TIME, SPACE, AND ENERGY:
A STRATEGY FOR INVESTIGATING
SOCIAL COMPLEXITY

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ANSI 242
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March 16, 2000
This paper addresses the issue of emerging social complexity, with specific reference to Andean prehistory. I contend that there are three distinct questions that we must ask, the first of which is partially answered by the declared subject of this paper. That question is “what happened?” The answer is deceptively straightforward: “egalitarian, kin-centered, relatively mobile, hunter-gatherers became non-egalitarian, hierarchically organized, sedentary agriculturists.” It is important to note that this answer does not reflect the actual variation and variability along the multiple continua from social simplicity to social complexity (egalitarian ➔ non-egalitarian, mobile ➔ sedentary, foraging ➔ agriculture).

The other two questions are no more easily answered. One is “why did social complexity emerge?” The other is “how did social complexity emerge?” These are inherently related, but not identical questions. To the former, my answer is that increased energy flows within human populations necessitated (in fact, triggered) changes in the scheduling of human activities (labor) in time and space (Adams 1988, Tchernov 1992). To the latter, my answer is that the necessary changes in scheduling produced both social differentiation and social leadership on a scale never before seen.

My approach to justifying those answers is decidedly “processual” and “evolutionary”. I believe both of those terms are used in different ways, by different people and for differing purposes. Therefore, I will begin with a clear explanation of how I intend to use the terms. Indeed, clear definitions are vital to the coherence of my argument in this paper.

I believe that the anthropological project is, by definition, “holistic”. In other words, both the mental and the material are worthy subjects for our investigation.
Separating them into two distinct categories confounds and obscures the inherent “complexity” of our species. Dualism and dualistic (dichotomist) thinking impedes understanding of complexity and complex systems. The dichotomization of the universe into “the mental” and “the material” falsely elevates mental constructs to the same plane as the measurable material world. It is not that mental constructs are uninteresting or that emic perspectives are uninformative or valueless. Such a prejudice is just as narrow-minded and unacceptable as the “paranoiac notion that positivism is some kind of predatory philosophy” (Adams 1978:299). Therefore, a more useful strategy is to adopt a monistic approach that seeks to understand the relationship between the mental and material as part of a single universe of processes (Adams 1988). I will argue in this paper that both the mental and material can best be understood as elements of a dynamic energetic process.

Another dichotomy that has been more a barrier to understanding than a facilitator is that drawn between the “particularist” (or interpretative, or postmodern, or post-processual) and the “processual”. Particularist descriptions or interpretations (mental or material) of human groups (populations, societies, cultures, etc.) can inform our analysis and understanding, but are fundamentally unfulfilling if not contextualized or compared cross-culturally and viewed from a broader perspective. In the extreme, they amount to “planless hodge-podge-ism” (White 1943:355). Similarly, the search for general “covering laws” or hypothetico-deductive explanations of human societal behavior is meaningless without the evidentiary behavioral detail of particular groups of people at particular locations at particular times. A “processual” approach necessarily requires both particularist detail and testable explanatory hypotheses. In the case of understanding the
process by which social authority and complexity emerge, explanations must be subjected to the assault of counter-examples. For a “covering law” to be worthy of the label, anomalies and counter-examples must be explained by relevant corollaries.

“Evolution” is a term so extensively, broadly, and variously used in virtually every walk of life, that in some sense it is almost meaningless. At the same time, it is the only theory that seems capable of explaining frequency variation through time. The presumption that any “evolutionary” model is necessarily unilineal and progressive seems to fly in the face of the modern synthesis in evolutionary biology and contemporary theories of social evolution. Therefore, for the purpose of this paper “evolution” means changes in relative frequencies of social, economic, and energy forms through time. Evolution is non-directional, as decline or extinction are, at least, as common as growth and innovation. “Selection” is not a reified condition that has an inherent intent or tendency towards greater complexity. Rather, it is a non-directed force or mechanism by which, based solely on relative (biological or social) reproductive fitness, (biological or social) forms continue or disappear (Kardulias 1995).

To understand the process by which human societies became increasingly complex requires an integrative approach that conjoins the particularistic detail of changes in various human populations (groups, tribes, cultures, or societies) with a theoretically well-grounded and falsifiable explanatory hypothesis. The theoretical tapestry I intend to weave is one that is grounded in an evolutionary perspective that views the various elements of the archaeological record (subsistence activities, settlement structures, architecture, ritual/ceremonial structures, labor utilization, and style, etc.) as proxies for energy forms. The appearance, modification or disappearance of specific
manifestations of each represents changes (evolution via selection) in energy forms within a self-organizing complex adaptive system. I will further argue that “energy”; although certainly fundamental to any thermodynamic model (which this is), may itself be a proxy.

The integrative approach I propose was inspired, in part, by a paper written by Gordon Willey in 1991 (Willey 1991). The second inspiration stems from two papers, one of which focused on Mesoamerica (Blanton, et al. 1996) and a second paper by Willey (Willey 1999) based on the paper of Blanton, et al. The final inspiration has two interrelated components as well. The first is a long-standing interest of mine in the work of the Sante Fe Institute on the subject of the emergence of complexity (chemical, biological, economic, and social). In that regard I have been exposed to the work of John Holland (Holland 1995), Stuart Kauffman (Kauffman 1995), and others. However, it was not until I read the work of Richard Adams that I saw a way to address complexity in an anthropological and archaeological context (Adams 1975, Adams 1978, Adams 1988).

In 1991, Willey observed that there was an alternating pattern of “horizontal integration” and “regional diversity” in prehispanic Mesoamerica and Peru. This “almost rhythmic chronological alteration of periods of cultural integration with periods of marked regionalism” suggests an oscillation or pulsing of social forms. This oscillation is manifested in changing styles and geographic distribution of art. “Horizontal” styles represented a widespread belief system or ideology that facilitated multi-regional interactions that were the ideological, economic and political prerequisites for “civilization”. Willey linked the meaning of “civilization” to the Latin *civitas*, “the city”, defined as urban population clusters, public buildings and monumental architecture.
These horizontal periods alternated with periods of regional diversity, during which there were fewer interactions and no overarching artistic style.

I will present Willey’s formulation of this alternating process, beginning with a brief overview of the fluctuations in Mesoamerica, followed by that of Peru. Because my personal research will focus on Peru, I will provide a more expansive coverage for that region. The second part of this paper presents the explanatory model developed by Blanton and his colleagues and the application of that model by Willey to his earlier interpretation of the pattern of organizational oscillation in Mesoamerica and Peru. Finally, I will present an introduction to several concepts related to non-equilibrium thermodynamics and how they might be applied to efforts to understand the emergence and evolution of social complexity.

COMPARATIVE OSCILLATIONS

In Mesoamerica the “Olmec Horizon” (1200/900-400 BC) appears during the early Middle Formative. It is marked by an idiosyncratic and recognizable art style that includes the were-jaguar as the central iconographic figure. Human representations are often “baby-faced” in appearance. There are a variety of other decorative motifs that are clearly recognizable as Olmec. At the same time, there are variations on these and other themes, with some appearing in greater or lesser frequency across the Olmec landscape. Ceramics, in particular, tend to be varied across the region, although showing a few shared design motifs (Willey 1991). The origins of the style and the basic ideas behind it are still unknown, but it is clearly a style that is integrative across the region.
The Olmec would be followed by the Late Formative and Early Classic periods, lasting from 400 BC to 450 AD. During this time a number of identifiably distinct regional art styles appeared. The period is also noted for exceptional aesthetic excellence. This was the time of Monte Alban, Izapa, Tajin and the lowland Mayan city of Tikal. It would be followed by another horizon, this time associated with the great urban center of Teotihuacan (450-650 AD). The identifying iconographic elements are “Tlaloc”, the “goggle-eyed” rain god and a feathered-serpent (Willey 1991). Whereas the Olmec horizon denotes the first appearance of public ceremonial buildings in Mesoamerica, the Teotihuacan horizon has distinctive architectural innovations, including tablero-talud terracing of the Feathered-serpent pyramid.

The Teotihuacan “Horizon” was twice as extensive as the Olmec, reaching throughout and across all of Mesoamerica. It also appears to have been engaged in more trade and commercial activity. It is still a matter of conjecture as to whether Teotihuacan commercial hegemony was enforced politically or militarily. Yet it would last only two hundred years, as the Late Classic and Early Post Classic periods (650-1425 AD) saw the return of regionally diverse styles, often showing residues of the earlier Teotihuacan motifs. This return to diversity is marked by the burning of Teotihuacan about 650 AD (Willey 1991).

In the place of a single hegemonic presence, a succession of city-states attempted to exercise control over central Mexico (Cholula, Xochicalo, and Tula, respectively). By the time of the Mixteca-Puebla culture period, numerous petty polities divided the area. Elsewhere in Mesoamerica, where Teotihuacán’s influence had been less dominant, Classic regional traditions (e.g., Oaxaca and Maya regions) continued. This post-
Teotihuacan period was also a time of frequent population movements and endemic warfare. In part, this attributed to the southward expansion and intrusions of groups from the northwest. The second factor was an overall increase of population in the region (Willey 1991).

Out of these conditions of dis-integration, competition, and demographic pressures, several groups would challenge each other for dominance. In 1428 AD, the Aztecs of the city of Tenochtitlan defeated the rival city of Atzcaptzalco, however, the extent of their direct control was less widespread than that of Teotihuacan (<1/3). Although the Aztec sculpture and ceramics were not as widespread as those of the predecessor horizons, the deity motifs are easily recognizable, as are the twin-temple constructions (Willey 1991). We do not know how extensive or how long-lived the Aztec Horizon would have been had Hernando Cortez not arrived on the scene in 1520.

In Peru, there is a similar pattern, commencing with the Chavín Horizon, named after the ceremonial complex of Chavin de Huántar in the Peruvian Andes. The horizon is dated to 1200/800-200 BC. Unlike the case of the Olmec Horizon, public buildings had appeared in Peru as much as 1000 years prior to the Chavín Horizon. These large ceremonial mounds appear first in the coastal valleys. The constructions at La Florida and Sechín are larger than any subsequent structures built in Peru. At Chavin de Huántar too, a distinctive, easily recognizable and idiosyncratic art style appeared that had a wide geographic range – from the highlands to the coast. (Willey 1991)

Chavin de Huántar is the site of a temple complex located about 250 miles north of Lima, Peru. It sits at an elevation of 3177 meters (Moseley 1992) (~10,325 feet) at the base of the eastern slopes of the Cordillera Blanca and at the point which the Huachesca
River flows into the Mosna River (Burger 1995). The monumental ceremonial center is situated to the south of the town of Chavín and is known as the “Castillo” (Moseley 1992). Two contiguous U-shaped structures (the “Old” and “New” temples) constitute the complex. As I already mentioned, the complex is significantly smaller than Sechín Alto (less than 1/10th) (Moseley 1992). The Old Temple was built at about 800 BC and was probably completed in one or two stages. The New Temple appears to have been constructed and remodeled over several stages, but the complex in its final form appears in what is known as the Janabarriu Phase (400-200 BC) (Burger 1995, Moseley 1992).

Architecturally, the finely engineered masonry platforms comprise the complex. Passageways (“galleries”) wind their way through the platform interiors, creating an intricate maize with the central passageway of the Old Temple leading to the remarkable carved-stone Lanzón stela, which stands 4.5 meters and has a point-down, knife-shaped profile. It is decorated with low relief carved depictions of a human form, with claws replacing fingers and toes and with a feline, rather than human, face. The lips are thick and pulled back in a snarl that exposes tusk-like canines. Snakes form the eyebrows and hair (Burger 1995, Moseley 1992). This is a common element of the Chavín style that tends to transpose elements. For instance, the teeth and claws of one animal may be transplanted to the body of another. Common characters include humans, jaguars, harpy (crested) eagles and crocodilians. As neither jaguar, crocodilians (caimans), snakes, nor crested eagles are indigenous to the highlands; their adoption into the Chavín thematic coterie remains a mystery. This suggests an origin to the east of the Andes, if not in from the Amazonian floodplains, then, from the mid and lower slopes of the Andes. Yet, not all iconographic symbols have their source in Amazonia, as coastal shellfish (Strombus
and *Spondylus*) and the hallucinogenic San Pedro cactus are also represented (Burger 1995, Moseley 1992).

The domestication of camelids (llama) during the Chavín Horizon facilitated interregional exchange. Llamas can carry up to 60 kg. (132 lbs.) 15-20 km. (9-12 miles) per day. In addition, they are herd animals that will follow a single lead animal. As a result, a single person can control a llama “train” of 10-30 animals. The llamas are not restricted to the highland areas, and may travel to the coast, as long as they have sufficient pasturage (or fodder) available to them. A caravan of 50 animals would require only two or three herders and could transport about 3 metric tons at maximum capacity (60 kg. X 50 = 3000 kg.) (Burger 1995).

Chavín is argued to have been a religious ceremonial center, indeed a cult center where elite individuals (“chiefs”) from throughout the Andean region came for initiation that included the ritual use of hallucinogenic drugs (San Pedro cactus, perhaps) and the temple galleries. However, beyond the religious and ritual focus, the Chavín-style art objects were also manifestations of technological innovation. Although the Initial Period had shown evidence of hammered gold and copper, by the Early Horizon forged and annealed gold and silver were used to produce three-dimensional forms. This was a significant technological innovation that permitted both the alloying and working of materials (gold and silver) in a new metallurgy (Burger 1995). Furthermore, it was not a laborsaving technology, but one that would have required significant labor (energy) inputs (Burger 1995). The production of Chavín-style objects would have represented both ritual/religious iconography/meaning and social power through the control of labor.
Thus, Chavín style and production were also alloyed in a clearly recognizable social form.

I will have more to say about the “collapse” of the Chavín Horizon later in this paper, but by the Early Intermediate Period (200 BC-550 AD), Chavín was no longer a center of influence. It was never a center of a state system that exercised political or military control over the Andes. With the recession or collapse of the horizontal period, regional fragmentation and diversity took its place (Burger 1995, Moseley 1992, Willey 1991). Ceramic designs clearly marked regions, contrasting the white-on-red painting, negative-painted and polychrome decorations from various locales. In the latter part of the period, the Moche life-modeled style and the stylized polychromes of the Nazca Valley are easily recognizable. Although residual elements of the Chavín style can be discerned, they have been reworked in the distinctive regional motifs (Willey 1991).

Metallurgical innovations were also introduced, including the first alloying of gold and copper, as well as the introduction of casting and gilding. These new metals were most often used for jewelry or ritual objects, but they also found their way into the production of some weapons (Moche) (Willey 1991). Innovations in textile production also occurred, especially on the south coast. Large adobe pyramids continued to be constructed in the coastal areas, while the highlands continued to see the construction of stone temples (Willey 1991). These massive construction projects demanded more time and energy (labor). In the Moche valley, the organization of labor and identification of labor units appear to be specifically identified by markings on the adobe bricks, as well as by variation in constituent materials and size of the adobe bricks (Hastings and Moseley 1975, Moseley 1975). Finally, war and conquest are clearly represented in the art and
iconography of the Moche “state”, as well as in the fortifications found in the valley itself (Willey 1991).

By the end of the sixth century AD, regional diversity fades with the expansion of the Huari-Tiahuanaco Horizon (Middle Horizon). The style of this horizon was centered in the area of Lake Titicaca and is most notably identified by the depiction of the “staff-god” that appears on various media but notably on the stone monolith known as the “Gateway to the Sun” at Tiahuanaco. This is an anthropomorphic figure that is holding staffs, spears or atlatls and often has radiating sunrays represented by snakes (Willey 1991). This clearly recalls the figure found on the Raimondi Stone of the New Temple at Chavín (Burger 1995, Moseley 1992, Willey 1991). The art and iconographic motifs of Huari-Tiahuanaco are found on ceramics, textiles, etc. The sudden appearance of the style across the region suggests that its expansion was due to military conquest resulting in the incorporation of diverse groups under a centralized political umbrella.

The Huari-Tiahuanaco Horizon encompasses an area substantially more widespread than Chavín, having expanded from the south northward to the Lambayeque Valley, with its strongest influence seen in the south and central regions and diminishing northwards (Moseley 1992, Willey 1991). By the later phases of the Horizon, old regional traditions began to recover. Moche realism re-emerges on the north coast, while the polychrome ceramics of Nazca are clearly reflected in the style of the Ica Valley (Moseley 1992, Willey 1991).

With the passing of the Huari-Tiahuanaco Horizon, regional diversity returns with the advent of the Late Intermediate Period (1000-1438/1475 AD). The regional polities now are geographically larger than their predecessors were. The Chimu State extends
from La Chira in the north to the Supe Valley in the south, well beyond that of the Moche State. On the central coast, the states of Chancay and Huancho are represented by their particular pottery complexes. To the south, the Chincha and Ica kingdoms also have distinct pottery styles. This variety continues in the highlands with the kingdoms of Cajamarca, Killke, Colloa and Wancani (successor to Tiahuanaco). Killke, located near Cuzco, was the small polity that would serve as the ancestral source of the Inca (Willey 1991).

Commercial, seemingly mass-produced, production of craft goods appears during this period. The abundant mold-produced Chimu blackware and great quantity of textiles of the period are evidence of this. There are metallurgical advances as well, with the introduction of tin-bronze technology from the (modern day) Bolivian highlands, Argentina and Chile. In addition to being employed in jewelry items, along with silver, gold, and gold-copper alloys, bronze also was used for weapons and tools (Willey 1991).

The end of the Late Intermediate may be dated either to 1438 AD, when the Inca began their expansion, or to 1475 AD, when they completed it. In either case, the Inca State would represent the last of the horizontal episodes in the Andes. The Killke-Inca embarked upon a series of conquests, defeating their adversaries in the southern highlands. They would extend their efforts to the coast and by the 1470s had conquered the entire Chimu kingdom and absorbed it into their empire. By the time the Spaniards arrived in 1532, the Inca Empire extended across 3,000 km (1800 miles) along the Andes and to the coast of the Pacific Ocean. It covered the widest geographic expanse of any New World polity and would have rivaled any preindustrial empire anywhere in the world (Moseley 1975, Willey 1991).
The fact that it did not overwhelm the local regional styles the way Huari-Tiahuanaco or Chavín did may have more to do with the relative duration of each horizon. The previous horizons had lasted at least half a millenium, but the Incan interregional dominance lasted just 57 years. Thus, we do not see a widespread dominant artistic style, although there are clear Incan styles represented throughout their empire. These are found in the distinctive aryballoid jars and geometric design patterns (Moseley 1975, Willey 1991).

Thus, the pattern that appears in both Mesoamerica and the Andes is one of oscillations between horizontal integration and regional diversity, beginning as early as the early second century BC. In both areas, this fluctuation ends with the arrival of the Spanish conquistadors in the early 16th century AD. The explanation for the oscillations requires a multi-step theoretical construction, beginning with the paper co-authored by Richard Blanton in 1996 (Blanton, et al. 1996) and the paper by Willey in 1999 (Willey 1999).

THE OSCILLATIONS: A POLITICAL ECONOMY EXPLANATION

Blanton and his colleagues argue that neo-evolutionary theory is inadequate to explain social change because it lacks a practical behavioral theory. They propose to fill that void with what they term a “dual-processual theory” (Blanton, et al. 1996). They contend that there are two types of power strategies for achieving and maintaining social authority. They are careful to underscore that the two strategies are not temporally mutually exclusive. Each may be operating at the same time in a given society, but only one is dominant.
The first is termed “exclusionary”. It is individual-centered. In small-scale networks it manifests itself in patron-client relationships, such as the vassalage of a feudal system. In larger scale networks bureaucratic systems supplant personalized control. In addition, there is a monopoly control of the sources of power (defined and discussed below) in both the small and large-scale networks (Blanton, et al. 1996). The other power strategy is corporate, where power is shared among various sectors and groups. This inhibits the monopoly tendencies of an exclusionary strategy. There are hierarchies but there are social or political mechanisms that prevent any one individual or group from dominating (Blanton, et al. 1996).

Furthermore, they argue that most researchers are biased in that they focus only on issues of political centralization and economic inequality. In other words, archaic “states”, including those of Mesoamerica and the Andes, are assumed to be dominated by exclusionary strategies. In contrast, they find that there are archaic state systems that exhibit corporate organizational features, such as the Greek polis of the Classical period, but that are rarely addressed in discussions of sociocultural evolution (Blanton, et al. 1996).

As to the sources of power, they delineate two general types: “objective” and “symbolic”. Objective sources are those related to wealth and the factors of production. Symbolic sources, on the other hand, are composed of elements of the cognitive code, such as religion and ritual. Two corollaries are important. First, they maintain that power is always exercised in a “culture-laden social situation.” Second, materials and symbols have power only if they move people to act. It is certainly difficult to argue with either...
and the second is of particular importance in understanding the energetic underpinnings of both the material and mental (symbolic) world (Blanton, et al. 1996).

Leaders are operating within both the exclusionary and the corporate power strategies. In terms of the archaeological record, the former should show evidence of competition, warfare, personal wealth accumulation and consumption of prestige items. On the other hand, corporate (group-oriented) chiefdoms should be characterized by massive public works (including large, open spaces or plazas for communal ritual), and a “comparative” egalitarianism in terms of individual wealth (Blanton, et al. 1996). (That may be true, but it is also possible that such wealth exists within the corporate society, but is anonymous, obscured or masked). In the symbolic realm, the corporate strategy or group-oriented social systems should emphasize collective representations (a corporate cognitive code) based on broad societal or cosmic themes (Blanton, et al. 1996). I would argue that such broad cosmic themes would necessarily incorporate elements of the natural world (sun, moon, animals, plants, etc.).

This returns us to Willey and his recent application of Blanton, et al., to his earlier model. Willey sees the fluctuation in Mesoamerica and the Andes as alternating dominance between exclusionary and corporate features. Although he has qualms that the exclusionary and corporate strategies are as dichotomous as Blanton, et al., suggest he does recognize that there is some form of dialectic operating (Willey 1999). He points to technological innovations that tend to be associated with periods or regional diversity, such as the advancements in metallurgy that took place during those periods. It is not that no innovations take place during the horizontal periods, but that they are fewer and less
dramatic. What the horizons do offer, however, is a means by which innovations are disseminated across a wide geographical area (Willey 1999).

Willey sees his concept of regional diversity reflected in the exclusionary power strategy described by Blanton and his colleagues, while the horizontal periods represent a corporate strategy. Willey fully realizes that there may not be a one-to-one correlation here, particularly in the earlier Olmec and Chavín societies. He states:

In both cases, the styles are rich in symbolism and iconography that suggests religious beliefs and, in judging from their geographic distributions, very widespread religious beliefs. Such beliefs would provide some of (sic) substance by which a large territorial political agrupement could be held together: but in neither Olmec nor Chavín do other lines of archaeological evidence fully support an integrated corporate polity. …Such symbolism must reflect at least some common understandings shared by many peoples, quite often groups speaking different languages and separated from each other by different cultures. I would think that it is symbolism such as this that holds the potential to be used for corporate political ends when the time is ripe. …Thus, corporate polities draw upon ancient shared traditions, and they rise and fall through the struggles between what are otherwise exclusionary components (Willey 1999:89).

Equally important to Willey is the Intermediate Area that lies between Mesoamerica and Peru, because this is a zone where regional diversity was always the case. There was no horizontal integration, yet sedentary agriculture and ceramics in the area predate that of Mesoamerica or Peru and agricultural technology was more advanced in the Intermediate Area than in Mesoamerica or Peru, as of 300 BC. Public buildings (Ecuador) appear about the time they do in Peru (2200 BC) (Willey 1991, Willey 1999). Were there environmental or ecological variables that influenced the development of horizons in Mesoamerica and Peru, but not in the Intermediate Area? To what extent would ideology have played a role in this difference? These are reasonable questions that
Willey asks. The final part of this paper does not necessarily answer them, but it does offer a theoretical basis for both re-phrasing and solving them.

THE OSCILLATIONS: A THERMODYNAMIC EXPLANATION

Is there another way to look at these dichotomies or dialectics that contrast corporate vs. exclusionary and horizontal integration vs. regional diversity? A Cartesian world may dictate such dichotomies for the purpose of exposition, but analyzing the underlying interplay between or among the categories may more accurately reflect material reality and lend itself to greater explanatory clarity. The starting point for this effort is the work of Leslie White, who was the first anthropologist to suggest that energy is a significant “player” in the field of human sociocultural evolution (White 1959, White 1943).

White built his model of human cultural evolution on the progressive stage theories of Edward Tylor and Lewis Henry Morgan, unilineal evolutionists of the 19th Century. White’s systemic approach began with the assumption that “the tendency of life process is always to achieve a maximum of matter-and-energy transformation” (White 1959:37). He built this idea on the work of Alfred Lotka, who had written in 1922, “in every instance considered, natural selection will so operate as to increase the total mass of the organic system, to increase the rate of circulation of matter through the system, and to increase the total energy flux through the system, so long as there is presented an unutilized residue of matter and available energy” (White 1959:37).

Two years later Lotka elaborated on his principle by declaring, “so long as there is an abundant surplus of available energy running ‘to waste’ over the sides of the mill
wheel, so to speak, so long will a marked advantage be gained by any species that may
develop talents to utilize this ‘lost portion of the stream.’ Such a species will therefore,
other things being equal, tend to grow in extent (numbers) and this growth will further
increase the flux of energy through the system. It is to be observed that in this argument
the principle of survival of the fittest yields us information beyond that attainable by the
reasoning of thermo-dynamics” (Adams 1988:36).

In 1960 Marshall Sahlins and Elman Service summarized Lotka’s principle and
applied it the question of cultural evolution, arguing, “evolution proceeds in such
direction as to make the total energy flux through the system a maximum” (Sahlins and
Service 1960:7). The conditional constraint of Lotka’s principle is the availability of
energy sources. If energy sources are restricted “life forms” that channel large amounts of
energy through the system, the system would be doomed, or in thermodynamic terms
would tend toward or reach a terminal equilibrium state (Adams 1988). In the terms of
human societies, failure to develop and extract additional energy resources (or more
efficiently utilize existing resources) would lead to collapse.

At this point some additional terms require definition. “Energy” simply means the
capacity to do work and it may be potential or kinetic. “Energy form” implies both matter
fuels such as wood, coal, petroleum, animal dung are energy forms. So are human beings
and to the extent that behavior involves the manipulation of matter, so are individual
human behaviors, social groups and assemblages of social interactions. Energy forms
also have two thermodynamic or “energetic” aspects. First, they have an inherent
potential or kinetic energy, meaning they have the capacity to do work. Second, there is
an energy cost of production and reproduction of any energy form (“no free lunches”) (Adams 1988).

An important corollary is that energy is dissipated through work (expenditure of energy). When work is performed there is a concomitant reduction in the capacity to do further work. As dissipation proceeds and energy is expended a system will move towards “equilibrium” which can be viewed as the relationship between a structure and its environment. An energy form reaches an equilibrium state (is in equilibrium with its environment) when there is no pressure on the form to change. In terms of thermodynamics, “equilibrium” is a state of total entropy. In such a state there are no energy forms because there is no potential energy (Adams 1988).

White discussed the importance of energy capture in his model, but where I believe he erred (and why his approach has been little utilized) is that he built his theory on equilibrium thermodynamics, but human societies are functioning through a non-equilibrium (or far from equilibrium) thermodynamic universe. Equilibrium thermodynamic systems are linear. In other words, if one were to take any point on a graph that plots change through time, equilibrium thermodynamics permits time reversal. One could predict (actually, “retrodict”) conditions \( t_1 = t_3 - t_2 \). In a non-linear universe, even if there is a regression line that shows a linear progression, a prior time state cannot be “retrodicted” from a present state. Nor may a future state be predicted. The graph on the following page helps to illustrate this problem. For simplicity, “measurement” could be anything (architecture, labor utilization, ceramic styles, settlement size). The graph simply depicts changes (“social flux”) through time. The red line represents a linear plotting of the change, while the blue shows the actual fluctuation from period to period.
The graph shows that there is no way to tell the condition at, for example, time period D, from any other time period on the chart. The trend from A to C would predict D at 20 on the measurement scale, but that would be wrong.

The problem this presents for understanding social complexity is that to look back from the present state of complexity or to look forward from the emergence of the hominid line can only inform us that complexity increased from point A to point K. It cannot reveal how that occurred. Simple energy capture formulas also do little to explain how human societies moved from “socially simple” to “complex.” It is for this reason that non-equilibrium non-linear thermodynamics is better suited for grappling with this issue.

Three other terms are introduced here that are necessary in understanding this model. The first relates to the idea of the dissipation of energy. “Dissipative structures” are complex structures that operate far from an equilibrium state (Adams 1978). An example commonly used to explain the relationship between dissipative structures and equilibrium states is that of a clock pendulum. Initially, the pendulum is not moving. It is in an equilibrium state. Once force (energy) is applied to the pendulum it will begin to
move in its rhythmic pattern, but it will eventually return to its equilibrium state. If a wind-up mechanism is attached to the pendulum it will be moved out of equilibrium. This introduction of new energy (wind-up spring) creates a more complex, nonequilibrium structure. It is complex because now the spring must be wound, presumably by a human agent, to keep the clock from reaching an equilibrium state. In turn, the human agent requires inputs (food, oxygen, etc.) to stay out of equilibrium (to live, as the equilibrium state for living beings is death). The more complex a structure (the more constituent parts) the longer it will take for them to dissipate or break down into their component parts (Adams 1978, Adams 1988).

Now human societies are even more complex dissipative structures and farther from equilibrium (Adams 1978, Colson 1976). A fundamental characteristic of dissipative structures that are far from equilibrium is that they fluctuate. It is their inherent internal complexity and the variation (unevenness) of external inputs that feeds and supports a constant and irregular oscillation. It is this fluctuation or oscillation (system noise) that forms the basis for self-organization (also termed “autopoieisis”) of complex, non-linear phenomena, such as human societies. The fluctuations within dissipative structures serve as triggering mechanisms for self-organization (the spontaneous increase in constraint redundancies). Thus, self-organization serves to export entropy (tendency toward equilibrium) by creating increasingly complex structures or systems. Such new structures or organizations are subject to both positive and negative feedback and it is this feedback that serves to fuel natural selection of organizational forms. Thus, changes in social organization that “stick” (and the resulting new

Such selection explanations of non-linear, stochastic processes are more suited for dealing with the indeterminism of complex structures or organizations. Proximate explanations, which describe relationships between particular antecedent or proximate conditions and the consequent conditions, are inadequate to understanding complex self-organizing systems (Adams 1975, Adams 1978, Adams 1988, Colson 1976). This is, in my view, why it is so difficult to pin down particular co-varying, a priori conditions of social complexity.

Within each dissipative structure are mechanisms that establish tolerance parameters and regulate the degree of oscillation or fluctuations within the system. These are termed “autocatalytic devices” and function as self-maintaining and self-reproducing mechanisms (Kauffman 1995). As an example, once human groups begin to produce subsistence resources beyond what is immediately necessary for survival, the regulation or control of that surplus develops to direct the flow of the surplus (stored, shared, and traded). For example, the rules of inheritance, rules of succession, status differentiation, and symbolic representation of that differentiation may serve as autocatalytic elements for the emergence of “chiefdoms.” Autocatalysis works to maintain a new energy flow (e.g., plant domestication) and it may also serve to support a continued expansion (large-scale irrigated agriculture).

Thus, changing energy forms and energy flows are directly related to the organization (and relative complexity) of human societies. As Bruce Trigger argues, it is the ability to control energy (forms and flows) that underpins political and social power
in any society (Trigger 1990). At a very fundamental level, human beings are an energy form that can be defined as “labor,” while energy flows manifest as work performed. The ability to expend labor in non-utilitarian activities (prestige goods, monumental ritual structures) is a means to represent and display power. To Trigger, “the control of energy” serves as a common currency marking and measuring political relationships (Trigger 1990). Thus, he measures political power in a social system by measuring the extent of non-utilitarian craft production and the construction of monumental architecture. This is an effort to go beyond both the “what?” and the “why?” of social complexity to address the issue of “how?” and Trigger sees the control of labor (proxying “the control of energy”) as a partial answer.

Trigger’s interpretation begs the question: if energy and energy flows are instrumental in the emergence and growth of social complexity how do we measure it? White wanted to look at “energy capture” and that produced something of a reductionist counting of calories or BTUs. On one level that can be informative, but it does not address the issue of transition of flows and forms. Abrams has argued that energetic content can be measured, but instead of counting calories, he suggests focusing on labor expenditures in terms of “person days” and the differential investment of labor on various types of construction (rural residential, urban residential, and palaces) (Abrams 1989, Abrams 1995).

I think Abrams’ approach is important because it recognizes differentiation within the organization and employment of labor. Specifically, there is a relationship between the energy a society can bring into play and the size and stability of the control system that schedules and manages activity (work). The initiation and/or expansion of
hierarchical control institutions can only follow a material increase in energy flows through the creation of new or the modification of already existing energy forms. Institutionalized centralization would not be possible (or necessary) in low-energy foraging systems that operated through much of the first 4.5 million years of hominid history. Culture is a “flexible response system” (Kardulias 1995) that permits humans to adapt to their environment (physical, biological and social). It serves as an information system that is under constant modification. As no two societies exist in identical physical, biological, and social environments, there is no reason to presume that all human societies would show identical paths to complexity. Some societies (low-energy systems) might not reach an appreciable level of complexity at all, but may continue to exist as long as they do not reach an equilibrium state.

What, then, can account for the horizontal–regional diversity oscillation or the exclusionary strategy–corporate strategy oscillation suggested by Willey and Blanton, et al.? Why is there no, as yet, recognizable oscillation in the Intermediate Area? In my view the oscillations represent periods of stability and dissipation towards equilibrium (horizons) versus periods of fluctuation (noise), self-organization and innovation (regional diversity). During the period of regional diversity the movement or trajectory is towards increasing non-equilibrium. New energy forms, which include technologies, social groups and social interactions (such as a trading network), develop and become subjected to the evolutionary force of natural selection. A return to a horizontal structure signals a resolution of forms (a settling out of the fit versus the less fit). Exclusionary strategies would be most productive in a time of systemic noise when fluctuations and innovations are generated. A corporate strategy would be most productive as a means to
stabilize new energy forms and flows across a broad geographical region. The stylistic motifs that appear to be commonly shared during horizonal or corporate phases, by virtue of their distribution across geographic space, may serve as persuasive ideological markers of linkage, association or authority. However, eventually, dissipation towards equilibrium would fuel a new round of fluctuation and innovation.

I contend that similar oscillations have likely occurred throughout hominid history, although the “opposing” poles were not between “horizons” and “regional diversity.” The earlier fluctuations were most likely occurring within the realm of kinship structures, but with much longer periods of stability. The fission and fusion of kin groups might be the best model for this oscillation regime. If humans, as primates, have a predisposition or preadpatation to hierarchies of social dominance (a question not explored here), then, the question of emergence is less problematical. One can argue that there have always been “leaders” of some sort. The question in the context of this paper is how would changes in energy forms and flows have contributed to establishing a marked, eventually hereditary leadership that could increasingly control peoples’ labor in activities that created no immediate subsistence product?

This is a question that I am not yet prepared to answer, but I do believe an energetic approach can be of assistance. The major obstacle is identifying measures of energy flows and expenditures for the wide range of human activities. Architectural measures, such as “person-days” can be useful, but require specific assessment and application to particular societies. For instance, human energy expenditures at very high altitudes will be different from those at sea level. Zooarchaeology and paleoethnobotany can help assess the energy costs of food procurement, while experimental archaeology
may be the most direct way to assess energy costs associated with the production of prestige goods.

As I suggested at the beginning of this paper, energy can also be viewed as a proxy. Carlstein has argued that several concepts, including energy, tend to obfuscate and neglect the importance of human time (Carlstein 1982). Thus, when someone says, “much energy is expended” what is meant is “time.” At some level of theoretical understanding it is necessary to distinguish between time and energy. It may even be necessary to view one as more fundamental than the other. In the case of the origins of the universe, does time precede energy or vice versa? I think this is a “chicken or egg?” kind of question, but I do belief there are certain concepts related to time and space relationships that are necessary for understanding a nonequilibrium thermodynamic model of social complexity.

Even the simplest activities require some planning and organization. Certainly, picking an apple from a tree as one walks by requires both a minimum of planning and management, but there is some. However, for the construction of residences or public buildings, or the production of ceramics or projectile points, or the non-incidental acquisition of plants or animals for food, some significant planning and organization are required. Yet both planning and organization are constrained by basic conditions which affect all human life, such as the inability to be in two places at once or to perform more than one task at a time. Therefore, any activity, no matter how simple or complex, consumes time (Carlstein 1978).

Activities occur within particular spatial boundaries and the volume of activities that can be packed into a particular space are limited (Carlstein 1978). This means there
are two fundamental limits on activities – space and time – and both are occupied simultaneously. As a result, time and space can be viewed as resources in themselves and they require budgeting, as would any other resource. Even the most basic human social organizations, mobile foragers, must budget time and space, simply by virtue of having to move through space to a resource at a particular time. Tasks (jobs) and tools are the means by which humans address the constraints of time and space. As societies become more complex, budgeting of space and time becomes more involved (Carlstein 1978).

I agree with Carlstein as to the fundamental importance of organizing human activities within time and space constraints. However, it is through the employment of energy forms and flows that such organization takes place. Time and space constraints cannot be modified directly but only through the scheduled and organized application of energy. In order for time or space to be “repacked” to permit an increase in productive activities, energy forms must be employed. Thus, the transition from low-energy, relatively egalitarian, mobile, foraging societies to emerging complex societies, must be viewed in the context of shifting relationships (self-organization) of time, space, and energy.
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