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- Arts & Humanities

## **Thermodynamic Perspective on the Human Journey A Contribution to the Debate Concerning Historical Objectivity**

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Philosophy, literary criticism, historiography, and the entire postmodern-inspired argumentative intellectual mode that took root toward the end of the 20<sup>th</sup> century pummeled into our minds that *history cannot be objective*. Social setting (“who you are”) will determine your political and cultural dispositions. Mega-narratives are, without exception, particular interests-serving interpretations -- agitation and propaganda disguised as academic work. I submit that the heterodoxy of beliefs about history is nature’s way of creating variety -- the raw material of social evolution. Without conflict among temporal analysis-honed and -justified blueprints to reorganize the world there could be no progress in human self-organization. And life without progress tends to eliminate itself.

Nonetheless, a new synthesis of social sciences and physics to develop a framework for consolidated and aggregate retrospection is due. Recent developments (in particular the fall of communism, 9/11, and cumulative global imbalances trapped in harmful feed-back loops) have not only revealed a macrohistoric pulsation that could not have been discovered before, but they also telegraph a vital message: “World, it is time to get your act together!” But alas, as contemporary philosophy has taught us, there is no teleology without archeology; there cannot be *Telos* unless there is *Saga*. Acceptance of global goals is predicated upon a shared understanding of the collective past.

Without delay a sobering note is in order: Global unification is neither around the corner nor can it be achieved with rational arguments, business as usual politics, or charismatic leadership. The emergence of “One World” is contingent upon first getting a glimpse of the abyss, which then, as Nietzsche put it, would stare back.

To develop a sense of physical realism about history, let us begin with some well-deserved self-effacement, by emptying ourselves of all culturally inculcated and maintained pride and ethical content.

## Good-by personhood, hello “thinghood”

We -- and I mean the entire global society or the human biomass -- are involved in a single physical process. To benefit from this perspective, we must put aside the exaggerated, sanctimonious importance that family, community, broader society, religion, mythologized national creeds, the social sciences, and the humanities bestow upon the individual. For a short while, we must consider ourselves “things,” organized matter, ensembles of atoms and molecules in the flow of time. Or, to paraphrase a great icon of the 20<sup>th</sup> century:

“You Ain’t Nothin’ But a Node in a Sutured Lattice.”

Let us define *culture* as a material entity that combines the human biomass and everything manmade. As leaps of abstractions go, the carpentering of this construct should not cause much mental anguish. All material structures -- let them be organic or inorganic, animate or inanimate -- share a lowest common denominator: subatomic particles. Deep (deep) down, both Jack’s liver and Jill’s toaster are atoms, stable configurations of locked up energy.

*Cultural evolution* is then the growth of *culture*, the combined result of demographic expansion and increase in material output (i.e., industry and agriculture). It is the growing weight of a Leviathan we love dearly. Of course, we do. It is us plus all the props of material civilization, from the coal miner’s helmet to the paraphernalia in beauty salons for dolls. The only problem is that the physical substances that this ever weightier entity ingurgitates, degrades, and ejects come from and remain within a closed space -- our wobbling, revolving, soaring into nothingness orb of night and its immediate vicinity.

## The terrestrial sphere

Considering the planet from the outside, imagine that the bulb in which we are enclosed as we ride around our sun and with the solar system through the cosmos, has a diameter of 20,000 miles. Its center is the center of the Earth. Meteors enter, hydrogen atoms escape, and dust becomes annihilated in nuclear explosions, but for all practical purposes, these events leave the weight and composition of matter fixed and unchanged in this 3-D surface we call the terrestrial sphere.

Modern thermodynamics distinguishes among three kinds of systems: open, closed, and isolated. The open system exchanges both energy and matter with the exterior; the isolated exchanges neither. Obviously, the terrestrial sphere is a closed system. Whatever we do with matter, incorporating it into our bodies, using it as raw material, discarding the bodies, throwing away or reusing matter again and again, our virtually permanent weight and composition of atoms remain constant. The matter that we are and use just rolls around “in the earth’s diurnal course with rocks, stones, and trees,” to quote William Wordsworth.

Much scholarly work has been based on the belief that the terrestrial sphere is thermodynamically open. After all, we receive huge quantities of solar energy, most of which remains unused, re-radiated, “bounced back” into outer space at night. Given the practically unlimited availability of energy and Einstein’s famous discovery about the equivalence of matter and energy, resources appear to be unlimited. Eternal progress in science and technology can support economic expansion on this planet *ad infinitum*. The discrepancy between the intellectual level of social scientists who think this way and the elementary (high school level) knowledge that they fail to factor into their thinking cannot be ascribed to simple oversight or the order of some arithmetic error. It raises complex questions that only structural linguistics in the context of broader cultural (not excluding political economic) studies can answer. Lack of space prevents us from delving into this issue here. Nonetheless, everybody needs to know that the terrestrial sphere is thermodynamically closed. (Beware as you try to spread this idea: There will be some heavy duty screaming and kicking, and the fuse might be extremely short.)

By discovering the fixed exchange rate between matter and energy (i.e., the speed of light squared), economics may indeed claim Einstein as one of its own. Just as the price of a commodity can be expressed in dollars or yens, matter can be expressed in terms of energy and vice versa, except that this rate is not subject to market fluctuations or monetary policy. But, despite their theoretical equivalence, matter and energy have an important asymmetry. While we can produce energy from matter, we lack the technology to do the reverse in economically significant quantities. Moreover, transforming energy for human use depends on matter – solar *panels*, hydroelectric and wind *turbines*, geothermal *stations*, etc. This circumstance seals our fate. The internal energy (the sum of kinetic and potential energy of all particles) in the virtually fixed number of terrestrial atoms and molecules limits the amount of solar energy we can harness.

The terrestrial matter is not only a certain quantity of energy but it is also an absolute constraint on the amount of work that can be done on this planet.

*Cultural evolution* is subject to the laws of thermodynamics

*Culture*, our beloved Leviathan, must obey the universal mandates of nature, the laws of thermodynamics.

The first, so-called conservation law guarantees that whatever happens to matter in the terrestrial sphere, the energy it contains will remain intact. But the second law informs us that this process is dissipative. The two main interpretations of the second law are “inevitable waste” and “increasing disorder.” The first refers to the fact that heat gained from the internal energy of matter cannot be transformed into mechanical energy with 100 percent efficiency (work output/heat input is always smaller than one). Not only is it impossible to

construct a perpetual motion machine but whatever we do also increases the portion of unavailable (latent) energy at the expense of available (free) energy. (Energy enclosed in matter is considered free if extracting it requires less energy than the amount we obtain. Latency means the exact opposite. Energy contained in fumes of gasoline or ashes of coal and copper cannot be accessed economically. Costs exceed benefits.)

The second interpretation states that disorder in a closed (or isolated) system tends to increase. This disorder is called entropy, a word that derives from the Greek word for evolution. Just like evolution, the growth of entropy is unstoppable and irreversible. Since the growth of disorder in a system corresponds to the increase of unavailable (latent) energy -- that is, progressive loss has two equivalent manifestations -- the concept of "entropy" may be applied to the general process of drawing down a system's fixed energy budget.

The most essential bears repetition: Energy is the capacity to do work. One form of energy cannot be transformed into another form without losing some of it beyond reprieve. By the equivalence of matter and energy, this restriction applies to our limited supply of matter. The more of it we use, the fatter Leviathan becomes, the more of it shall be dispersed and rendered useless. Since *cultural evolution* is the process of co-opting increasing quantities of matter, we ceaselessly increase the portion of unavailable or latent energy as well as disorder in the terrestrial sphere. The idea of elementary physics, namely, that "entropy tends to increase in an isolated system," implies that "entropy also tends to increase in a closed (or partially isolated) system if the theoretical symmetry between energy and matter is only one way" (i.e., since we cannot produce matter from energy and energy without matter).

### The nature of Leviathan

The "clump of matter" image of civilization ("clump of mud" if we insist on dispensing entirely with anthropocentric narcissism) is not a mere metaphor. It is what physicists call a "far-from-equilibrium, dissipative structure" that evolves unidirectionally and irreversibly and has emergent properties. "Far from equilibrium" means not only life but also everything that has structure (including tornados and magnets) because equilibrium for the physicist is the homogenous dispersion of matter in the universe. Ilya Prigogine, the Russian-born American Nobelist, is the *spiritus rector* of a school of physics called disequilibrium thermodynamics that focuses on the evolution of far-from-equilibrium dissipative structures.

Studies in modern thermodynamics have shown that the growth of dissipative systems follows a pattern of phase-like evolution. It is characterized by an alternation of relatively steady and unsteady states. The first ones may be called periods of dynamic equilibrium (or stable disequilibrium) and the second ones, *chaotic transitions*. Relative steady states tend to be longer in duration

than the unsteady phases separating them. *Chaotic transitions* “punctuate” dynamic or relative steady states. A further characteristic of far-from-equilibrium dissipative entities is that they need to grow in size and complexity to avoid decline and extinction.

Since *cultural evolution* is a thermodynamic process (i.e., the increase of a self-organized dissipative entity), it must also go through distinct phases of dynamic steady states (or stable disequilibria) and periods of chaos (or bifurcations)! Equipped with the thermodynamic view of the human condition, let us look down the hallway of time and discover that global history is as objective as our inevitably language-conditioned analysis allows us to say so.

### The narrative version of *cultural evolution*

The history of the past half-millennium lays bare a scheme of thermodynamic unfolding. The combined growth of population and material output is pushing the world toward self-organization. The process, which has scientific, technical, socio-philosophical and political dimensions, accelerates after the discovery of America. This period, which we may call *late feudalism/early capitalism* (GS0), lasts until the outbreak of the French Revolution. A *chaotic transition* from 1789 until the symbolic year of 1834 (the “birth date” of industrial proletariat, according to Karl Polanyi) leads to the establishment of the first *global system*.

**First *Global System* (GS1):** Laissez Faire/Metal Money. From 1834 to the outbreak of World War I. The state guaranteed property rights and the exchange of paper currency for metal money (primarily and increasingly gold).

**Chaotic Transition:** 1914 to the end of World War II.

**Second *Global System* (GS2):** Mixed Economy/Weak Multilateralism. From 1945 to present. Free enterprise-based national economies, with the state responsible for overall growth and stability. The United Nations and its charter organizations represent “weak multilateralism.”

Schematically, the chart below depicts the structure of world history (or the “archeology” of our current world order) where the arrows indicate *chaotic transitions*:

GS0 (1500-1789) Late feudalism/ early capitalism	→	GS1 (1834-1914) Laissez fair/ metal money	→	GS2 (1945-present) Mixed economy/ weak multilateralism
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A more detailed look at this periodization follows.

With the discovery of the Americas and news about circumnavigation, the planet incontrovertibly acquired the mental image of a finite globe. Geographic

globalization was accomplished; global-scale interactions could emerge. *Cultural evolution* reached the crucial point of being recognized in its full (contemporary) extent. The long but accelerating march from the correct notion of what is “worldwide” to the “worldwide web” began.

The period that lasted from the beginning of the 16<sup>th</sup> century to the outbreak of the French Revolution (labeled *late feudalism/early capitalism* or GS0) witnessed rapid economic diversification, the growth of trade (the early signs of economic globalization), and the emergence of modern science and philosophy. While agriculture and a social organization reminiscent of landownership-based feudalistic social hierarchies -- or pure military subjugation -- remained dominant around the world, industrial activities gained in significance and the ratio of population living in towns (though slight) began a secular upward trend. The evolution of economic institutions and social thought reflected the development of incipient capitalism, the gradual coming to power of the bourgeoisie. Although these trends were most keenly present on the European continent, they had also been documented in Asia, particularly in Japan.

Burgeoning industry and commerce stretched the limits of agrarian, aristocratic-military-, and spiritual authority-dominated social frameworks but the world was not yet ready to engage in conscious self-organization.

Retrospective analysis reveals the three fundamental conditions that were required to move from self-standing, mutually hostile monarchies engaged in the crudest form of competition to conscious cooperation with a global scope: (1) a sufficient number of territorial units (compartments) each of which recognizes the value of cooperative behavior, shows durability, and partner-worthy reliability; (2) a minimum threshold of interaction among them (e.g., travel and trade); (3) the development of a single body of governing principles that is both immanent and transcendent, i.e., that leads to the creation of domestic (intracompartamental) economic systems while allowing for intercompartmental cooperation based on the recognition of mutual benefits.

As later history demonstrated, nation states (countries) became the basis of global networking. They are the compartments that are sufficiently analogous in their organization, legal foundations, general intentions, and stability to consider each other “partner-worthy.” History has also shown that the simultaneous occurrence of the three necessary conditions was sufficient to induce “positive network externalities.” As the number of participants grew in the worldwide scheme of cooperation, joining it became more and more beneficial; or, alternately, staying outside of it brought increasingly prohibitive opportunity costs.

The noted fundamentals were absent during most of GS0, appearing only towards the end of the period.

Condition 1: Nation states already established at the outset of GS0 followed the doctrine of *mercantilism* in their domestic economic organization and international policies. *Mercantilism* approximates the behavior known in microeconomics as the “zero sum game” (i.e., your gain is my loss). The players (nation states) operated under the impression that the volume of international trade was constant and to win meant to have a trade surplus (exports minus imports) so as to acquire precious metals (gold and silver).

Not only did individual nations strive to accumulate precious metals at the expense of others, but their numbers were also too small and unevenly spread to form a global network. The epoch’s most advanced state organization in China under the Ming and Qing dynasties, followed by the period known as *Pax Sinica*, gradually decomposed under internal ecological, economic, and external pressure. In Europe, although the concept of a modern sovereign nation became legal reality at the conclusion of the Thirty Years War (1648), most of the continent remained divided among small territorial units or multi-ethnic conglomerations under dynastic rule or outright foreign domination. The compartments were unstable because they lacked communitywide interest-serving territorial governance. (For example, marriage between the children of two princes or a successful military campaign could change administrative borders, altering the fiscal system with total disregard for “public interest.” This notion, so crucial in modern electoral politics, had no practical significance.) Perpetual warfare, revolts, colonial status or complete isolation characterized the rest of the world. But the arrow of time pointed unmistakably toward the formation of modern nation states, a trend that gathered momentum in the 19<sup>th</sup> century and continued through the 20<sup>th</sup> century.

Condition 2: We see a gradual increase in economic interactions, particularly in Western and Northern Europe. Relatively small-scale trade (mainly in luxuries and precious metals as far as exchange with other continents was concerned) led to the accumulation of commercial gains, which then transformed into industrial capital (sufficiently large to be invested in the formation of physical capital), producing increased amounts and variety of traded goods.

Condition 3: Although the gold standard mechanism, which ends blind mercantilist ambitions as well as the rivalry between precious metal and paper money, and the economic doctrine of *laissez faire* were known during the second half of the 18<sup>th</sup> century prior to the French Revolution, their application remained extremely limited. These ideas were considered liberal, untried, even utopian by established authority still mired in the conviction that the bigger the trade surplus, the stronger the nation. Principles approximating a zero sum game (e.g., Holland’s gain is France’s loss measurable in gold) prevailed in international economic relations.

The conditions required for the existence of a *global system* matured and united in early 19<sup>th</sup> century Great Britain. The first *global system, laissez*

*faire/metal money* (GS1), entered the stage of universal history there in the symbolic year of 1834, but not before a *chaotic transition* shook Europe, which moved into the driver's seat of general progress.

A *chaotic transition* is like a brainstorm that leads to remaking or, equivalently, rethinking the world. It begins as the established world order (a deterministic system) becomes increasingly prone to disruption through stochastic (random) developments. (This characterization corresponds to the "butterfly effect" known in chaos theory or nonlinear dynamics.) An innocuous and totally unpredictable event escalates in significance and marks the beginning of a period during which the world identifies the parameters of a new scheme of relative (dynamic) global equilibrium.

The *chaotic transition* that led to the establishment of the first, most primitive global order (GS1) lasted from the outbreak of the French Revolution in 1789 until the symbolic year of 1834. From the clash of extreme intentions, such as the creation of an egalitarian society through Jacobinian despotism, territorial integration through imperial conquest, and aristocratic restoration, emerged the triumphant bourgeoisie. This new ruling class of entrepreneurial revolutionaries was, in a way, egalitarian, in a way, aristocratic, and yet, in another way, successful in integrating the world.

The first *global system* appeared when conditions necessary for its existence were ripe to be put into practice by a mover-shaker social group. Before the French Revolution, the aristocracy, in alliance with the Church, would have blocked such a transformation. Inertia would have prevailed over innovation and progress. By the 1830s the bourgeoisie was strong and confident enough to push through legislation required for the free functioning of markets in commodities, labor, and money. Unobstructed entrepreneurship and free competition were on and the factory system could expand. GS1 spread quickly to the rest of Europe and to other continents, including the United States, which was born with a great penchant for GS1's spirit of liberty and entrepreneurial creativity.

The main attribute that distinguishes GS1 (and for that matter any *global system*) from GS0 is the recognition that national self-interest is best served by making allowances for similar ambitions in the rest of the world. The digit in denoting *global systems* (i.e., 0,1,2 in GS0, GS1, GS2) refers to the level of cooperation through harmonization among nations, in principle and practice. Since GS0 did not feature any such conscious harmonization it was not a *global system*. (It was *global system naught*.)

In terms of institutions, national economic systems under GS1 were built on the doctrine of noninterference by the state in private economic activities (*laissez faire*) and on the mandatory exchange of national paper money for precious metals (mainly gold coins or bouillon) at bank windows. In contrast, GS0

national economic systems featured strong central authority and the state's ambition to amass as much gold as possible. GS1 reflected the recognition that national self-interest could be advanced by institutional harmonization and by overcoming the state's "jealous fear" (David Hume's expression) over losing gold. GS0 lacked such integrative global scope.

GS1 had a pivot or "world leader" -- Great Britain. It became the reference point against which other nations would measure their institutional arrangements, their business and personal conduct. The closer to the British model, the better! There was no such leadership during GS0.

With GS1, the most developed nations (the *vanguard*) became involved in conscious self-organization. They submitted to the principle of allowing the ebb and flow of precious metals across their borders. They tuned their domestic systems (adjusted immanently) so as to allow universal economic laws to do their magic. The compartments (i.e., the countries, the players) discovered and agreed on a global framework for maximizing their objective of economic growth and tended toward standardizing their institutions and strategies. (This is, of course, an abstraction. Practice and experience were divergent enough to suspect a functioning mess with unabated suspicion and, in some cases, outright hostility among the players. Nonetheless, the retrospective characterization of GS1 presented above remains valid in its coarse outlines.)

Although GS1 was born in the midst of pain and trauma, it gradually raised living standards and led to the creation of the middle class. Between 1850 and 1900, per capita global output (income) more than doubled despite an increase of world population from 1.2 billion to 1.6 billion. Further acceleration in per capita income was recorded during the Edwardian period (the first decade of the 20<sup>th</sup> century). The world's population began to see elegance and luxury on levels undreamed of before. But the evolutionary clock was ticking toward the demise of GS1, which became increasingly unable to accommodate further economic growth. The following were GS1's four most obvious limitations:

- The rigid dependence of the money supply on gold became a straightjacket on economic growth.
- Industrialization reached a point at which national economies were prone to accelerate and decelerate if left on their own. (The fiscal and monetary measures required to deal with this phenomenon through countercyclical government intervention were outside GS1's parameters).
- Lack of framework for labor/management bargaining prevented the move to mass production and consumption.
- Economic and financial interdependence called for concerted action among national governments. GS1 had no institutions or schemes for such international cooperation.

GS1 was blown to smithereens with the outbreak of World War I.

The period 1914-1945 was the *chaotic transition* that ushered in the second and current *global system*, called *mixed economy/weak multilateralism* (GS2). As observed in thermodynamic processes, world history (the narrative version of *cultural evolution*) exhibited the signs of diverse and conflicting approaches to re-establishing the conditions of a (dynamic or relative) steady state. These were the alternatives:

- Restoration of GS1 by attempting to bring back the gold standard.
- Communism: A new form of self-organization.
- Fascism: Territorial conquest through military aggression; winner takes all (i.e., semi-colonial or colonial status for the rest of the world).
- Mixed economy: A new relationship between public authority and the market as well as between labor and capital.

As befits the physical and mathematical descriptions of chaos, these alternatives clashed in an experimental melee – a Darwinian showdown -- from which the mixed economy emerged victorious.

The mixed economy, developed in the United States during the New Deal in the 1930s, became the backbone of GS2's domestic economic organization. It implies private-ownership-based market economy with important roles assigned to the state in securing economic prosperity and social peace.

The United Nations and its charter organizations represent *weak multilateralism*. Its flagship agencies in the economic and financial sphere are The World Bank, the International Monetary Fund (IMF), and the General Agreement on Tariffs and Trade (GATT), which became the World Trade Organization (WTO) in 1995. The United States took the role of pivot or "world leader" from Great Britain, upgraded with the functions of system administrator.

GS2 outshined and outperformed GS1. It brought material welfare within the reach of billions. During the 50 years from 1950 to 2000, despite an increase in world population from 2.5 billion to 6.3 billion, per capita global output (income) grew more than four-fold.

But the clicking of the evolutionary time machine heralds the onset of a new transition. The reason is not, as Marx thought, that capitalism (now in its modern or reformed version) could not provide prosperity for the masses, or that it suffered from incurable limitations in ensuring economic expansion. The reason is the exact opposite: GS2 cannot stop growing. Its existence is conditioned on maximum economic expansion and, therefore, it is incompatible with a predominantly renewable-resource based global society in agreement about the use of scarce nonrenewable resources and the environment. The terrestrial sphere's ability to support unbridled economic growth is limited and we are approaching the limits.

Three factors had to come together to expose the thermodynamic pulsation of macrohistory: The fall of communism, 9/11, and the accumulation of global problems without realistic solutions.

While there was a socialist commonwealth, the world lived with the impression that it had two parallel, competing *global systems*. Planet-wide self-organization appeared to be bi-systemic. This view was uniform, except that the communists considered their system a promise to the world while everybody else regarded it as a menace.

In retrospect, Communism was not and could not have become a *global system*:

- Communist-controlled countries had to deal with the rest of the world in terms of GS2 (i.e., had to join UN organizations to be recognized, earn hard currencies not to fall hopelessly behind the West).
- The Communist Bloc represented only around 5 percent of global trade.
- The communist system appealed only to a tiny minority, thus disqualifying it from becoming the foundation of a new world order. No *global system* could exist against the will of national majorities.
- Communism did not develop a distinct socioeconomic behavior. It only suppressed and deformed GS2-typical behavior. (Populations in formerly communist controlled countries snapped out from socialist institutions and immediately adopted multiparty, private entrepreneurship-based economic organizations roughly at their respective pre-communist level of social development.)

This is not to deny or even belittle the historic significance of Communism. Its early economic growth performance and proclaimed idealism presented the rest of the world with a major political challenge. It became (1) the “balance wheel” that helped define the mixed economy and (2) the socio-psychological, philosophical prop needed to ensure that the real hegemonic world order (GS2) did not acquire ontological status; i.e., that its attributes would not become confused with natural laws.

1. As a balance wheel, the communist threat helped define the respective weights (“the mix”) of private and public expenditures in the mixed economy. It pushed the balance in favor of public expenditures (e.g., military spending in the United States and social programs in Western Europe and Japan). Worldwide restriction of public authority followed the collapse of communism. The era since 1991 has witnessed a forceful wave of deregulations and privatizations in most nations and in international economic relations.

2. Were it not for antagonism and occasional militant criticism, the radical presence of the prevalent human-made environment would appear to the individual as an unchanging and unchangeable objective reality. The willingness

to criticize social arrangements is a culturally maintained and transmitted trait. It increases the species' evolutionary potential. Without this antithetical “negativity” shadowing every single social arrangement, institutions would become dogmatic in-growths, taking on the guise of natural laws (e.g., electromagnetism or gravity). This would endanger *cultural evolution* because it is contingent upon the systematic renewal of global self-organization. Since the fall of communism, environmental and anti-globalization movements have become the primary reminders that GS2 is of human authorship. Like GS1 or any other future *global system*, GS2 is a collaborative contrivance of billions of interconnected neuroanatomical states expressed through characteristic institutional architecture and socioeconomic behavior.

The remaining two points, 9/11 and global problems, herald a new period of macrohistoric turbulence.

The events on and since 9/11 ended the “end of history” illusion –an optimistic, mainly occidental *Weltanschauung* that followed the Cold War and the demolition of the Berlin Wall. Multiple imbalances (especially in income distribution within and among nations) are on the rise. Emerging resource and environmental problems have no solutions that would simultaneously preserve GS2 institutions and maintain global economic expansion. The current world order is potentially untenable. A new form of self-organization will be needed to bring mankind into a sustainable equilibrium with its ecological niche and thermodynamic reality.

We may conclude that, thus far, only the sequence “GS0→GS1→GS2→” corresponds to the thermodynamic process we call *cultural evolution*. (The first two arrows symbolize *chaotic transitions*; the one after GS2 indicates only the breakdown of GS2 without knowing for sure where exactly it would lead. We need an end-point after a chaotic interlude to be able to label it *transition*.)

*Cultural evolution's impending autoparalysis or why GS2's demise is apodictic.*

*Cultural evolution* means the accelerated throughput of matter, the exponential immission of useful, free-energy containing (low entropy) structures and their subsequent emission in degraded, latent energy-containing (high entropy) forms. The world approaches its shrinking material limitations exponentially. To see this, consider the following.

Culture (  $C$  ) is maintained by the use of somatic and extrasomatic energy (  $SE$  and  $XSE$ , respectively). In a functional form,

$$C = \mathcal{H} ( SE, XSE )$$

Since *culture* increases, its first time derivative, i.e., *cultural evolution*, is positive with regard to both somatic and extrasomatic forms of energy. As a

matter of historical experience,  $C\mathcal{E} \Leftrightarrow \Delta\mathcal{H}_1 / \Delta t$  and  $\Delta\mathcal{H}_2 / \Delta t$  (i.e., *cultural evolution* has been equivalent to the increasing use of somatic and extrasomatic energy).

*Culture* is conceivable as energy performing work ( $\mathcal{W}$ ). The larger the number of atoms absorbed by *culture* (i.e., the larger doses of energy it contains, the more it weighs), the more work it will perform. *Culture* is proportional (in *joules*) to the product of a (very large) vector of forces ( $\mathcal{F}$ ) and a matching vector of distances ( $d$ ):

$$C \propto \mathcal{W} = \mathcal{F} \cdot d$$

(*Culture* -- an ever bigger and more effective machine with a human ghost? Shocking, but this is what we get when we throw the stoic detachment lever as far as it can go and observe ourselves from the cosmic perspective of indifferently accumulating seconds since the Big Bang.)

*Cultural evolution* may be seen as a rising quantity of work linked to the increase in human activities and the motion of human-crafted objects. (The time derivative of *culture* and the work it performs remain proportional.) Since the total amount of matter *culture* uses ( $m$ ) increases (i.e., since there has been and there is *cultural evolution*), the force ( $\mathcal{F}$ ) is an acceleration even if the speed at which this matter moves ( $v$ ) may vary. Based on Newton's Second Law, the force, which transforms energy ( $S\mathcal{E}$ ,  $\chi S\mathcal{E}$ ) into work, may be captured by a rate of increased momentum:

$$\mathcal{F} = \Delta (m \cdot v) / \Delta t$$

By definition, the variable  $m$  is equivalent to free energy. (Its complement, latent energy, is unavailable for use.) The quantitative relationship between  $m$  and  $v$  is obviously indeterminate, but note that the velocity at which matter incorporated into *culture* "moves" (i.e., as we push and pull and make our tools and machines push and pull) is also a function of matter. Human actions or those performed by human-crafted objects cannot deploy energy without terrestrial matter. Defining the total substance dependence of *culture* ( $m'$ ) as the sum of matter built into culture ( $m_1$ ) and the "low entropy feed" required to "move" it ( $m_2$ ), we can rewrite the above expression as

$$\mathcal{F} \propto \Delta (m') / \Delta t$$

(For example, the airplane and its crew belong to  $m_1$ , whereas the jet fuel the equipment runs on and the food the crew consumes is part of  $m_2$ . The principles

according to which substance is present and made to function may vary and seem arbitrary. Nevertheless, the binary division of free-energy containing matter into structural and functional requirements can be shown to remain exhaustive.)

Thus, the force ( $\mathcal{F}$ ) is proportional to the depletion of “free” (and a corresponding increase in the “latent” or “unavailable” portion of) energy enclosed in terrestrial matter.

If we consider the work *culture* does by maintaining itself and expanding during a given period of time, we arrive at the concept of power as defined in physics. This way we can perceive the bill Mother Nature charges humanity (through a fictitious Global Town and Country Utility Co.) in kilowatt hours. At present, the world has not yet acknowledged that it is running up the charges.

Acceleration in the force that converts the energy-equivalent of *culture* into work unequivocally escalates the drawing down of free energy enclosed in matter. *Cultural evolution* is an impulsive force, a growing momentum of matter (i.e., mass x velocity) that exponentially dissipates its constraint. This phenomenon remains unchanged as the process approaches its limit.

The abstract notion of *cultural evolutionary* acceleration has a heuristic, deductive exposition. As long as worldwide demographic expansion lasts (i.e., the birth rate exceeds the rate of mortality), while material and energy inputs into the global economy keep rising, the ratio of atoms incorporated into *culture* (within the total number of available atoms) increases at an exponential rate. For instance, an x-percent increase in *cultural evolutionary* “substance use” this year will be in addition to a similar increase last year. This cumulative induction of low entropy structures follows the rules of “compound interest,” a process which is always expressible by some exponential function with a positive power (exponent).

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We cannot and ought not to accuse Leviathan for having a character flaw, a lack of will to stop overeating. It can live only if its fat keeps growing. *Culture's* weight gain is GS2's life blood -- our livelihood, our money.

GS2's defining feature is its unquestioned commitment to, and complete dependence upon, economic growth. We know that growth will eventually (most likely during the first half of this century) encounter the planet's physical limits for economic reasons. (If the encounter – i.e., an inelastic collision between Leviathan and the terrestrial sphere's material limitations -- were purely physical, *homo sapiens* would cease to exist.) This spells crisis for GS2 no matter what happens. Both continued and stalled expansion is lethal to its institutions and ideology. While growth would eventually be slowed and then stopped by the drag of increasing resource costs, no-growth would entail galloping impoverishment with violent individual and group actions in its tow. No matter how human society finds out that *cultural evolution* threatens its existence, it will have to deal with the

contagion of discontentment economic stagnation brings. Hypertension, fatigue, and nausea await Leviathan. A rude awakening hides behind the arrow that follows GS2. A new *global system* that can live with green constraints will have to emerge.

### What's next, GS3?

As the world's growing population and economy encounter terrestrial limits, a new *global system*, called "two-level economy/strong multilateralism" will be needed.

On one level, activities that depend heavily on nonrenewable natural resources and put the environment at risk would be subject to globally determined constraints. These activities would be allocated to nations and transnationally dominated sectors such as the petrochemical and automobile industries. On the other level it would be market economy as pure and ideal as is conceivable.

Strong multilateralism implies democratically organized world governance (complete with a global central bank, global currency, and global minimum wage) with a framework of cooperation in space engineering and colonization. The world would have a 100-year agreement on goals and constraints.

Comparing a world that could have such an agreement with the one that lived through the past century gives us pause. It hints at such a profound change that to reach it may require either a very deep and long-lasting *chaotic transition* or intermediary *global systems* separated by *chaotic transitions*. Under either alternative, *chaotic transition* is the next expected phase of macrohistoric evolution.

### Cultural evolution at a crossroads

The 21<sup>st</sup> century will answer the following critical question: Can transition to a sustainable harmony between *homo sapiens* and its ecological niche be achieved through a gradual, that is, economic growth-sustaining and current institutions-preserving transformation? Can *cultural evolution* soft-land or is it in for a hard landing? The present theory maintains that a soft-landing is extremely unlikely. The coming (hopefully transitional) macrohistoric chaos associated with a major collision between our growth-dependent civilization and its material limits appears to be physically inevitable.

The acceleration principle behind the expanding human presence is tied to the present, largely unconscious conviction that man lives in an open thermodynamic system. Such a system is indispensable for individual existence, but this indispensability has extended to communities, business firms, industries, and nations. Practically all groupings and organizations, small or large, behave

as if they also lived in an open thermodynamic environment. “Not in my backyard” is the primitive manifestation of a deep and ominous conviction: “I live in an open thermodynamic system; you deal with it.” This glaring inconsistency and self-contradiction will have to be worked out at the global level.

The expansiveness of the “cowboy” perspective in business will have to transmute into the defensive mentality of a “Dutch” economy in the terrestrial sphere. The “cowboy” perspective and mentality will have to be redirected to outer space in order to fend for humanity’s long-term survival.

Let us call the currently prevalent state of the world, characterized by the unconscious belief that we live in an open thermodynamic system and the related “cowboy” mentality in economic affairs, *State No. 1*. Then *State No. 2* is the steady state in which weak acceleration in the exhaustion of material resources is subjected to long-term plans to capture matter from outer space; in which the notion that we exist in a closed thermodynamic system is widely accepted and this acceptance is paired with individual willingness to live with the consequences. Then the question is reduced to “How do we get from *State No. 1* to *State No. 2*?” *The thermodynamic insight into world history suggests that there is virtually no chance for a smooth (i.e., economic growth as well as institution-preserving) transformation. A new period of macrohistoric turbulence looms large.*

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Since this argument is critical for understanding and accepting the proposition that global society is enveloped into a single process that appears as universal history, let us reiterate it, by emphasizing both aspects of the proposed dualistic (socioeconomic and physical) theory.

The individual, bent by nature on reproduction and the accumulation of material wealth, must come to grips with the same bent in every other individual. At humanity’s current and foreseeable level of development, *chaotic transition* is the only algorithmic maneuver the global community disposes to move from one relative steady state to the next. Thermodynamics tells us that self-organized entities that grow in size and complexity must go through periods of disorder. During such periods, the characteristic parameters of the system that held the entity together leave their range. Equilibrium changes into disequilibrium and symmetry is broken (particles of matter organized into individuals move in new ways, collective routines such as local divisions of labor are perturbed, graphs depicting key developments abandon secularity and become volatile.)

The physical evolution behind universal history centers on the collective transformation of *global system*-specific material states in individual brains. These states are interconnected in such a way as to correspond to the rules of the prevalent multibillion-person socioeconomic game. (With appropriate qualifications, every *global system* is also “Nash equilibrium.”) Since this network

is part of a unidirectional thermodynamic unfolding, it cannot move from one major phase to the next by skipping *chaotic transition*.

The unidirectional and irreversible nature of *cultural evolution* brings to bear the decisive argument in support of this inference. The evolution of the clump of matter that *culture* is (with individually-anchored neurobiological traces characteristic of the *global system*, interconnected into a worldwide web at its center) cannot occur without hesitation, search, and experimentation. If it could, *cultural evolution* would not be a thermodynamic process because it would be reversible and not unidirectional (i.e., the accumulation of entropy enclosed in the terrestrial sphere could be halted or reduced). The only imaginable way for the particles in *culture* to increase in number and accomplish crisis-free changes in their self-organization (i.e., to have *cultural evolution* without *chaotic transitions*) is that, by some miracle of coordination, they would know their positions and velocity at every second. By induction, all particles would move on deterministic (“Newtonian”) trajectories, holding out the theoretical possibility for the whole material entity (*culture*) to reverse its evolution. Such an assumption conflicts with the *second law of thermodynamics*: The accumulation of entropy through *cultural evolution* is deterministic only in direction. *Ex ante*, its manifestations remain stochastic. We know this from our everyday experience, so common that -- like fish do not notice water -- it escapes our consciousness: Developments in the world consistently defy divinations inspired by coupling current situations with putative historical precedents.

Consequently, at least from the human perspective, “hesitation, search, and experimentation” are irreducible features of *cultural evolution* and these motions swell to the proportion of macrohistoric crisis when the transition is major, i.e., it occurs from one distinct major state to the next. (That the transformation from *State No. 1* to *State No. 2* is a major one is immune to any rational challenge.)

This general physical process appears as a seemingly unrelated multigenerational chain of events. Political movements with economic organizational agendas (known before the chaotic interlude or develop during it) create a variety. But the array of emergent solutions (“mutations”) is too wide and uneven. There is a “surplus of possibilities” (Derrida’s expression applied to the interpretation of texts.) A process of pruning must first eliminate unfit mutations and then sort out affinities among the remaining (“surviving”), widely diverse groups to create a handful of forcefully supported alternatives (“historical blocks,” to use Gramsci’s expression; groups with “adaptive value” in terms of evolutionary science). In the end, these few (at minimum two) would have to slug it out among (or perhaps between) themselves in direct confrontations. In the evolution of human-made environments, genetic tendencies, vaguely sensed or presupposed beliefs and values do the selection. The restoration of dynamic equilibrium (or stable disequilibrium) globally and enduringly is the only proof that the newly ensconced system has been selected for survival. (I.e., proof is available only *ex post*.) Both the two historically recorded examples of *chaotic*

*transition* and evolutionary adaptation (as a generalized Darwinian mechanism) point to this system of fluxions as the only workable one to accomplish institutional/behavioral transitions at the global scale.

Thus, the world both as nature (linked neurophysical states in human brains) and as universal history (with its recorded places and events) evolves through phases of stable disequilibrium, punctuated by chaotic interludes. From the cosmic perspective of a much faster temporal flow than we perceive, our traumatic and costly *chaotic transitions* may appear to be nothing more than periods of introspection and self-correction in a certain “observed form of life.”

While this general assertion may be accepted as logically plausible, or even compelling, it faces insurmountable obstacles when one tries to demonstrate its validity through specific aspects of contemporary life. When the debate moves from topic-neutral physics to the analysis of social, political, and economic issues, the resistance hardens into reinforced concrete. And we may thank our good fortune that things are this way. If people could be convinced with words that they had to change themselves and their institutions in order to solve problems (no matter how imposing and threatening they may be), human society would be dangerously labile. It could not hold on to a functioning form of self-organization and would be subject to erratic changes. It would resemble a delirious individual wandering aimlessly in the wilderness.

The necessary disappearance of GS2 is obscured by contesting any possible way it may happen. This phenomenon is not unique to the present context. The individual fights every disease with unshakeable belief in its own resilience and trust in medical-pharmaceutical know-how. Yet, sooner or later, there will be a death certificate on the shelves of the Office of Vital Statistics. The case of a *global system* is analogous. It is resilient and ascribes to itself an infinite capacity of adaptation and problem-solving but, eventually, it must become history.

The impossibility for GS2 institutions and behavior to survive adjustments required for the species' long-term survival finds expression in discursive stalemates over energy, raw materials, the environment, and poverty. Rational thought, trained and constrained by the radical presence of the world order, is inclined to consider irrelevant or unfounded any suggestion that the future cannot be secured by the repertoire of tried approaches. Combative refusal to admit that the required future social consciousness does not overlap with the prevalent one is natural and expected.

Why bother then?

True, the greatest transformation the world has ever seen will not occur unless some rude awakening triggers it. Physically, this means an inelastic collision between *culture* and its economically perceived material limitations. In

humanistic terms, the more inelastic the anticipated collision (i.e., the more kinetic energy changes into heat), the worst tribulations and griefs individuals will have to suffer through organized and spontaneous stampedes and confrontations.

Let us not overlook the importance of the second word in “rude awakening.” The “rudeness” must not be so intense and complete that it endangers human survival. In the best possible world, the self-engineered ordeal will have to be just marginally sufficient to create global consciousness. Not a single iota more! This is not wishful theorizing. We may already be witnessing humanity’s instinctual search for a *collision of optimal inelasticity*.

The growing support of the environmental and conservation movement, the development of renewable energy alternatives, the increased attention paid to worldwide pauperization and to the dilating contradiction between economic globalization and the lack of commensurate planetary institutions are so many signs that, at some deeper level of panhuman consciousness, the race is already bracing to cushion the impact of the collision and to have the wherewithal of recovery in its aftermath. Supporting these tendencies helps optimize the collision by reducing its inelasticity.

The more people understand that we are physically linked and our linkage forms a material entity that is subject to laws of evolution beyond individual or group control, the shorter and less damaging will be the macro-dislocation, the shadow of which has already darkened the world.

To deal with its collective future rationally and coherently (to stack our chances in this “Darwinian lottery of existence,” to use S.J. Gould’s expression), the world will need to embrace a long-term program (*Telos*). Such unified consciousness is unimaginable without a common view of the past. We may well label it *Saga*, since by now philosophy has made it amply clear that history cannot aspire to be more than a hermeneutic, a certain reading of a process whose relation to the broader and unknowable reality eludes our limited minds.

Postmodern philosophy may be entirely correct in suggesting that humanity’s mega-narrative can never be objective. But universal acceptance of one of its versions as an inter-subjective accord of collective self-mythification (with caveats about potential falsification and certain evolution setting the standards of acceptance at realistically low levels) is part of the fundamental precondition of human longevity. Hence, the thermodynamic rationale applied to world history is ecumenical in spirit and implies a hopeful teleology.