isolated, idealized systems that most of us studied in formal schooling, rather the non-equilibrium thermodynamics of open, complex systems at the frontiers of science today. Resources flow in, wastes flow out, and system entropy actually decreases locally while still obeying thermodynamics' cherished second law that demands environmental entropy increase globally, all the while energy orchestrates changes throughout.
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> "But it's not just energy. It can't be, for the most primitive weed in the backyard is surely more complex than the most intricate nebula in the Milky Way. Yet stars have much more energy than any life form, and the larger galaxies still more. Our complexity metric cannot merely be energy, nor even just energy flow. That energy flow must be normalized to open

> systems' bulk, thereby putting all such systems "on that same page." And when that's done, we find a real and impressive trend—one of increasing energy per time per mass for all ordered systems across more than 10 billion years of natural history" (Chaisson E, 2005: 2).

Obviously the flow of free energy received by our planet from the sun is absolutely greater than that used by a person. However, when the size of the world is compared with that of an individual, a person of 70 kilograms will use 250 times as much energy as that used by the world. This author compares the average density of free energy flow since the beginning of the galaxies, through its gradual increase in stars, planets, animals, and finally the human brain and human societies.

The relevance of Chaisson's proposition lies not merely in that it is a single measure serving from the beginning of the universe down through organic forms and contemporary society, but that that it is a *measure of complexity*. The direct relationship it proposes between the system's complexity and the density of free energy flow make it useful for social scientists to pursue this inquiry. As students of society we must either accept that our subject is part of this universe, and therefore must reflect that same dynamics moves the whole, or we reject it. For one who wants to understand how society works, it is essential to clarify these basic dynamics. They provide a model against which any empirical case we may want to examine must be compared for coherence.

The energy flow-complexity relationship is also useful because we can begin by presuming that it works both ways. That is, if we find envidence for increased energy flow–e.g., more resources, more people, etc. –we are alerted to look for the changes in the complexity– in the activities and organization of the society that necessarily follow. The reverse it is equally important and perhaps more useful in social analysis. If there are changes in complexity, in activities and organization, then we are alerted look for changes in energy flow, in resources, people, etc.

To summarize Claisson's arguments, cosmic evolution refers to the entire course of evolution of the material universe as we know it, including its likely initiation with the Big Bang, down to the activities that are taking place today. The Big Bang was followed by ten or eleven billions of years of radiation, followed by the emergence of matter. Some four and a half billion years ago the earth emerged and another billion years later chemical forms appeared, from which life followed. From our perspective, the emergence of life marks a new epoch. The reason for this is not merely that we are more interested in what happened then, but because evolutionarily life introduced a whole new level of complexity of matter, a new level that can be measured in terms of the *energy rate density*. Life marked a significant acceleration in the complexity of new forms.

Let us return to the question of values in our analyses. I earlier argued that energy provides an analytical tool that helps avoid problems that arise from the values provided us by our society. This does not mean that we avoid dealing with values. On the contrary, energy provides us with a way of comparing values both within a society and, for evolutionary purposes even more interesting, to compare values of different societies. We can compare, for example, various solutions to social problems in terms of the energy cost of the alternative solutions. Higher energy-cost solutions will probably require more complexity than those that require less. If the values of the society so demand we seek more energy, at least we will know that we will have to pay in complexity for this privilege.

The New Biology

The emergence of life saw perhaps a billon years of *primordial soup* followed by a longer era of the emergence of more diverse life forms. Within the past billion years fossil forms have survived that provides us with a history of the shape of the more recent evolution of life. Until a few years a go, Darwinian evolution had done much to eliminate the earlier Lamarckian version of evolutionary change. Biological characteristics were seen predominantly to be determined by natural selection of inherited traits occurring over the course of generations. Lamarckian thinking–that traits could be acquired within one lifetime and be passed on to subsequent generations–survived in models of *cultural* evolution where it was accepted that cultural traits were absolutely not inherited in a Mendelian mode, but only through learning.

Developments in molecular biology and genetics led Carl Woese to challenge the notion that the Darwinian generational model of evolution adequately described the entire course of biological evolution. He proposed that biological evolution should be seen as composed of two epochs, only the second of which has generally conformed with the Darwinian model of genetic inheritance through the generational selection of genes. Instead, there was long pre-Darwinian era that was, he wrote:

> "more a world of semiautonomous sub-cellular entities that somehow group to give 'loose' (ill-defined) cellular forms…"
> "The…interactions that such an image evokes …is strongly suggestive of physical communal organization, one not only of 'cells' but of a spectrum of biological entities, many of them not self-replicating in their own right and not all on paths to become 'modern' cells" (Woese, 2004: 173).

A salient feature of this protean community was that it was rife with *horizontal gene transfer (HGT).* These life forms were not yet species. There was no generational inheritance because there were no generations of organisms to pass on the genes. Prior to the Darwinian transition there existed,

> "horizontal gene transfer (HGT), the non-genealogical transfer of genetic material from one organism to another–such as from one bacterium to another or from viruses to bacteria…In the wild, microbes form communities, invade biochemical niches, and partake in biogeochemical cycles. The available studies strongly indicate that microbes absorb and discard genes as needed, in response to their environment" (ibid: 180).

In short, the author propose that this leads,

> "to the striking prediction that early life evolved in a Lamarckian way with vertical descent marginalized by the more powerful early forms of *horizontal gene transfer* HGT..." (ibid: 183)

The question follows of how did these horizontal communities evolve into the complex, multiple species world that Darwin described in his theories? Woese writes:

> "How are…these loose confederations…turned into the much more complex cells of today?... The thrust of early evolution is towards greater organization, complexity that leads to finer discrimination, to increased coordination, to biological specificity in general. Key to this transition is an increase in the connectivity of the parts, leading to a more complex and integrated network of

> interactions… One thing…seems likely: horizontal gene flow… was essential to evolving the protein-based cellular organization from its onset… Refinement through the horizontal sharing of genetic innovations would have triggered an explosion of genetic novelty, until the level of complexity required a transition to the current era of vertical evolution” (ibid: 186).

This suggests that biological evolution can be seen in terms of two phases, a *biological community phase* and *a Darwinian generational phase*. We will visualize these respectively as *horizontal* and *vertical* phases of evolution. Characteristic of the horizontal phase is that there is little residual history, few fossils left from the interactions and evolutionary process. In the vertical phase, components combine into more permanent forms characterized by an internal dependency on and domination by some parts on others. The vertical phase creates a new degree of increasing complexity based on increasing concentrations of energy. Verticality may displace some horizontal evolution, but more importantly it adds to it, builds upon it, reshapes it, creating a denser complexity

Woese’s propositions help places cultural evolution in a perspective within the larger biological evolutionary picture. If life first appears some four billion years ago and the first eukaryotic organisms (i.e. complex cellular structures) between one and two billion years, this means that most of life’s span on earth has been accomplished be horizontal gene transfer, and Darwinian generational selection has operated for a shorter period. In contrast to the Darwinian model, which has often been compared to a tree, horizontal gene transfer was reticulate, basically a networking process.

These horizontal processes did not, of course, stop when vertical development began to make their appearance. Research in retrovirology is making clear that viruses have been central to the emergence of complex biological forms, and that they have continued to be constantly active since their earliest appearance. In them can be seen the continuing dominant role of horizontal strategies.[2]

[2] See review by Michael Specter, “Darwin’s Surprise,” *The New Yorker*, Dec. 3, 2007, pp. 64-73. This review also refers to the “fossils” of early viruses.

The Emergence of Culture

In the more recent past of the biologist's Darwinian era, human beings appeared with their ability to create culture. Life itself had seen an acceleration of the rate of free energy density, but with culture this was further hastened. The complexity that emerged with the human nervous system created the ability to associate internal mental states–ideas and values–with external events, and its most effective conveyor, language. These abilities introduced an entirely new energy capturing capacity into life on earth.

The complexity of the brain introduced a new phase of horizontal transfers. Organisms had long since been capable of thought and of relating it to action, and many animals had developed the ability to communicate by signs–sounds, bodily motions–and to interpret signs found elsewhere in nature. Culture greatly facilitated the reappearance of the Lamarkian process of *horizontal transfer*–although now it was not of genes, but of ideas, information, and habits.

Many advantages were afforded by culture. It was applied directly to energy capture by the improvement of tools and weapons on the one hand, and by the improved organization of the hunt and food collection. Better organization allowed what was, in comparison with biological evolution, a very rapid development of social complexity, specifically the emergence of social hierarchies.

The social hierarchies that began to emerge 10,000 years ago accelerated the emergence of new elements and dimensions in human life. Human beings until that time had been migrating across the world as local conditions became unattractive or intolerable; perhaps overpopulation, the exhaustion of favored game, natural disasters–floods, volcanic eruptions, droughts, earthquakes–all made people move. Human life was essentially playing out a horizontal strategy. Hierarchies, however, introduced the vertical strategy.

What is now a traditional paradigm of cultural evolution–progressively laid out by Morgan, Childe, Leslie White, Elman Service, Morton Fried, and Robert Carneiro–still sits well today. The more recent work of Joseph Tainter frames questions in terms that I find useful because he uses energy as an analytical concept for understanding complexity in evolution. Tainter sees evolution as a process of problem solving, where the solutions set the condition for subsequent problems. Let us begin with his proposal of three societal conditions, or historical phases, in terms of what he calls 'outcomes' to the way 'long term institutions' have taken to solve their problems. (1) Societies may survive by keeping energy consumption low and retaining simplicity; (2) they may survive by aggressively increasing energy use and becoming more complex; and, (3) they may fail to get enough energy, and therefore break down, collapse and/or disintegrate.

The first phases of his model accords well with what can be characterized in Woese’s work as a *biological community phase* marked by horizontal gene transfer. The second parallels Woese's *Darwinian generational phase*, which he described as, “refinement through the horizontal sharing of genetic innovations would have triggered an explosion of genetic novelty, until the level of complexity required a transition to the current era of vertical evolution” (ibid, 2004). Each of these phases now accords, respectively, with a *horizontal phase or strategy* and a *vertical phase or strategy*.

To these Tainter adds a third–collapse– “a rapid simplification, the loss of an established level of social, political, or economic complexity.” In energetic terms it occurs when, for whatever reason, the available energy is reduced and the society fails to get the resources it needs to survive at its accustomed level of complexity. In cosmic evolution Chaisson recognizes this may occur in various ways, including selection or what he prefers to call “nonrandom elimination”, destructive energy flow leading to a breakdown or explosion and disappearance into a black hole (2001: 150-159). In biology, this phase is summed up in terms of the various paths to extinction–meteorites, drought, changing sea levels, volcanic explosions, over hunting, changing climate, etc.

A Shape of Evolution

The three phases here set forth can be seen in a number of ways. First, they describe historical phases in the evolutionary history of any system. I prefer to see them as problem solving strategies that a society uses to pursue survival. The *horizontal strategy* occurs at the beginning of any system, when energy and resources are limited, posing a long initial horizontal period during which the various forms of matter find conditions apt for the emergence of new complexities. Of equal importance are later horizontal eras during which systems find it necessary to adapt to a reduction of resources. *Vertical strategies* are those during which energy sources are increasingly exploited, expanding with new technologies, finding new resources, during which increasingly complex organizations come emerge to take advantage of the resources.

The final phase is, of course, highly varied, depending on the kind of system and the conditions that lead to its decline.

The line traced since the beginning of the universe is, of course, a gradually accelerating curve or, better said, a series of accelerating curves, many of which end suddenly or decline into extended horizontal eras. Given the consistency that seems to exist in these diverse phases of the evolution of matter, it is not surprising that they have been described in terms of some general principles. The horizontal strategy, what Tainter cites as, "resiliency through simplification," is a *process* that can be mapped on to Prigogine's *principle of minimum entropy production*:

> "When given boundary conditions prevent the system from reaching thermodynamic equilibrium (i.e., zero entropy production), the system settles down in the state of 'least dissipation" (Prigogine; Stengers, 1984: 137-140).

This principle has been widely examined and applied to biological systems, but is seen to have limits as a broad general principle. It has been applied analogically by Jeffrey S. Wicken to biological and ecosystems as a *selection of efficiencies*, or as an *efficiency principle*, which he describes as being a part of natural selection: "That evolution occurs under conditions of limited resources means that it occurs under economic boundaries with limiting kinetic means of degrading energy." Here we also use it analogically, to describe a *process* whereby human social systems also will reduce complexity and entropy production rather than collapse.

What Tainter describes as, "continuity based on growing complexity and increasing energy subsidies," can be mapped on to the principle of energy maximization described by Alfred Lotka in 1922:

> "In every instance considered, natural selection will so operate as to increase the total mass of organic system, to increase the rate of circulation of matter through the system, and to increase the total flux through the system, so long as there is presented a utilized residue of matter and available energy" (Tainter, 1996: 2)

This proposes that natural selection favors those dissipative structures that use greater amounts of energy. This dynamic is evident in the process of life: the society or species that more successfully use resources have advantages over others. The second clause of Lotka's statement proposes a critical condition: it states that when energy is not available, continuing maximization is frustrated. Lack of availability may result from the exhaustion of resources (the path to the "the limits of growth") but may also be due to other circumstances that prevent access or expansion.

The energy dynamics of the third phase–disintegration, collapse, and catastrophe–are diverse. Chaisson cites cosmic explosions, or the gravitational pull of a black hole, either of which may destroy stellar or planetary systems, and indeed, galaxies. This occasionally happens in human societies, as when heavy rains cause landslides that cover entire communities, or as in the nuclear age, the bombing of Hiroshima and Nagasaki. Catastrophe may take place at any time in both in horizontal and vertical situations. Collapse of vertical systems is most likely when the expansion of the system demands more energy than is available to run it–when the energy or material costs exceed the resources–then the system must run down and stop[3].

We have now brought together a three-phase model of energy-driven evolution. Chaisson describes a process, cast over billions of years, of a slowly accelerating curve of increasing complexity for which he proposes three major phases–radiation, materials, and life. His discussion also makes clear that there are various ways of cutting the cosmic curve. If we follow Chaisson and use the free energy rate density to measure the biological and socio-cultural, it would describe the same smooth accelerating curve that describes cosmic evolution. Why then in social and biological evolution, do two phases seem to stand out?

What we are calling *a horizontal phase or strategy* is a situation in which matter and energy enter and leave the system at approximately the same rate. Such a system may be in a steady state, or may be gradually expanding. Expansion occurs when matter and energy expand proportionally, but no increase in Φ_m. This horizontal expansion allows for a reticular increase in complexity. The more families there are in a community, the more networking takes place, thereby increasing the complexity of the social organization. However, just as there are socio-material constraints on the size a family may reach, so there are also constraints on the size of a community. At some point, it will segment into multiple communities. With no increase in $\Phi_{m,}$ however, hierarchy can only tentatively emerge and will remain unstable. The fact that matter and

[3] I have elsewhere characterized this as a situation where the energy cost of the trigger to release energy is greater than the energy released.

energy are likely to fluctuate independently means that the particular nature of the horizontal activity will also fluctuate, ranging from limited expansion through a steady state, to collapse or disintegration.

The vertical phase or strategy takes place when Chaisson's *free energy rate density*, (Φ_m), increases. This means that the energy necessary to order a given amount of matter increases. This is expressed in *units of energy per time per unit mass*. It is this relative increase that entails, and correlates lineally with, increased complexity. The critical difference in these three states is how they relate to complexity. A *steady state* entails no change in structure or function; changes do occur, but the degree of complexity does not change. In an *expanding state* the increase in energy flow and matter entail organizational changes, but the degree of complexity in some degree remains proportional to mass. Tainter argues that a major problem with such expanding systems is that diminishing returns eventually reduce the abilities of societies to respond to challenges (Tainter, 1996).[4]

What has classically been called the Paleolithic era of social evolution saw the horizontal expansion of the species. First out of Africa into Europe, Asia and Australasia, ultimately through the entire Western Hemisphere. These movements were primarily made by small bands. Prehistorians have not tended to see these migrations as an increase in complexity. However, these are changes not only in the locus of human populations, but are also an increase in population pressure, and introduce ecological changes while that they destroy something of the order that preceded them.

In socio-cultural evolution the horizontal strategy was by no means limited to the early eras of Paleolithic expansion. Much of human life on earth has been spent in eras of low or declining energy access and social simplification. Tainter's favorite example is the so-called Byzantine Dark Age, that occurred in the 7th Century after the Empire had been dismembered and under constant pressure from Arab forces. The rulers, Tainter writes, "adopted a strategy that is truly rare in the history of complex societies: systematic simplification. Soldiers salaries were slashed, and they were given grants of land for their continuing service, civil and military administrations were combined, the economy was shrunk to locally self sufficient units, and education was

4 Joseph A. Tainter, *Complexity, Problem Solving,And Sustainable Societies, From Getting Down To Earth: Practical Applications of Ecological Economics*, Island Press, 1996, p. 1. <http://www.amazon.com/exec/obidos/ASIN/1559635037

reduced to basic literacy. With these economies and reductions in complexity, the Empire gradually rejuvenated" (Tainter, 2006: 91).

It is a common error assuming that complexity is somehow tied only to vertical processes. In fact, both horizontal and vertical processes create complexity, but of a different nature. Complexity consists of an increase in parts and connections. Horizontal complexity appears with increased networking, more interconnections, more feedback, and more new parts. Members of an ethnic group are interconnected by communication through a common language, a field of common symbols, common forms-with-meanings, i.e., a common "culture." Woese has nicely phrased this communication as "interaction at a distance." Vertical complexity consists in compounding parts and connections. It always takes advantage of horizontal networking, incorporating it within the vertical expansion. In human social organizations, vertical structures take on the appearance of hierarchies, but these are often overlapping and always fluctuating.

The Larger Picture Today

It is easy at this point to reflect on the Lotkian trajectory on which the human species is currently engaged. Mathias Wackenagel has examined the world-wide exploitation of resources including growing crops, grazing animals and pasture, harvest in timber, fishing, building up on land, and burning fossil fuels. He writes:

> "For each year since 1961, we compare humanity's demand for natural capital to the earth's biological productivity. The calculation provides evidence that human activities have exceeded the biosphere's capacity since the 1980s. This overshoot can be expressed as the extent to which human area demand exceeds nature's supply: whereas humanity's load corresponded to 70% of the biosphere's capacity in 1961, this percentage grew to 120% by 1999. In other words, 20% overshoot means that it would require 1.2 earths, or one earth for 1.2 years, to regenerate what humanity used in 1999" (Wackernagel, 2002: 266-271).

In this picture, biological and socio-cultural evolution blends into one. It is the expansion of a single species that is consuming the world more rapidly than nature can reconstitute it. Human beings are not the only species to destroy an environment; elephants are accused to being quite destructive, ants and locusts have been known to devastate entire regions. But so far, human beings are the only species that seems to be omni-destructive. We destroy forests and the tops of mountains, we play around with the temperature of oceans, and pollute the atmosphere of the entire globe. It is not comforting that the human species–in which the advanced industrial powers take the lead—are clearly exploiting their resources at a rate greater than nature can restore them. It is a startling illustration of how the trigger/flow ratio of energy leads to decline and, if no corrections are made, disintegration.

Unfortunately, we are not dealing with a single civilization where the leadership might learn of the dangers and take steps to correct for them. Rather, the world is composed of "islands of complexity," where the Lotka-like dynamics of every society is driven by its own understanding of how best to seek its own survival. Thus far in human evolution, this has led societies to ignore the welfare of the species and the ecosystem in their immediate concern for themselves. There is little question that in the long term (which may not be very long) our civilization will have to come to terms with the process of minimum entropy production

The problem of collapse lies in the fact that what we collectively call "human society" is evolving in many different aspects and components simultaneously. The species is evolving *biologically*, witnessing the emergence of new series of adaptive conditions that are, in themselves, fields of competition between emergent forms of viruses, bacteria, and the human species itself. Thus in parts of Africa we are witnessing the collapse of segments of the population under the spread of AIDS and malaria. Further, our species evolves within an *ecosystem* that is itself evolving, in which the atmosphere is increasingly warming while fossil fuel pollution is dimming of the sun.

Demographically there are areas such as Rwanda and Darfur where our species is failing to solve the political consequences of population pressure, and is killing itself off through starvation and homicidal competition. Horizontal alternative choices have not been found to allow people to continue to survive and propagate.

Survival is a continuing challenge to those societies that have to operate on minimum entropy production, that pursue life seeking horizontal alternatives. For some an attractive alternative, if it is available, is to surge vertically, to find the extra energy to create hierarchies. Until the 18^{th} century the principle extra energy was the human population, and the resultant hierarchies were always vulnerable to the loss of this human energy fuel. Then the western world explosively began exploiting fossil fuels. This at first seemed to be a great advantage in that it relieved human beings of providing the basic productive energy. However, it has rapidly become apparent that removing human labor from the productive process has in fact marginalized growing sectors of the world population into poverty. The world that has been created by fossil fuels has blocked or destroyed many of the formerly available horizontal alternative opportunities. There are few frontiers in which one can pioneer, there is little land open to small scale farming, and handicraft production cannot compete with industrial production.

Verticalization has produced what appears to be successful expansion of hierarchical societies. At the same time, it has created a continuing process of degeneration. The visible growth of wealth in some parts of the world has been accompanied by equally visible increases in poverty, delinquency, and terrorism in others. The success of verticality has led to an ever-growing society of comfort, longevity, and wealth for some. With these advantages has arisen a polarized world where that kind of apparent success has as its counterpart an equally strong sector of potential and, periodically, actual collapse.

Collapse and horizontal strategy are not merely possible alternatives for the successful evolutionary expansion of a society, but a constant structural companion of that expansion. This is obviously the case with human beings whose animal structure evolved as a device that could, by its regeneration and death, convert energy at a great rate and then die off (collapse) and be replaced by others. This succeeded in channeling more energy than was possible in the mere cellular structures that preceded the emergence of species where individuals emerge, decline and die. Human beings today are in a Lotkian festival that has made the evolution of the universe seem like a miserably slow and unsuccessful cosmic experiment. It is for better or worse part of an on-going evolutionary process in which we are ultimately dispensable.

Local Evolution

Evolution goes on constantly and simultaneously at all levels and among all kinds of living and non-living things. During horizontal processes, there are innumerable beginnings of verticality, attempts that fail. This is the scene that anthropologists have drawn of the emergence of chiefdoms, centralized organizations that last only as long as a given chief succeeds is holding his followers together. Today such attempts at verticality are evident in the business world, in the initiation and competition of political parties, in the appearance of revolutionary cells–wherever people bring control of energy under more unified controls. In the larger picture, the collectivity of businesses and governments are part of at larger process in which national states, transnational corporations, and terrorist organizations vie for ascendancy. And–to bring this back to the core dynamics of evolution–all this happens through the increasing energy rate density, energy that, as it is expended, increases complexity.

Past usages of evolution have made it synonymous with progress or advancement, often with a teleological implication, and the assumption that what comes later is better, and what is more complex is, somehow, superior. Hopefully it is clear by now that we are not using the term in this way. On the contrary, what is better depends on where one stands in the process. From the point of view of the actor, what is better is presumably what promotes his or her survival. At some points it may be better to go into a minimum entropy crouch, while at others the best thing might be a sudden Lotkian expansion.

We are now going to explore whether this shape can help us in understanding of one small corner of contemporary human society. We want to see how the four largest Mayan language, or ethnic, groups, the K'iche', Kaqchikel, Mam and Q'eqchi' evolve in this horizontal-vertical model[5]. History has often been contrasted to evolution as dealing with details whereas evolution is supposed to deal only with macro-processes. Here we will argue that history is really just micro- evolution. In so doing, we will see that what we have thought about as *development* may also be seen as one phase of socio-cultural evolution.

Biological evolutionists have for years been examining how natural selection operates constantly to generate evolutionary change. Bumpus' work with Sparrows (1989) Lack's (1968) and the Grants' extensive studies of Darwin's Galapagos finches (1989), Endler's experiments with tropical guppies (1986), Lema's work with Death Valley pupfish (2008) –all make abundantly clear that evolution is constantly going on all around us, all the time. In contrast, anthropologists and sociologists have shown little

[5] Our reason for not including more language groups is that the data is based on statistical data provided in terms of municipal population. Most of the other groups are limited to very few municipios, and therefore data concerning them is more likely to be misleading.

interest in seeing their history as part of an evolutionary process. To that degree, this is something of a new departure.

The Evolution of Maya Ethnic Groups

Every sector of society will have its own profile of evolution, at the same time that it forms part of a larger evolutionary context. We are curious to see to what degree the K'iche', Kaqchikel, Mam and Q'eqchi' each have their own course of evolution, while they also articulate with and form part of larger social, political and economic networks and hierarchies. I choose Mesoamerican indigenous societies because I am most familiar with them. Apart from my own prejudices, however, these societies have provided a clear example of how horizontal and vertical strategies can compete for dominance in the local evolutionary process. Half a century ago Eric Wolf described the so-called "cargo system," whereby individuals were assigned progressively more responsible community positions and leadership. This vertical process was, however, neutralized by the fact that the higher the position one achieved, the more financially costly it became for him; the more power one gained in the system, the more likely it was that he would become bankrupt. Thus rather than power enabling one to become more wealthy and to increase vertical power, just the opposite occurred (Wolf, 1957: 1-18). Having said this, it needs also to be said that by 2002, these communities had almost totally given up the cargo system and were operating much more as part of the national vertical system. In spite of this the differences we will now examine reflect the degree to which horizontal dynamics still dominate in some parts of the system.

In 2002 the four groups collectively comprised 78% of the total Indian population, and 32% of the total national population. As ethnic populations, they are defined by their claim to a common ancestry, but they do not necessarily constitute politically organized populations. This quality of ethnicity makes them particularly interesting for study in a model of evolution. Without going into the question of how people are assigned or assign themselves to one ethnic group or another in Guatemala, today the closest we can get to it is by personal identification. In the censuses of 1994 and 2002 respondents were individually asked concerning their identity. While Maya are culturally distinct in many respects, their variations are sufficiently great that it is not safe to try to define them in cultural terms. A particularly important cultural feature–an indigenous language–can usually be ascertained easily, but not all members of any group speak the language.

At the time of the conquest, these peoples constituted autonomous states that had evolved their own vertical structures and formed part of a network of sometimes warring Maya states. Following the conquest they suffered a severe demographic collapse–losing between 90% and 95% of their population. With the imposition of Spanish rule, the higher level of their own vertical hierarchies disappeared and was replaced by Spanish colonial authority. Spanish control was more intense in central and eastern Guatemala where the Indian states such as the Pocomam, Xinca and Pipil barely survived. Because Spain was less invasive in the western and northern Guatemalan highlands, the K'iche', Kaqchikel, Mam and Q'eqchi' were better able to survive and gradually grew again with some local political independence, although under colonial military control and the economic demands of the *repartimientos*.

Under colonial rule the four populations evolved through their own population growth. Spanish hierarchical controls restrained the conflict and competition that characterized their pre-conquest indigenous relations. The communities developed under '*repartimientos'* and '*cofradia'* systems. During the first years of independence, conservative governments perpetuated many colonial practices. Later in the 19th Century Liberals regimes intensified forced labor and so weakened the church that it lost control of the *cofradias*.

From 1870s to mid-20th century, strict vertical control was imposed through dictatorial governments that supported the regional forced labor through *caciques* and export *fincas*. The Indian communities generally survived with a high degree of local independence that continues today. Foreign investments in coffee, cotton, rubber, cattle and bananas introduced global investments–more vertical controls–but now penetrating the local Guatemalan hierarchy with transnational economic interests.

The Revolution of 1944 put an end to the forced labor and the Indian population began to operate more freely in pursuing its own economic development. Efforts to pursue political development were inhibited by continuing racial discrimination and the continuing revolution activity. Nevertheless, Indian cultural renaissance efforts rekindled ethnic identities that had been weakening under the forced labor, and population pressures were triggering economic migrations to the south coast and then into the Petén. The revolution, continuing into the 1980s, saw the massacre of ten thousands. Many more fled into in Mexico as well as to the United States.

In recent decades the development of foreign oil and mining interests on the one hand and the international efforts to create a Central American Common Market and the Plan Pueblo-Panama on the other have increasingly opened the direct economic penetration of the Guatemalan countryside. In a sense, the global vertical power structure is displacing the national hierarchy’s control over local development.

Measuring Complexity

We now want to explore how the K’iche’, Kakchiqel, Mam, and Q’eqchi’, whose access to energy resources is primarily horizontal, are finding different ways of surviving and developing while enveloped in a complex global network of vertical power structures. Since energy flow data does not exist for these populations, we are going to reverse the tactics of our analysis and, instead of examining how energy produces complexity, we will compare the relative complexity of these groups and take those differences as indices of the rate of free energy density for lack of a direct measure of the energy involved.

The question we will address is, to what degree the organization of these groups is horizontal and to what degree vertical? In agricultural communities where many are corn farmers, the structure is simple. Where farmers sell some of their produce, it is more complex. When a store is opened, then it becomes more complex in two ways. The store keeper adds complexity both by introducing two new roles–buying and selling products rather than producing–and thereby introducing a new kind of relationship, that between the buyer and the seller. As different kinds of stores appear, it becomes more complex. And when they have a mayor, and police chief, more complex yet. While we tend to keep the political and economic separate conceptually, both involved increased complexity.

The census provides two sets of data that allow us to approximate how complexity has evolved in different parts of Guatemalan society. These are the *Ramas de Actividad Economica*, and *Población Económicamente Activa…por Ocupación,* both of which classifies everyone seven years and older. It is possible to classify the categories in both sets as pertaining more to either horizontal or to vertical strategies.

Although oversimplified and subject to some obvious problems, there are significant differences in the categories of ‘*ramas’* and ‘*ocupaciones’* among the four populations. Moreover, there are important differences between the Indian groups and the non-Indian population.

The four language groups manifest two quite different profiles in terms of their evolutionary phase. The great majority of both the Q'eqchi' and the Mam are primarily in the agricultural sector and with a very small percentage having moved into other areas of more diverse production. The Mam have a modest number in commerce, and the Q'eqchi' somewhat more. Both groups have among the lowest administrative percentages in the entire 21 Maya language groups and are following horizontal strategies. These two populations are quite separate, and each follows the horizontal paths in different ways. Both seek developmental opportunities. The Q'eqchi' are spreading north because it is an open frontier. The Mam are leaping over Mexico to the U.S. because they are surrounded by other populations.

In contrast, well under half of the K'iche' and the Kaqchikel are agriculture, and both have the highest percentages in other productive activities of all Mayan groups, well above the figure for the nation. Both have agricultural figures near that of the nation and both have moved strongly into commerce, with K'iche' being higher than the national figure. In this respect, it should be noted that one aspect of K'iche' expansion in commerce involves a horizontal migration to many other parts of the country, especially the Oriente and South Coast. These two groups have also expanded their complexity into administration. While their development is among the highest of all the Mayan population, they fall considerably below that of the nation. It is here and in education that one sees where the Maya have not increase their vertical complexity to the degree that has been the case among non-Indians.

The K'iche' and Kaqchikel have advanced vertically by different paths. The Kaqchikel lie close to the national capital and many of their *municipios* have ready access to both Guatemala City and Antigua, both active commercially but also the homes of many administrative centers. The K'iche', however, have succeeded in scoring as high–often slightly higher–on most of these measures of complexity. These high K'iche' percentages derive primarily from internally generated commerce and productive enterprises have long displaced agriculture; they comprise a solid belt of midwestern highland *municipios* extending from the seven southwestern municipios of

El Quiché, the entire Department of Totonicapán, and the northern-most municipios of the Department of Quetzaltenango[6].

Differential Evolution of Language Groups

The complexity of the four ethnic groups differ markedly with the Q'eqchi' and Mam less complex and with a horizontal strategy, and the K'iche' and Kaqchikel more complex and with a marked vertical development. We now want to see how the differences between these two strategies may be manifest in various characteristics that are available to us in the national census of 2002[7].

Population changes. Unfortunately I have been able to obtain Indian vital statistics only for 1994 and there is reason to think that it has been changing significantly since then. Nevertheless, the natural increase of the Kaqchikel and K'iche' are lower than the other two, and for both the death rate has declined. The natural increase is greater with the two horizontal groups, the Mam and Q'eqchi, due to their relatively higher birthrates. The Kaqchikel, the most cosmopolitan of the four, has achieved the lowest natural increase, also due to its relatively low birthrate. These tendencies are supported by data on pregnancies and knowledge of birth control.

The K'iche' natural increase is greater than that of the Kaqchikel, which accord with the fact that the northern K'iche municipios tend more to follow a horizontal strategy. Both the Mam and Q'qechi' have more pregnancies do either the K'iche' or Kaqchikel. None of the groups have knowledge of birth control that approaches that of the non-Indians, although the Kaqchikel are far ahead of the others It is not surprising that the Q'eqchi' and Mam show higher population growth than do the other two groups.

The annual growth and natural increase of these populations is least for the Kaqchikel and increasing larger for K'iche', Q'eqchi' and Mam. It is to be expected, then, that population pressure would be relative greater for those with greater growth. There are basically two solutions to population pressure: on the one hand is increasing

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[6] The importance of this belt for its non-agricultural development was described by Carol Smith: "Class Position and Class Consciousness in an Indian Community," in Carol A. Smith, ed., *Guatemalan Indians and the State, 1540 to 1988*, pp. 205-229, New York: Academic Press, 1976.

[7] While the census is gratefully used because it provides us with about the only data we can get on these questions, it is also frustrating in that it does not provide more! In any event, the components of our analysis in this essay are restricted to those things about which we could find data. Most of it comes from the Census of 2002, but some came from Public Health statistics, and Vital Statistics from 1994.

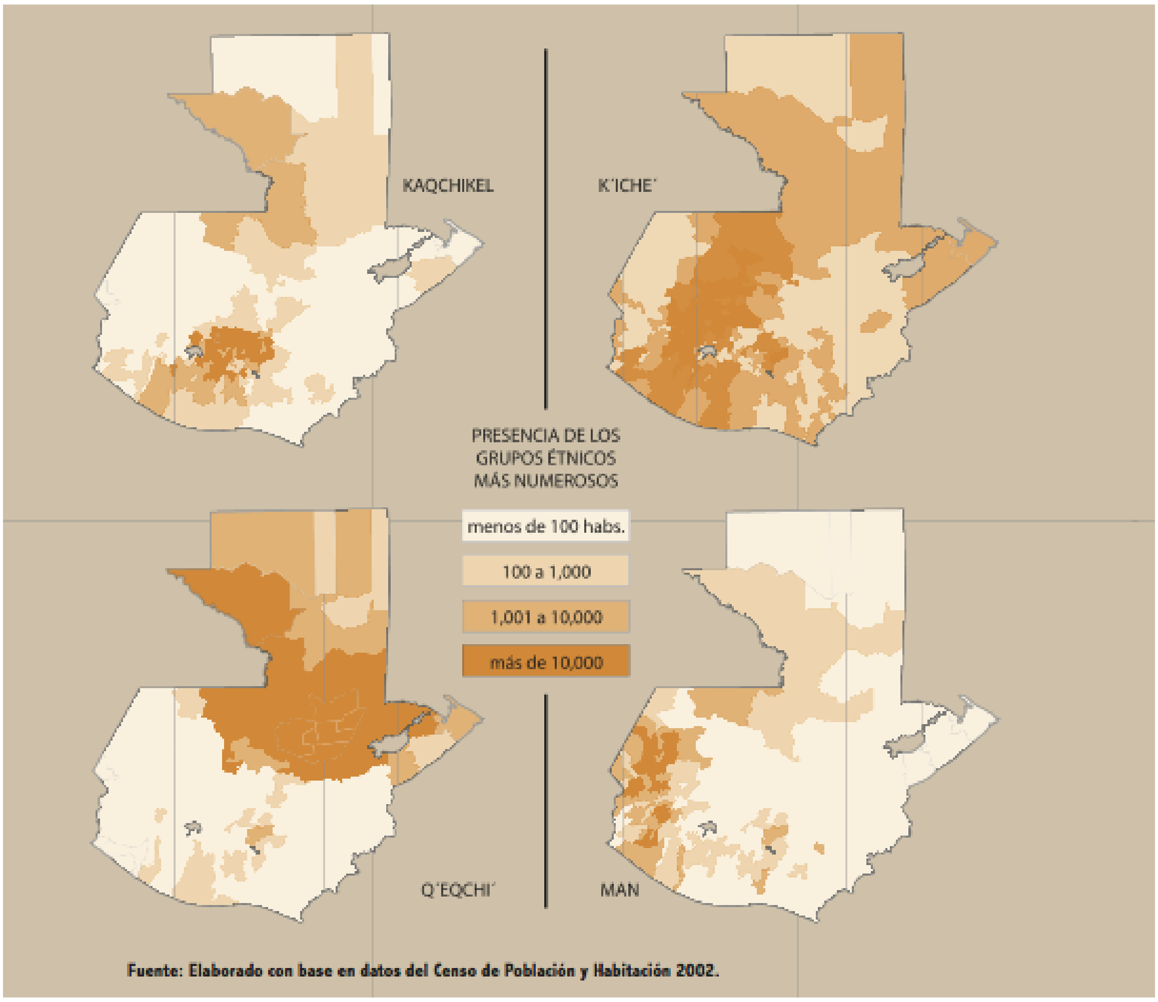
energy cost and complexity, and on the other hand, migration. The first, a vertical solution, has been an important alternative for both the Kaqchikel and the K'iche' as is evident from the greater complexity of most of their municipios. The migration alternatives have usually been to the south coast, to Guatemala City, to the northern frontier (Izabál and El Petén), and to Mexico and the United States. Migration to the south coast was especially popular in the Oriente, but was more or less exhausted by the 1980s.

Migration to the north was available mainly to 'campesinos' of the Oriente and to the Q'eqchi' of the Alta Verapaz. The Q'eqchi' have made great use of this since the middle of the last century, and continue today. The number of lifetime Q'eqchi who are migrants reporting in 2002 constituted more than half of the total Q'eqchi population, and those reported as emigrating "recently" constitute almost a quarter of the total.

Migration to Mexico and then to the US grew briskly after 1970, but figures on international migration of ethnic groups are hard to come by. The Mam and K'iche' have, by far, the highest percentage of relatives in foreign countries. But again the northern populations K'iche' can also be seen to follow the horizontal solution.

Migration to Guatemala City has been used principally by the Kaqchikel and K'iche'. In the 2002 census the first account for 38% of the Indian language speakers in Guatemala City and the K'iche' for 33%. The city is a logical alternative for the Kaqchikel as their population borders directly on it. For the K'iche', however, Guatemala City is merely one part of a much broader movement. Unlike the Mam and Q'eqchi', each of which has opted for a specific territorial movement, the K'iche' have chosen to migrate widely in Guatemala. Map 1 show how the K'iche' have spread over much of the south coast, into the Oriente, the northeast, and over much of the Petén. One characteristic of this population that accounts for this movement is their commercial activity. The belt of K'iche' municipios from central Department of El Quiché west through the Department of Quetzaltenango is heavily commercialized. Markets in communities throughout the south coast and the Oriente are now the home of commercial K'iche'. Where a century ago Chinese merchants were prominent in these communities, it is now the K'iche' who have taken over much of the local trade.

Map 1



Concentration and dispersion of four Mayan languages groups (Programa de la Naciones Unidos de Dessarrollo, 2005).

Ecology concerns with local adaptations, based on the realities of the individual's command over the local environment. An important aspect of horizontal strategy is the dependence on the immediate environment–both natural and socio-cultural. The most immediate index of the two strategies can be seen in the degree of rurality. Here the Mam and Q'eqchhi' are well above the other two groups.

They are also more dependent on the immediate natural, but again the K'iche generally fall between them and the Q'eqchi' and Mam. This can be seen in the intensity of local subsistence work of the four populations. The Mam and Q'eqchi' have a higher percentage than the other two of people economically active in agriculture, more land under cultivation for annual crops, permanent crops, and forest. In every way, their dependency on horizontal adaptation is clear.

Health Status. Another dimension of ecological adaptation can be seen in the health status of a population. The Mam and Q'eqchi' are clearly disadvantaged in comparison with the K'iche' and the Kaqchikel with respect to diarrhea, to respiratory infections, and to have benefit of medical attention. In contrast, however, the percentages of children with rickets and chronic malnutrition are the markedly lower among the Q'eqchi' than other the three groups, with percentages closer to the national average. They also score lower than the other groups with respect to the prevalencia of illnesses and accidents. The Q'eqchi', particularly those on the pioneer frontier, may benefit from being more separated from other populations. Their way of life may also account for their superior nutritional status and the lower score on children with rickets. So it is also not surprising that the Q'eqchi' score the lowest on the percent of the population that has seen a medical doctor in the last month. The Mam's horizontal strategy does not accord them the same advantages; they are the most disadvantaged, or close to it, of all groups in all categories. Unlike the Q'eqchi' they have no frontier for escape and are forced into competition with more vertically oriented populations, or seek to escape through migration out of the country.

Poverty. The role of poverty as part of an evolutionary process difficult to examined. It is obviously a problem of adaptation to the social and "natural" environment. Evaluations of poverty in Guatemala tend to reflects the perspective of a vertical society. The SEGEPLAN[8] analysis of poverty criteria include satisfaction of basic necessities, per capita income, per capita home consumption, and an Index of Human Development–including life expectancy, literacy, years of education, and PIB per capita. Much of the data is taken from the *Encuesta Nacional de Condiciones de Vida* (ENCOVI) of 2000[9]. In examining the data sought in making poverty evaluation, it becomes clear that the factors are in many cases characteristics of a hierarchical, relatively high energy, society. In a sense, some horizontality in provincial is, by definition, *poor*.

It can easily be argued that poverty is a characteristic of the minimum entropy process in operation. While seldom chosen by an individual, it is overwhelmingly the way a society keeps entropy down at the cost of the people's welfare. Poverty is rarely chosen; rather, it is one way, unfortunately, a hierarchical society keeps the economic

[8] SEGEPLAN (2005) *Mapas de pobreza y desigualdad de Guatemala*. Guatemala, pp. 6-8.
[9] Instituto de Estadistica Nacional (2000) *Encuesta Nacional de Condiciones de Vida*. Guatemala,

order. The vertical strategy of a society may make poverty inevitable, or at least worse that it might be under a more purely horizontal strategy. The Q'eqchi' and Mam have very high levels of poverty, both with respect to the other Indian groups, as well as to the non-Indian population. The Mam may be worse off because they have no frontier to which to escape.

Language. While the indigenous language is an important identifying feature for the ethnic group, in fact some 30% of all Indians do not speak one. The commitment to a vertical or horizontal strategy is manifest in the language one first learns and the degree to which the population is monolingual in Spanish. Q'eqchi' and Mam have the highest percentage with a Maya first language, and the smallest population monolingual in Spanish. At the other extreme are the Kaqchikel in both capacities. The K'iche', part of whose population is more horizontal, falls between. Verticality goes with increased participation in national life, a complexity that is dominated by the non-Indigenous sectors of national society.

While both use horizontal strategies, the Mam and Q'eqchi' differ in important ways. Frontier migration allows The Q'eqchi' relative isolation from national and foreign cultures and languages. The Mam's migratory solution, in contrast, forces them into greater contact with national culture and migration abroad, with the inevitable problems for the keeping the Indian language alive.

Education and literacy are both indicators of verticality. A school system is itself a hierarchical structure. It not only imposes a teacher over a group of students, but the teacher is employed by a bureaucracy that provides the necessary equipment–buildings, books, etc. Even in rural indigenous Guatemala, where the government often fails to provide books, and some instances even furniture, the teachers belong to a national teachers' union that has been able to halt the entire education process for weeks at a time.

In dealing with education and literacy it is important to remember that the data are taken from municipios in which over 50% of the population are Indian. It is very likely that many educated–especially highly educated–Indians may be omitted because they are not resident in their home communities. Many Indians with university educations find employment elsewhere. The figures with which we are dealing give us an imperfect picture of higher education and literacy.

It is not surprising that the Kaqchikel score higher than any other major group in most phases of schooling. Their proximity to Guatemala City makes opportunities more available. It is, therefore, interesting to note that while they score lower than the Kaqchikel in all school levels, at the university there is a greater proportion of K'iche' than Kaqchikel.

Q'eqchi' and Mam score well below the K'iche' and Kaqchikel but show rather different profiles of educational success. The Mam have the highest level at the first primary level, and remain fairly high in the second. However, in secondary education their percent drops to be the lowest and remains that way through the rest of the process. The Q'eqchi, in contrast, are lower in the primary phases, but they have a slightly higher participation in the later phases than do the Mam. Nevertheless, one test of the education system is the level of literacy in the population. To have students in primary school is the first, and therefore most important phase; and in this, the Mam prove to be more successful than the Q'eqchi', the literacy of the latter group is the lowest of the four. The horizontal spread of the population into the Petén may have outstripped the reach of the government's educational system.

Education illustrates an important aspect of the vertical dynamics. While a society's complexity may increase sufficiently to create an educational system, the question arises as to whether it becomes self-reproductive. While evolution is neither guided nor tested by *progress*, as was thought to be the case a century ago, it can be measured by whether it succeeds in becoming self-sustaining. In the case of the four Indian populations, the manner in which education has evolved is not everywhere being carried with the same degree of success. Both Kaqchikel and K'iche' have developed the system to a degree that is producing more graduates than in either the Q'eqchi' or Mam. In the latter cases the percentage of students reaching the university suggests that their advance into self-sustaining education is less than that of the K'iche' and Kaqchikel.

Horizontal and Vertical Strategies of Evolution

Of what value are the notions of the *horizontal* and *vertical strategies* of evolution? As a description of phases of history they grossly simplify the accelerated curve described by Chaisson in his model of cosmic evolution. They offer a visual model of the phases of biological evolution proposed by Woese and of Tainter for cultural evolution. But in both cases they leave the borders of the processes poorly defined; they are shorthand descriptions that are incomplete and fuzzy. As components of a model of evolution they are not very helpful.

If, however, we see evolution as a relentless dynamic process that is driven by the expanding universe and that if it happens at all it happens everywhere, then we may propose these two models as two strategies that the universe uses to keep itself evolving. They have for years been described by the Lotkian and Prigoginian principles of maximization and minimization of energy use. Whether they were proposed as laws or principles will not concern us here; they certainly serve well as strategies.

Perhaps we can think of these strategies as two descendents of Maxell's genie–Lotka's demon and Prigogine's demon. Whenever rapidly moving molecules pass by, Lotka's demon opens the door for them to continue, promoting maximization, building vertical complexity. When they pass close to Prigogine's demon, he closes the door, reducing the production of entropy and complexity. Unlike Maxwell's demon, who has yet to be caught in the act, these second generation genies are constantly at work, hastening and slowing–but always promoting–the course of evolution.

Most evolution has been horizontal. In the thirteen billion years of Chaisson's cosmic history since the Big Bang, vertical expansion only begins after life appeared some four billion years ago. Then followed Woese's long era, three billion years,

> "in which HGT (Horizontal Gene Transfer) dominated the evolutionary dynamic (and evolving cells had no stable genealogical records and evolution was communal)" (Woese, 2004: 185).

Since the appearance of bipedal hominine some seven million years ago, modern humans appeared possibly as early as 200,000 years ago, and had reached Southwest Asia a 100,000 later. The beginnings of verticality in human cultural history appear with agriculture, some 11,000 ago, but become more dominant around 5000 years ago with the appearance of city-states[10].

Verticality has been a series of surges, expansions, even explosions, of energy expenditures. All human social organization, even the earliest, involve leadership. This was the beginning of social hierarchy that became institutionalized with community

[10] This calendar follows the analysis of David Christian (2005).

leaders, headmen, and chiefs. Chiefdoms, then states, created new socio-political environments for the families and communities that reproduce the species. Verticality, as a strategy, experiments with finding ways to use more energy by making things more complex. (For Lotka's demon, it is unimportant whether the motivation is to make things more complex–hence needing more energy–or simply to use more energy.) While Prigogine's demon may be interminably successfully simply in keeping entropy low, the process may be broken at any time by Lotkian experiments, after which the system may subside to the earlier level or settle down at a higher level of energy expenditure.

The horizontal strategy thus may be assumed at any level of energy expenditure. The universe continues to expand, and the HGT continues in the world of retroviruses. Neolithic agriculture fluctuated for centuries, as did the appearance and disappearance of city-states and empires. If we use I. G. Simmons'[11] estimates of energy per capita consumption for various levels of cultural development, the Q'eqchi' and Mam societies probably operate at levels upwards of 26 Kilocalories per capita per day. They operate in a political environment of the Guatemalan state and of the international economic domains where the daily per capita energy level is closer to between 200 and 300 Kilocalories. Another way of seeing the effect of being committed to a horizontal strategy in a vertical environment is by comparing the percent of the four group populations that live in municipios where the percent of economically active population in the vertical sector is above 15%. Here we can see that the overwhelming majority of people in the first two live in the complexity, whereas in the second two only a small minority live outside it.

Although much of this discussion is concerned to differentiate horizontal strategies from vertical, in fact within any ecosystem both are constantly at work. This is particularly true in the more developed complex systems where horizontal strategies are constantly experimenting with efforts at verticality, and vertical failures retreat to horizontal survival modes. It seems as if the mentality of evolution says, in effect, wherever there is an opportunity for either, lets try it. Whether one wants to see it as a materialistic determinism or some kind of cosmic teleology, the dynamics seem dedicated to promote the use of energy. Among the horizontally committed Q'eqchi' are families in Coban and San Juan Chamelco dedicated to gaining power and vertical success. Every level of vertical success opens new horizontal opportunities. The

[11] Human per capita Energy Consumption in Historial Perspective (Units of Energy = 1 Kilocalorie per day). Simmons, I.G. (1996: 27)

promotion of education is as much an effort in the horizontal spread of capabilities as it is opening new vertical opportunities. In an ecosystem both strategies are constantly at hand and at work, often intertwined and entangled one with the other.

Recently there have been suggestions about new horizontal strategies in our global civilization. Thomas Friedman's *The World is Flat* (2007) concerns the manufacturing, commerce and information outsourcing that now reaches across the globe with few obstacles, especially in microelectronics. With computers and the internet individuals many economic levels can communicate over the entire globe. While much of this is of direct benefit to the higher sectors of the North American hierarchies, it is potentially connecting one or two billion people into a direct communication network. Part of this is manifest in the massive exporting from China, accounting for some of the increase in energy in transportation that now accounts for 27 % of the total caloric expenditure of our highly technological society–up from perhaps 18% half a century ago (Table 17).

At a different level Freeman Dyson proposes that a Woesian horizontal phase may be emerging from the fact that biotechnology now allows us–in addition to viruses–to become directly involved in horizontal gene transfer. First, Dyson sees our two phases of human civilization in terms of a metaphor of colors–green for the long horizontal phase, and grey for the vertical. He writes:

> "Roughly speaking, green technology is the technology that gave birth to village communities ten thousand years ago, starting from the domestication of plants and animals, the invention of agriculture...the manufacture of textiles and cheese and wine. Gray technology is the technology that gave birth to cities and empires five thousand years later, starting from the forging of bronze and iron,…wheeled vehicles and paved roads,… and processing plants that made agriculture more productive and transferred much of the resulting wealth from village-based farmers to city-based corporations (Freeman, 2007s/d).

Dyson's proposition, however, does not concern the horizontal transfer of culture, but of genetic material.

> "And now, as Homo sapiens domesticates the new biotechnology, we are reviving the ancient pre-Darwinian practice of horizontal gene transfer, moving

> genes easily from microbes to plants and animals, blurring the boundaries between species. We are moving rapidly into the post-Darwinian era, when species other than our own will no longer exist, and the rules of Open Source sharing will be extended from the exchange of software to the exchange of genes. Then the evolution of life will once again be communal, as it was in the good old days before separate species and intellectual property were invented" (ibid).

Dyson believes that this ability will empower people outside the cities, the rural peoples, to directly participate in gene transfers that will improve their lives. This vision of reducing inequality sounds a little like Tainter's *resilience through simplification*, i.e., a reduction of the differences that are the hallmark of vertical phases.

Seeing these differences in the Mayan groups in this manner suggests we might reevaluate what, in the last century, we called *development*. Lotka's demon has been the guiding spirit of Western Civilization: to expand, to search for new wealth, and in recent centuries, specifically to expand control over energetic resources. The notion of evolution became defined in terms of *progress*, and progress was defined as *good*. The vertical has been accepted as the virtuous path, and those who for whatever reason–lack of interest, ability, or by choice–have opted for horizontal alternatives have been classed as inferior, backward, or incompetent.

Yet when seen as a strategy of evolution, it is clear that the vertical is by far less common and more likely to lead to catastrophe than the horizontal. In simplest terms, it hurries evolution along. In seeking to expand control over energetic resources, its tentacles inevitably reach into any horizontal developments at hand, thereby affecting their ability to survive. This has become the global strategy of the human species today, and as such it now challenges that species to control the demon or to face catastrophes and collapse. The survival of the species depends on finding horizontal strategies that can reduce the use of environmentally damaging energy resources, and controlling the expansive urge to a level where compatible resources are adequate to sustain it

Horizontal strategies in today's world are easy to depreciate. Many are marked by poverty, malnutrition and starvation, and high death rates. Most also are subordinate to expansive vertical efforts and are economically and ecologically marginalized and some even driven towards collapse through genocide. To find reasonably independent horizontal efforts, we need to delve into history and old ethnographies. The early pictures of surviving hunting and gathering peoples are likely candidates; agricultural peoples are already often in competition under vertical expansive efforts. But so today are the Q'eqchi', and Mam, each in their own way finding solutions marginal to the expansion of verticality.

If the goal is to make the human society sustainable, then which strategy is more advantageous depends on the circumstances. Illiteracy, rural living, poverty, illness, poor nutrition, are "bad things." But if not actual targets for destruction, people often survive. Today the United States is home not only to the Mam, but to some 11 million Latin American horizontal immigrants seeking the recources of a high-energy vertical society, as southern Europe is the goal for millions of Africans.

If so many living with a horizontal strategy seem to seek vertical protection, should we assume that the horizontal strategy is inferior to vertical expansion? Let us compare the Mam with the Q'eqchi'. The latter have found the horizontal strategy to be preferable to the vertical alternative. The Mam, to the contrary, find that the vertical umbrella offered by Guatemala is not adequate for survival, and have sought the alternative in the United States. But there, they are now confronting deportation.

When comparing these populations, it becomes clear that living with "bad things" maybe the only alternative for survive. But are the agrarian migrant Q'eqchi' in some way inferior to those K'iche' who may want to get a university education? Can one argue that they are "worse off"? Or are the international Mam migrants better off than those who remain at home and receive the remittances?? If vertical solutions were available, then some comparison could be more easily made.

Unfortunately, even though for some Lotkian maximization still carries with it an ideology of *progress* and *cultural superiority*, evolution is following its own design. If we regard an increasingly high energy density system as being progressive, then it is a progress that portends the final phase. The more durable evolutionary strategy is most likely to be Prigoginian minimalism. The life forms that have been most successful over the longest eras of time are those that have taken the horizontal strategy. Many of those that have built increasingly complex and costly energy structures have, in the past, become extinct. The most serious human competitors appear not to be the builders of nuclear devices, but the resistant forms of streptococcus, tuberculosis, and the rapidly mutant viruses, all evolving horizontally within environments partially created by vertical expansion.

Bibliography

Bumpus, Herman C.
1989. “The Elimination of the Unfit as illustrated by the Introduced Sparrow. In: *Passer domesticus*”. Wods Hole, Mass: Biological Lectures Marine Biological Lagboratory. Pp. 209-26.

Chaisson, Eric
2001. *Cosmic Evolution, The Rise oif Complexity in Nature*. Harvard: Harvard University Press.

Chaisson, Eric
2005. “Follow the Energy: Relevance of Cosmic Evolution for Human History”. In: *Historically Speaking: Journal of Historical Society*. Vol. 6, number 5. Massachusetts: The Historical Society.

Christian, David
2005. *Maps of Time. An Introduction to Big History.* California: University of California Press.

Diamond Jarrod
2005. *Collapse, How Societies Choose to Fail or Succeed.* New York: Viking.

Endler, John A.
1986. *Natural Selection in the Wild*. Princeton: Princeton University Press.

Grant Rosemay B. and Peter R. Grant,
1989. *Evolutionary Dynamics of a Natural Population.* Chicago: The University of Chicago Press.

Friedman, Thomas
2007. *The World is Flat, a Brief History of the Twenty-first Century.* New York: Picador/Farrar, Straus and Giroux.

Freeman Dyson
2007. “Our Biotech Future”. In: *The New York Review of Books.*Vol. 54, Nº 12, July 19.

Lack, David
1968. *Ecological Adaptations for Breeding in Birds.* London: Methuen.

Lema, Sean C.
2008. “The Phenotypic Plasticity of Death Valley’s Pupfush”. In: *American Scientist,* Vol. 96, Nº 1, pp.28-36.

Programa de Desarrollo de la Naciones Unidas
2005. *Diversidad Étno-cultural…Informe Nacional de Desarrollo Humano.* Guatemala: ONU.

Simmons, I.G.
1996. *Changing the Face of the Earth: Culture, Environment, History*. Oxford: Blackwell.

Specter, Michael
2007. “Darwin’s Surprise”. In: *The New Yorker*. December 3, 2007.

Spier, Fred
1996. *The Structure of Big History: From the Big Bang until Today*. Amsterdam: University Press.

Tainter, Joseph
1996. *Complexity, Problem Solving, And Sustainable Societies, From Getting Down To Earth: Practical Applications of Ecological Economics*. Washington: Island Press. Download in June, 2009 http://www.amazon.com/exec/obidos/ASIN/1559635037

Tainter, Joseph
2006. “Social complexity and sustainability”. In: *Ecological Complexity* Vol. 3. Recovered July, 2008
http://www.elsevier.com/wps/find/journaldescription.cws_home/701873

Wackernagel, Mathis
2002. “Tracking the ecological overshoot of the human economy”. In: *Proceedings of the National Academy of Sciences*. Vol. 99, Nº 14. Standford: Stanford University's Highwire Press.

Woese, Carl R.
2004. “A New Biology for a New Century”. In: *Microbiology and Molecular Biology Reviews*. Vol. 68, Nº 2. June.

Wolf, Eric
1957. “Closed Corporate Peasant Communities in Mesoamerica and Central Java.” In: *Southwestern Journal of Anthropology*, Vol. 13, pp. 1-18.