COMPLEXITY, SUSTAINABILITY, JUSTICE, AND MEANING: CHRONOLOGICAL VERSUS DYNAMICAL TIME

Horacio Velasco

ABSTRACT: It is shown that time may be appreciated in at least two senses: chronological and dynamical. Chronological time is the time of our naïve acquaintance as transient beings. At its most extensive scale, it corresponds to history encompassing both the abiotic and the biotic universe. Dynamical time, deriving from classical mechanics, is the time embraced by most of the laws of physics. It concerns itself only with present conditions since it is held that that the past may be reconstructed from the present (literally) and the future predicted from the present, a position known as Laplacian determinism.

Nonlinear dynamics has shown the fallacy of this supposition: The concrete values that may be assumed in the variables of the equations of motion constituting the laws of physics (what are known as present or starting conditions) as a result of the spontaneous or intentional interaction of subject or measuring systems and of object or measured systems cannot be of infinite precision. Indeed, even if they could be, it is not at all clear that they would permit Laplacian determinism because of what is thought to be the ubiquity of K-flow dynamics in nature in which even infinite past information leading to the present cannot yield prediction of the future. In consequence, nonlinear dynamics, in rebellion against dynamical time, generates a primitive form of history distinguishing past, present, and future that may be termed nonlinear dynamical hysteresis.

When nonlinear dynamics came to be complemented with semiotic modulation through the implement of symbol-mediated language (a complementation subsequently termed semantic closure) as first instantiated through the communicating as opposed to the merely dynamically interacting molecular complexes of the cell, what can be termed semiotic hysteresis was born. The paper attempts to show that indefinitely evolving complexity, sustainability, justice, and meaning are indissolubly bound with chronological time in the sense of semiotic hysteresis (i.e. non-cognitive semantic closure first instantiated in the cell developing into cognitive semantic closure in human society): This semiotic hysteresis yields the indefinite evolutionary time of the living condition—including culture.

KEYWORDS: chronological time; dynamical time; nonlinear dynamical hysteresis; semiotic hysteresis; semantic closure; non-cognitive semantic closure; cognitive semantic closure; complexity; sustainability; justice; meaning

1. INTRODUCTION

The Nobel laureate in literature, Henri Bergson, famously argued that the role of time in nature is to prevent the simultaneous incidence of all events.[1] He viewed time as a

1. Ilya Prigogine, *The End of Certainty: Time, Chaos, and the New Laws of Nature*, New York: The Free Press, 1996, p.14.

"vehicle of creativity and choice". The distinction between dynamical and chronological time bears out Bergson in this assertion. Dynamical time is the time embraced by most of the laws of physics. It originally derives from the oldest branch of physics—classical mechanics. It is not the irrevocable time of our naïve experience in which irrevocable choices, whether intentionally or not, are made. Rather it is what may be termed an "*indifferent time interval*"—a time interval devoid of qualitative variation or significance. Classical mechanics makes a similar substitution in the spatial dimension: the "*location*" of human experience is replaced by "*indifferent distance*"—a spatial extension devoid of qualitative variation or significance.[2]

How inimical to complexity the indifferent time interval and indifferent distance of classical mechanics are is rhetorically impressed upon us by the applied mathematician, Ian Stewart , as follows:

> If the laws of physics are the same for all places and at all times, why is there any 'interesting' structure in the universe at all? Should it not be homogeneous and changeless? If every place in the universe were interchangeable with every other place, then all places would be indistinguishable; and the same would hold for all times. … The problem is, if anything, made worse by the cosmological theory that the universe began as a single point, which exploded from nothingness billions of years ago in the big bang. At the instant of the universe's formation, all places and all times were not only indistinguishable but identical.[3]

The indifferent time interval or dynamical time of classical mechanics is responsible for the philosophical position called Laplacian determinism—that the distinction between past, present and future is illusory because both the past and the future are already implicit in the present. More precisely, the past may be reconstructed, literally, from the present and the future predicted or constructed from the present. The past and the future may therefore be collapsed upon the present into a timeless, non-actualized potential. Hence, the homogeneity or identity Stewart speaks of above.

Nonlinear dynamics has disclosed the fallacy of Laplacian determinism. Laplacian determinism, nonlinear dynamics instructs us, can only be upheld if the present or starting conditions (i.e. the values of the variables in the equations of motion by which the laws of physics are expressed) are specified with infinite precision. Indeed, it is not at all clear that even infinite precision in the specification of starting conditions would suffice to uphold Laplacian determinism because of what is thought to be the ubiquity of K-flow dynamics in nature in which even infinite past observations leading to the present fail to predict the future.[4]

The specification of starting conditions adverted to above transpires in what physicists call the measurement process. This process may be contrived in the laboratory, as when scientists are checking out a new detecting instrument sensitive to some aspect of the universe hitherto

2. Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*. Cambridge, Massachusetts: Harvard University Press, 1971, p. 96.

3. Ian Stewart, *Nature's Numbers: Discovering Order and Pattern in the Universe*, London: Weidenfeld and Nicolson,1995, pp.84-85.

4. John L. Casti, *Complexification: Explaining a Paradoxical World Through the Science of Surprise*, New York: HarperPerrenial, 1995 [1994], pp. 287-288. See also Prigogine, *The End of Certainty*, pp. 105-106.

unobservable; or when, for some reason, calculation from first principles is impossible and only experimental measure will yield the relevant starting conditions; hence the origin of the term "measurement". Alternatively, the process may spontaneously occur in nature. In the process, a subject or measuring system selects particular dynamics for propagation from an object or measured system.[5] The selection is implemented through what are called, in physics, as boundary conditions; or more complicated boundary constraints (i.e. the range of admissible values to the variables at issue). The subject system selects a particular dynamic from the object system for expression in itself as a record in a material structure, such as a gene; or as a modulated action, such as enzyme catalysis.[6] For the boundary constraint exerted by the subject system to be able to discharge its selective function, however, it is required that it lie outside the descriptive embrace of physical law. This is not to say that it is beyond such embrace (at least, for finite measurement precisions). It is only to say that if one insists on such an embrace, then the boundary constraint will forfeit its ability to discharge the measurement function and another boundary constraint not within the descriptive embrace of physical law must be brought in.[7]

The subject and object systems involved in the measurement process, if they are not already present from a prior act of measurement, may be created during the measurement process itself; in which case, measurement is more accurately termed a bifurcation.[8] Measurements and bifurcations arise from instabilities (further explained below) defying the prediction of the laws of physics. In the case of the subject system, for example, consider the radiation process: This process can only transpire when the radiation sources (technically, the material oscillators) have succeeded in creating the necessary selecting environment (technically, the field oscillators) which will propagate radiation. There is a pause preceding this creative process that is not explained by the relevant equation describing the dynamics involved.[9]

Instability, as described above, transpires because the concrete or particular values assigned to variables in the laws of physics by natural or intentional processes are not and cannot, for finite beings in the observable universe, be of infinite precision; indeed, even infinite precision may, as described above in connection with nonlinear dynamics, be unavailing to prevent instability. Einstein, in effect, succinctly summarized this state of affairs when he said: "'Insofar as the propositions of mathematics are certain, they do not refer to reality; and insofar as they refer to reality, they are not certain.'"[10] Instability implies that, in both classical and quantum physics, "events" independent of laws (i.e. not predicted by laws) are necessary if we are able to account for the observable universe.[11] The events adverted to may be identified with the

5. Howard H. Pattee, "The Physics of Symbols: Bridging the Epistemic Cut," *Biosystems*, 60 (2001): 5-21, pp. 15, 19.

6. H. H. Pattee, "Simulations, Realizations, and Theories of Life," in: *Artificial Life: SFI Studies in the Sciences of Complexity*, Langton, C. (ed), Boston: Addison-Wesley Publishing Company, (1988): 63-77, pp. 73-74.

7. See Pattee, "The Physics of Symbols", p. 15.

8. See Prigogine, *The End of Certainty*, p. 69.

9. Gregoire Nicolis and Ilya Prigogine, *Exploring Complexity: An Introduction*, New York: W. H Freeman and Company, 1989, p. 214.

10. H. H. Pattee, "The Limitations of Formal Models of Measurement, Control and Cognition." *Applied Mathematics and Computation*, 56 (1993): 111-130, p.121. In this cited reference for the quote in the manuscript, the word "truth" is used instead of the word "certain". Pattee informs me in a personal communication that it should be the latter. Accordingly, the quote as it appears in the text.

11. See Prigogine, *The End of Certainty*, p.5.

contingent emergence and selective effects of boundary constraints and attest to the dictum of nonlinear dynamics that the whole is greater than the sum of the parts, over chronological time. The implication is that, for sufficiently complex systems, it is indeed possible to exercise ethical choice, initially at least, through the collective or macro-level imposition of selective boundary constraints on dynamics embracing the indefinite future. The embrace of the indefinite future in the imposed macro-level boundary constraint is necessary if ethical choice is at all to be made since the demands of the indefinite future act as a filter against the simultaneous incidence of all choices. Once the macro-level boundary constraint (which may be seen as a selecting environment) has been imposed, nothing prevents the exercise of ethical choice at the individual or micro-level.

The significance of the measurement process should be underscored: Prior to the measurement process in physics, the laws of physics are in a sort of timeless limbo without actual contact with what would be the observable universe.[12] That is to say (to echo Bergson), physical laws are so general of application (they represent the simultaneous incidence of all events within their descriptive embrace) that they find no particular application unless and until the measurement process selects a particular dynamic permitted by them for propagation in the actual universe.

Because of measurement and the consequent intrusion of nonlinear dynamics into mere linear or deterministic dynamics (or should it be the other way around?), chronological time is generated through a primitive history that may be termed nonlinear dynamical hysteresis. More precisely, when the imposed boundary constraint in the measurement process is sufficiently strong to permit several selections from the same parameter values in the boundary constraint such that chance alone determines the selection of particular dynamics for propagation (i.e. the selection of dynamics is not determined by physical law), then the "system is imbued with a historical dimension in the sense of a critical event that will influence subsequent system behavior. Such historically determined behavior is called [nonlinear dynamical] hysteresis".[13]

Nonlinear dynamical hysteresis, while it is necessary, does not suffice to generate the type of chronological time that fosters the indefinite evolution that characterizes the living condition. As Prigogine (who has done the most in elucidating how what we have termed nonlinear dynamical hysteresis is generated) instructs us:

> Irreversibility, and therefore the flow of time, starts at the dynamical [micro- or individual] level. It is amplified at the macroscopic level, then at the level of life, and finally at the level of human activity. What drove these transitions from one level to the next remains largely unknown, but at least we have achieved a noncontradictory description of nature rooted in dynamical instability. The descriptions of nature presented by biology and physics begin to converge.[14]

That convergence was consummated in successful bridging through the emergence of symbol-mediated boundary constraints complementing nonlinear dynamics as first

12. Prigogine, *The End of Certainty*, p.157.
13. See Nicolis and Prigogine, *Exploring Complexity: An Introduction*, pp. 14-24.
14. Prigogine, *The End of Certainty*, p. 162.

instantiated in the cell. As the fundamental example, consider protein synthesis: Genes only specify the linear sequence of amino acids constituting proteins. How these linear sequences then subsequently fold into three-dimensional conformations to confer the specific functional properties of proteins relies on complicated nonlinear dynamics not specified by the gene but rather resulting from attractions and repulsions between chemical bonds in the amino acid sequences and the chemical bonds in the environment of those sequences. This complementation of symbols and nonlinear dynamics in the living condition has been termed semantic closure in theoretical biology.

2. SEMANTIC CLOSURE AND INDEFINITELY EVOLVING COMPLEXITY

What is it that distinguishes complexity in the living domain from complexity in the non-living domain? In a seminal study initially ventilated through a lecture in 1948, the mathematician, John von Neumann, informed us that complexity in the living domain, with its ability to indefinitely evolve (a capacity not observed in complexity in the non-living domain), must involve the complementation of syntax or symbol manipulation and semantics in the form of nonlinear dynamics. This complementation, termed semantic closure, developed and evolved from the measurement process in physics.[15] The syntax involves molecules or other material structures invested with symbolic or linguistic significance serving as boundary constraints and capable of copying or transmission, without interpretation; and the semantics involves the dynamical selections of the boundary constraint and the subsequent interpretation of the constraint through the propagation of the dynamics, which propagation considerably augments the extremely limited information in the boundary constraint.[16]

We have already noted above the complementation of syntax and semantics in protein synthesis. This same complementation of syntax and semantics is observed at higher levels of aggregation, such as ribosomes, microtubules, membranes.[17] Through this complementation, semantic closure is able to manage complexity through resort to dynamical semantics that would defeat syntactic manipulations alone as disclosed by the preponderance of non-computable real-world problems that defeat digital computers; further, through successive syntactic selections, to cumulatively evolve that complexity over time. As Pattee amplifies of this latter point: "At higher evolutionary levels, the products of genes can become symbol tokens themselves within semantically closed epigenetic [i.e. developmental] loops."[18]

The semiotic or message conveying nature as opposed to the dynamical nature of the

15. Howard H. Pattee, "Evolving Self-Reference: Matter, Symbols, and Semantic Closure", *Communication and Cognition—Artificial Intelligence: The Journal for the Integrated Study of Artificial Intelligence, Cognitive Science, and Applied Epistemology*, 12 (1995): 9-27, pp. 10-11, 3.

16. H.H. Pattee, "Causation, Control, and the Evolution of Complexity," in: *Downward Causation*, P. B. Anderson, P. V. Christiansen, C. Emmeche. N. O. Finnemann (editors), Aarhus: Aarhus University Press, (2000) [1997]: , p.71; John L. Casti, *Complexification: Explaining a Paradoxical World Through the Science of Surprise*, New York: HarperPerrenial, 1995 [1994], pp. 221-223.

17. Howard H. Pattee, "Cell Psychology: An Evolutionary Approach to the Symbol-Matter Problem", *Cognition and Brain Theory*, 5 (1982): 325-341, p.333.

18. Pattee, "Cell Psychology: An Evolutionary Approach to the Symbol-Matter Problem", p.339.

complexity wrought by semantic closure should be emphasized.[19] The complementation of syntax and semantics means that we are dealing with "records, codes, signals, and messages" rather than mere dynamical interactions. This ability of semantic closure to convey messages embodied in the living condition reposes on the fact of the dialectical disjunction and continuity of syntax and semantics: The syntax, by avoiding complete microscopic description (which is beyond its ability anyway as revealed by the seminal investigations of Turing in computation theory) and resorting to dynamical elaboration (as when syntax only specifies the linear sequence of amino acids and leaves the semantic of sequence folding into functional proteins to nonlinear dynamics), means that the consequent semantic closure achieves a non-tautological description. Such non-tautological description is a requirement of information theory and symbolic dynamics if meaningful messages are to be at all possible. We shall see this point elaborated in our discussion of meaning below.

The peculiarity of this semiotic description to the living condition, with its ability to yield simplification of results into intelligibility and relevance (e.g. syntax leading to a computationally intractable crevasse of nonlinear dynamics leading to a functional protein) must be contrasted to the dynamical description championed by mainstream physicists and their adherents: In physics, an opposite trend is observed—the ubiquity of the simplest possible problems in the nonliving domain that produce such complicated results that the physicist must content himself with mere statistical descriptions forsaking *all* individual details.

Several properties of the symbolic boundary constraints in semantic closure make them naturally suited to embrace chronological time and indeed refine it beyond nonlinear dynamical hysteresis, to yield semiotic hysteresis. One of that property is, of course, memory: Genes (collectively, the genotype) afford the reproducibility, with slight modification, of their complementary nonlinear dynamics in the phenotype (i.e. the physical and behavioural characteristics) of the organism. That the phenotype is nonlinear dynamical in character explains why species with minimal differences in genotype (e.g. chimps and humans) can nonetheless display vast differences in attainments. That the changes in phenotype are also dialectically slight is the reason why the emergence of one species from another is difficult to discern, even in retrospect. Contrast this with the dramatic and non-equivocal character of emergence in simple nonlinear dynamical hysteresis, such as the fracture of a beam. In beam fracture, the cumulative production of "precursor structures of fracture" due to stress concentrators from imperfections in the three-dimensional molecular or atomic disposition of the bulk material, means that the repeated application of even an ostensibly safe load (way below the theoretical tolerance of the material in question if imperfections of molecular or atomic disposition in space were prevented, which they cannot be because this would take infinite time) must eventually yield to complete structural failure in the bulk material.

Another property of symbolic boundary constraints in semantic closure that lends itself to the embrace of chronological time is that of linguistic displacement: An alteration in a gene, for example, may presently have neutral effects. (Most alterations, however, have lethal effects.) Millions of years hence, it may be found to have a selective effect for survival in a novel environment.

19. Howard H. Pattee, "How Does a Molecule Become a Message?" *Developmental Biology Supplement*, 3 (1969): 1-16.

Linguistic displacement exhibits the power of the living condition to couple itself with the indefinite time horizon that nonlinear dynamics demands: Nonlinear dynamics' dictum that whole is greater than the sum of the parts means that the long-term cannot be built from the mere addition of the short-term. Accordingly, the long-term, macro-level goal or choice must, by intention, through cognitive semantic closure; or by inadvertence, through non-cognitive semantic closure, be imposed at the outset if the addition of short-term , micro-level, individual choices is to have a benign, let alone a prosperous conclusion.

In the evolution of life on the planet, the embrace of the indefinite future was achieved by non-cognitive semantic closure through bacterial intervention operating through epigenetic loops. The reference being made here is to the planetary superorganism termed Gaia by Lovelock.[20][20] As Lovelock has argued with great persuasion, it is only because of bacterial activity on a planetary scale that conditions hospitable to life have been preserved for and beyond the 3 billion years in which only bacteria and archea (another group of single-celled organisms) were the only living organisms on the planet. If bacterial activity had been absent and what we have identified as non-cognitive semantic closure had not been in operation through epigenetic loops, the planet would have evolved solely according to the equilibrium laws of physics and chemistry. In that case, all possible chemical reactions capable of transpiring from micro-level interactions would have done so. We would then expect the predominance, in our atmosphere, for example, of equilibrium gases of a generally non-reactive nature, such as carbon dioxide (which is in fact the case for Mars and Venus). Instead, we find gases that react with one another, such as oxygen and methane, co-existing indefinitely. This argues the intervention of life in preserving conditions hospitable to life (i.e. non-cognitive semantic closure).

This conclusion is at variance with mainstream, neo-Darwinian evolutionary biology, which takes the hospitability of the environment to life as a given. Accordingly, Lovelock points out, the neo-Darwinians have been the most vigorous objectors to his Gaia concept. Lovelock cites the example of the prominent, if not pre-eminent, neo-Darwinian, Richard Dawkins, who "[i]n his second book, *The Extended Phenotype*", attempted to quash the Gaia concept by arguing that genes could never express themselves on a planetary scale. Lovelock objects, however, that genes, through the mediation of the cell membrane, can in fact express themselves on a planetary scale: The necessity of keeping the cell membrane intact means that the biochemistry selected for propagation by genes and which reciprocally considerably augment the information content of the genes to a level of complexity beyond their own must, on pain of extinction, result in extracellular metabolites which operate to adjust environmental conditions towards compatibility with the cell membrane. Those environmental conditions as regards, say, "temperature, salinity, acidity, redox potential, water availability", are extremely restrictive in their range and it is exceedingly unlikely, if the equilibrium laws of physics and chemistry alone were in effect, that they would have persisted in the far-from-equilibrium ranges that they have.

For example, without the action of hydrogen-sequestering bacteria that metabolize hy-

20. James Lovelock, *Healing Gaia: Practical Medicine for the Planet*, New York: Harmony Books, 1991, pp. 21-22, 79-83, 95-101, 130.

drogen sulphide to sustain themselves; and without the oxygen generated by photosynthesizing bacteria that then combine with available atmospheric hydrogen afforded by the hydrogen-sulphide bacteria, hydrogen liberated from the reaction of water with rocks in the presence of carbon dioxide would, in a period of 1 or 2 billion years, have effectively caused the depletion of all ocean waters through eventual escape of hydrogen into space. Fortunately, because of bacterial intervention beginning in the Archean eon (spanning 3.7 to 2.5 billion years ago) and continuing to this day, calamities of this sort have been averted. Furthermore, they have been averted, contrary to the neo-Darwinian assertion that competition is the primary organizing principle for the evolution of life, through cooperative communities of bacterial mats on lagoons or as communities on rocky substrates that were being transformed into structures called stromatolites (some of them the size of houses). The cooperation involved, it must be emphasized, was achieved, not by intention, but simply through chemical signals and the selective effects of those signal in fostering survival or not.

Such bacterial communities are still around and constitute the basal steps towards epigenesis that includes endosymbiotic evolution. Endosymbiotic evolution, deriving from the work of Margulis, argues that the evolution of complexity in the biosphere has proceeded from the symbiotic assimilation of formerly autonomous bacteria in ever more complex structures. Dawkins, neo-Darwinian though he is, informs us that this endosymbiotic theory for the evolution of complexity in the biosphere is now almost universally accepted by biologists. He describes the result of that evolution as follows:

> Each one of us is a community of a hundred million million mutually dependent eukaryotic cells. Each one of those cells is a community of thousands of specially tamed bacteria, entirely enclosed within the cell … A single animal or plant is a vast community of communities, packed in interacting layers, like a rain forest. As for a rain forest itself, it is a community seething, with perhaps ten million species of organisms, every individual member of every species being itself a community of communities of domesticated bacteria.[21]

So we see that without non-cognitive semantic closure operating through epigenetic loops embracing the indefinite future (at least, approximately or effectively so, as we shall see in the next section) through the maintenance of the restrictive, far-from-equilibrium conditions compatible with the cell membrane, life on Earth would have not progressed beyond the bacterial stage before coming to an end. Semantic closure, cognitive or otherwise, is required, as von Neumann effectively argued (the concept of semantic closure was a subsequent distillation and elaboration from the work of von Neumann by Pattee), if complexity is to indefinitely evolve through semiotic hysteresis in what we have come to distinguish as life.

3. SUSTAINABILITY AND COGNITIVE SEMANTIC CLOSURE

In this section, we shall inquire why it is that cognitive semantic closure will be necessary if true sustainability is to be possible (again through semiotic hysteresis) beyond what even non-

21. Richard Dawkins, *River Out of Eden: A Darwinian View of Life*, London: Phoenix, 1996 [1995], p. 52.

cognitive semantic closure can manage. To see the necessity of cognitive semantic closure on first instance, it might be well to reflect on why it is that human culture has apparently been so destructive to the ability of this planet to support life. As the most direct demonstration of this assertion, consider that human activity (i.e. through habitat clearing, habitat fragmentation, unsustainable harvesting, pollution, introduction of alien species) has raised the background rate of extinction by ten thousand percent. This development qualifies then as the sixth great mass extinction episode to be suffered by the planetary biota. Certainly not helping in this regard is anthropogenic or human-induced climate warming resulting from the fact that we are liquidating geologic capital, in the form of fossil fuels, in a matter of centuries whereas the accumulation of that capital (representing the sequestration of heat-trapping carbon dioxide) transpired over hundreds of millions of years.

This destructive state of affairs may be readily ascribed, in light of the preceding discussion, to predominance of mainstream, neoclassical economics in the government of our affairs: Neoclassical economics was explicitly intended by its originators to be the equivalent, in the behavioral sciences, of classical mechanics in physics.[22] Accordingly, it instructs human affairs with dynamical time. That is to say, only with present conditions. It secures that only present conditions govern human affairs through deliberately adopted temporal myopia achieved through such practices as ceteris paribus (Latin for "all other things being equal") assumptions that are then used to prop up a spurious pseudo-dynamics (i.e. spurious because the conserved quantity is not identified as it is in, say, Hamiltonian dynamics in physics in which energy is the conserved quantity);[23] the "by-gones" principle that counsels that only the balance between *immediate* future costs and benefits, with benefits outweighing costs, should determine whether or not a project should go on;[24] and by discounting.[25]

The by-gones principle of economics, by effectively ignoring the cumulative costs of our actions, renders the economic process ahistorical, an isolated cycle of production and consumption that neither induces qualitative change in the environment in which it is embedded nor is affected by qualitative change in that environment.[26] Discounting is the inverse compound interest calculation to determine whether or not to invest in a project or simply put money in the bank. Its effect is to contract time horizon of consideration because of exponential increase of inverse compound interest (i.e. the successive sums to be added quickly approach zero), thereby militating against investments in sustainability. A rationale often urged for upholding the temporal myopia secured by discounting is risk aversion. Thus, for example, it is often the case that loggers would rather harvest trees and place the revenues in the bank to earn interest because of fear from risk of, say, disease wiping out the trees or a logging ban preventing their harvesting. This temporal myopia fostered by discounting, ceteris paribus assumptions, the by-gones principle, and by risk aversion is enforced by market competition and deliberately chosen in

22. See Georgescu-Roegen, *The Entropy Law*, pp. 1. 318, 320.

23. Philip Mirowski, "From Mandelbrot to Chaos in Economic Theory", *Southern Economic Journal*, 57 (1991): 289-307, p. 290.

24. Paul Samuelson and William D. Nordhaus, *Economics*. New York: McGraw-Hill, 1989, pp. 581-582.

25. Herman E. Daly and John B. Cobb, Jr., *For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future*, Boston: Beacon Press, 1989, pp. 152-154.

26. Georgescu-Roegen, *The Entropy Law*, p. 2.

cost-benefit analysis (i.e. to secure analytic tractability by eliminating increasing uncertainty, with chronologic time). The irony of this latter observation should be savored: cost-benefit analysis was precisely originated to correct for the market's temporal myopia!

How inimical to complexity the government of human affairs by present conditions alone or what is effectively dynamical time secured through temporal myopia is may be appreciated as follows: Temporal myopia militates against sustainable logging because agriculture yields quicker, more reliable, less risky returns to investment. By precisely the same reasoning, agriculture yields to manufacturing. In the same way, manufacturing gives way to speculative and financial institutions. The present financial crises shows in no uncertain terms how ultimately destructive dynamical time or government by present conditions or temporal myopia is: Even the abstract exchange value represented by money (as opposed to the concrete use value it purchases) is destroyed (e.g. the failure of financial institutions) by unrestricted pre-occupation with short-term gain authorized by instruction from present conditions or dynamical time alone. Accordingly, the necessity of instructing the economic process with chronological time.

As with non-cognitive semantic closure, the aim is to institute semiotic hysteresis and permit gradual evolution by supplanting the non-graduated qualitative transitions yielded by nonlinear dynamical hysteresis. As with non-cognitive semantic closure, to do this, we want to impose symbol-mediated boundary constraints embracing the indefinite future (in recognition of the fact that nonlinear dynamics decrees the whole to be greater than the sum of the parts) and which permit the reproducibility of nonlinear dynamics, with slight variations, as in the phenotype. In non-cognitive semantic closure, we saw that this embrace of the indefinite future was achieved, initially and primarily still, by cooperative bacterial intervention within epigenetic loops on a global or macro-level. This macro-level intervention preserves conditions hospitable to the cell membrane through the appropriate extracellular metabolites. In cognitive semantic closure, the same intervention must be effected through public policy and the appropriate implementing social institutions. The public policy concerned is sustainability and its implementing social institutions (at least, the minimum ones) are Daly's institutions for a steady-state economy.

Before we discuss those institutions, it might be well to digress a bit on how dynamical and chronological time affect the notion of sustainability as conceived by neoclassical economists (who champion the former) and ecological economists (who champion the latter). The neoclassical economist's notion of sustainability may be termed weak sustainability. This notion asserts that natural capital and man-made capital are substitutes rather than complements. They are qualitatively homogeneous rather than qualitatively heterogeneous. Natural capital (such as petrol) may therefore be completely converted to man-made capital (such as automobiles). The ecological economist's notion of sustainability is that of strong sustainability. This notion asserts that natural and man-made capital are complements rather than substitutes. They are qualitatively heterogeneous rather than qualitatively homogeneous. Accordingly, natural capital cannot be completely converted to man-made capital. Rather, quantitative restrictions or boundary constraints must be imposed to preserve the qualitative heterogeneity and consequent functional complementarity between them.

The untenability, if not absurdity, of weak sustainability as opposed to strong sustainability

is elaborated by Daly as follows:

> Man-made capital (along with labor) is an agent of transformation of the resource flow from raw material inputs into product outputs. The natural resource flow (and the natural capital stock that generates it) are the *material cause* of production; the capital stock that transforms raw material inputs into product output is the efficient cause of production. One cannot substitute *efficient cause* for material cause—one cannot build the same wooden house with half the timber no matter how many saws and carpenters one tries to substitute. Also, to process more timber into wooden houses in the same time period requires more saws and carpenters. Clearly the basic relation of man-made and natural capital is one of complementarity, not substitutability. Of course, one could substitute bricks for timber, but that is the substitution of one resource input for another, not the substitution of [man-made] capital for resources. In making a brick house one would face the analogous inability of trowels and masons to substitute for bricks.[27]

If it is granted that natural resources and man-made capital are complements, then the question of time horizon in the serviceability of resources cannot be avoided. In this respect, Beckerman writes:

> … Clearly, resources are either finite or they are not. If they are, then the only way to ensure their continuation in perpetuity is to stop using them. Stopping growth is not enough. Levels of consumption would have to be reduced to infinitesimal levels if finite resources are to be made to last forever.[28]

Accordingly, Beckerman concludes that an indefinite time horizon for resource use must be rejected and be reconciled with more pressing demands not instructed by the indefinite future. He recommends project-level sustainability "over the economically optimal period".[29] In other words, the indefinite future is to be built piecemeal rather than it governing what we should be doing in the short-term, as nonlinear dynamics demands if the short-term is to be compatible with the long-term.

Georgescu-Roegen put it well when he wrote:

> The claim that standard economics is not concerned 'with very long-run projections, but rather with the immediate future', is another means of avoiding the main issue that would incriminate the standard position. The problem of resources is not confined to the 'forseeable future', as many writers also insist, but concerns the entire future …. If the standard postion concerns only what will happen to natural resources 'in the immediate future' of this moment of the twentieth century, then all the din about how the market mechanism (especially that moulded on standard assumptions) can save us from ecological catastrophe is utterly idle. But if the claim is that exponential growth can prevail not only in our immediate future but also in any 'immediate future' in the future, then the claim acquires a factual, non-parochial significance.[30]

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27. Herman E. Daly, *Beyond Growth: The Economics of Sustainable Development*, Boston: Beacon Press, 1996, pp. 76-78.

28. Wilfrid Beckerman, "Economic Development and the Environment: Conflict or Complementarity?", Policy Research Working Paper, Report No. WPS961, Volume no. 1, 1992, p. 26. (A background paper for the World Development Report 1992 of the World Bank.)

29. Beckerman, "Economic Development and the Environment: Conflict or Complementarity?", p.30.

30. Nicholas Georgescu-Roegen, "Comments on the Papers by Daly and Stiglitz, in: V. Kerry Smith (Ed),

If the indefinite future is to govern our resource use, however, then cognitive semantic closure demands selective boundary constraints incorporating values expressed as public policy and implemented through social institutions explicitly embracing the indefinite future be imposed at the outset. Thus, the value of sustainability has been enunciated as meeting the needs of the present without compromising the needs of the future. A strong element of justice as fairness is clearly involved with the notion of sustainability. We shall amplify upon the notion of justice as fairness in the next section and how chronological time, through historical contingency, bears upon it.

If the indefinite future or an infinite time horizon is to govern our short-term actions in society as concerns resource mobilization, however, a problem arises: Due to the fact that at any given time the resources available to us as a *society* of finite beings is finite (the emphasis is made because what is rational from an individual vantage point, such as discounting, is often *not* rational from the collective vantage point, e.g. while individuals are mortal, collectives can be quasi-immortal), Georgescu-Roegen points out that this would mean (as also pointed out by Beckerman), over an infinite time horizon, that a null amount of resources would have to be "used".[31] To circumvent this paradoxical result, what needs to be done then is to spread resources evenly in time to secure the longest life-span for the species. The physics of how to secure this aim has apparently been afforded us by Dyson.[32]

The key to securing the longest life span for the species, despite the fact that at any given time the available resources to the species is finite, is to vary the schedule of resource mobilization such that it observes a pulsing mode. That is to say, we want resource mobilization to be suspended altogether in what may be termed as periods of stasis, with these periods of stasis being allowed to lengthen without bound. In these periods of stasis, we follow the lead of nature by going to seed, as it were: We store the information for modulating resource mobilization in the next cycle of existence in non-resource-dissipating equilibrium or quasi-equilibrium structures, such as seeds, spores, or crystals. If we follow such a resource mobilization regime, then Dyson's calculations show that even a finite amount of resources would suffice for a virtual infinity of time in sustaining the species. For example, Dyson showed that, if only energy mattered, then solar output for a mere eight hours would suffice for literally eternity to support a population of the order of magnitude that presently subsists on this planet.

The hindrance to achieving an actual infinity of time is the fact that matter decays to energy over illimitable, chronological time. Thus, even black holes evaporate through Hawking radiation. Ultimately, it is thought that the only recently discovered cosmological-scale phenomenon called dark energy will rip apart all material configurations down to the sub-atomic scale. The only solace to this depressing conclusion is the possibility of further cycles of existence due to the possibility, if not probability, that energy is a "bottomless ocean of which we can observe effectively only the waves on its surface."[33] If so, this is tantamount to finding new

Scarcity and Growth Reconsidered, Baltimore: RfF and Johns Hopkins University Press (1979): 95-105, p. 96.

31. Georgescu-Roegen, "Comments on the Papers by Daly and Stiglitz,, pp.101-102.

32. Freeman Dyson, "Time without end: physics and biology in an open universe", *Reviews of Modern Physics* 51 (1979): 447-460.

33. See Georgescu-Roegen, *The Entropy Law*, p. 138.

particles of matter, with novel properties, however deep we plumb that ocean.[34]

What would be the quality of life afforded in Dyson's resource mobilization regime? Surprisingly, the quality of life possible in Dyson's resource mobilization regime need not be bounded by any upper limit (excepting only the limit imposed by matter decay) precisely because there is a distinction between quality and quantity (supposing quantitative restrictions are able to preserve qualitative heterogeneity).[35] Such a distinction between quality and quantity has in fact been urged upon economic policy by Boulding.[36] Boulding argued that since it is from the capital stock that we derive our satisfactions from, not from the additions to it (production) or from the subtractions from it (consumption), the object of economic policy should be to minimize production or consumption. Otherwise, if we were to maximize either, the maintenance cost of the capital stock would also be maximized.

So much for the physics of sustainability. As to the economics of the implementation of this physics (at least at a minimum level), mention has already been made of Daly's institutions for a steady-state economy (SSE). These include an institution for controlling resource inflows into the economy; one for controlling income differentials; one for controlling population.[37] The necessity for a social institution controlling income differentials shall be discussed at greater length in the next section. Suffice it to say in this section, its necessity is indicated because, among other things, the institution for controlling resource inflows into society uses implements that actually amount to a regressive tax that hits the poor harder than it does the rich.

One such implement that is completely acceptable to Daly for servicing a SSE is the present cap-and-trade system in carbon dioxide emissions. The idea of the cap-and-trade system is that a limit to permissible carbon dioxide emissions from fossil fuel use is imposed at the outset and this limit is translated into permits to pollute which are then auctioned off to users of fossil fuels (in the main, corporations). The revenues from the auctioning of the permits constitute public revenue and may be used to offset the regressive nature of the permits through government transfer payments. (The regressive nature of the permits arises from the probability that the corporations may shift some of the costs, at least, to consumers of their products, e.g. electricity bills) Over time, the limit to permissible carbon dioxide emissions would be contracted towards compatibility with ecological tolerances. The consequent rise in fuel prices would then provide market incentive for more efficient industrial processes.

The cap-and-trade system was first realized in the European Union (albeit, from what the author knows, without the auctioning of the permits, initially). The system need not be confined to a continent, however. In a recent BBC debate (June or July 2009, if the author remembers correctly), the author of this paper heard an academic from the Lee Kuan Yew School of Public Policy in Singapore talk of the necessity of a global cap-and-trade system in carbon dioxide emissions that would act as a conduit for transfer payments from rich to poor countries, not as a matter of mere pragmatism, but rather as a matter of entitlement and justice due to

34. John D. Barrow, *Theories of Everything: The Quest for Ultimate Explanation*, London: Vintage, 1992 [1991], pp 78, 85.

35. Dyson, "Time without end: physics and biology in an open universe",

36. See Daly, *Beyond Growth*, pp. 67-68.

37. Herman E. Daly, *Steady-State Economics*, San Francisco: W. H. Freeman and Company, 1977, pp. 50-75.

the injustices inflicted by historical contingency (i.e. the rich countries are primarily responsible for global warming).

The cap-and-trade system as an implementing social institution of public policy is a good instance of cognitive semantic closure: It displays macro-level control reflective of a collective value (i.e. sustainability) incorporated through the total number of permits imposed at the outset in recognition of the fact that market prices, even when augmented by cost-benefit analysis, are unable to properly instruct micro-level control exerted by individuals in the marketplace. So the cap-and-trade system displays the complementation of macro- and micro-level controls we have come to identify with semantic closure. The necessity of the macro-level control should be emphasized, however. In economic terms, this is due to the fact that market prices cannot incorporate the market bids of future generations, not even with the considered anticipations of economists performing cost-benefit analysis. Accordingly, quantitative allotments of resources must be availed of in the interest of justice as fairness, which fairness also has a salutary effect upon the present generation: It restrains that generation from making choices in dynamic time that, as discussed above, is so inimical to complexity and therefore, by extension, the continued possibility of life, let alone quality of life.

This is where Dyson's calculations naturally come in: Dyson's calculations, in effect, demands that the entire sequence of generations possible to the human species should instruct the resource allocation for each generation in that sequence. As Dyson's calculations show, the time scales involved are virtually infinite. It may seem absurd that such scales of time should be involved in the instruction of economic policy. The author submits that it is not: The weak anthropic principle in cosmology articulates that the observable universe must exhibit certain properties if it is to contain living organisms. One such property has to do with chronological time: The universe must be of a certain minimum age if it is to permit the evolution of life. For example, life is literally made from star-stuff: the debris of supernovae explosions incorporated into less violent star systems induced into existence by those same explosions. So we already know that prodigious amounts of time have been involved in preparing the stage for life. Dyson's calculations only show, in accord with the nonlinear dynamical dictum that the whole is greater than the sum of the parts, that the perpetuation of life (as was already approximated by non-cognitive semantic closure on this planet through bacterial intervention) also requires the embrace of an even more prodigious amount of time—the indefinite future in its entirety.

Historical time, in the sense of semiotic hysteresis, thus truly asserts its indissoluble linkage with the living condition and binds that condition with the fate of the universe and Purpose. As Dyson himself counsels:

> It is impossible to calculate in detail the long-range future of the universe without including the effects of life and intelligence. It is impossible to calculate the capabilities of life and intelligence without touching, at least peripherally, philosophical questions. If we are to examine how intelligent life may be able to guide the physical development of the universe for its own purposes, we cannot altogether avoid considering what the values and purposes of intelligent life may be. …
>
> If our analysis of the long-range future leads us to raise questions related to the ultimate meaning and purpose of life, then let us examine these questions boldly and without

> embarrassment. If our answers to these questions are naive and preliminary, so much the better for the continued vitality of our science.[38]

If we therefore desire sustainability beyond even what non-cognitive semantic closure can afford (i.e. it is unlikely that non-cognitive semantic closure can observe the peculiar pulsing schedule described by Dyson's calculations), then we must instruct the cap-and-trade system with Dyson's pulsing-mode resource mobilization. In this way, we would be able to more creditably demonstrate the superiority of brains over genes. As to when instruction of the cap-and-trade system with Dyson's calculations is to be achieved, this action explicitly requires the development of stasis technology. Accordingly, awaiting this development, it has been suggested that Daly's SSE institutions be first employed to slow down world economic growth so that human civilization's course may be safely charted according to the Kardashev nomenclature of civilization types.[39]

Slowing down world economic growth should help chart a safe course through the Kardashev nomenclature because it would reduce consumption stresses upon the natural environment and corresponding inequity stresses upon the social environment (i.e. because of the well-recognized trade-off between growth and equity). The Kardashev nomenclature recognizes three civilization types: Type I, Type II, and Type III. A Type I civilization controls the resources of an entire planet. A Type II civilization captures the entire output of the star in its star system and therefore, by extension, controls the resources of an entire star system. (Dyson himself has done the engineering studies for the capture of the energy output of an entire star through what has been appropriately termed the Dyson sphere and concludes that it is definitely technically feasible.) A Type III civilization controls the resources of an entire galaxy.[40]

We have not reached the status of a Type I civilization yet, according to Dyson, but shall probably do so in several centuries time—provided that ecological catastrophe does not overtake us.[41] To help avert such a possibility, Dyson has suggested the genetic modification of ecosystems *while respecting ecological relationships* so that natural ecosystems yield human necessities and wants (e.g. whatever chemicals we might need, including fuels) in addition to maintaining themselves in viable health. He concedes that the creation and nurturance of such a biologic industrial system might always remain an art rather than a science. He, however, considers that possibility just one more reason to opt for such a system.

The transition to a Type II civilization would, at a modest growth rate of one percent compounded annually, be achieved in 2500 years. It has been suggested that the instruction of Daly's SSE institutions with Dyson's pulsing mode resource mobilization be effected when we have achieved Type II status: Not only would this schedule probably afford the appropriate time to develop stasis and other germane technologies, we would also need the resources of a Type II civilization to seed other star systems with colonies as a buffer against species extinction from truly catastrophic events, such as stellar gamma-ray bursts or supernovae explosions.

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38. Dyson, "Time without end: physics and biology in an open universe",

39. Horacio Velasco, Sustainability: the matter of time horizon and semantic closure, *Ecological Economics*, 65 (2008): 167-176, pp. 173-174.

40. Freeman Dyson, *Disturbing the Universe*, London: Pan Books, 1981 [1979], p. 212.

41. Dyson, *Disturbing the Universe*, pp. 228-231.

Mention has been made of the necessity of respecting ecological relationships if we are to achieve Type I status. Certainly helping in this regard is the control of population growth. This is explicitly recognized by Daly when he includes as one of his SSE institutions one for controlling population growth. Basically, this would work the same way as the cap-and-trade system for carbon dioxide emissions, with the difference that we would be working with birth permits rather than pollution permits. As well, the birth permits wouldn't be auctioned off but rather freely given to the population. The permits are then yielded to government, along with proof of sufficient means of child-rearing support, when one desires to conceive progeny. People who violate this requirement would have their children put up for adoption. People who desire more children than the permits they have would warrant could purchase additional permits in the marketplace and people who don't desire children could sell their permits. This system ensures that children are likely to be born to or raised with families that not only truly cherish them but also have adequate means to raise them. As concerns the total number of birth permits to be allotted, this should be only what organic agriculture (i.e. agriculture that does not avail of fertilizers and chemical pest control) could sustain.

4. JUSTICE AND COGNITIVE SEMANTIC CLOSURE

In the previous section, we saw that sustainability, purely on the level of physics, demanded, as Dyson himself explicitly articulated, that "questions related to the ultimate meaning and purpose of life" be raised. This is exactly what nonlinear dynamics, with the primitive hysteresis associated with it, would indicate since it tells us that the future cannot be built up through repeated iterations of short-term choices. Rather, the entire future must instruct what our choices in the short-term must be. This, we can only do if we are clear what purpose the future is to serve, at least, nay, of necessity at the most fundamental level allowing the greatest elaboration, over time. That purpose, if the future is to serve any purpose at all, can only be sustainability since without sustainability the existence of the future cannot be guaranteed. Sustainability, in agreement with Dyson's seminal investigations, has been defined as meeting the needs of the present without sacrificing the needs of the future (i.e. the entire future, as Dyson's calculations indicate). The future therefore exercises restraint on the claims and choices of the present and in so doing the present achieves safe passage into the future. Sustainability therefore demands a complementarity between the future and the present, a complementarity achieved through cognitive semantic closure: the macrolevel or collective purpose of sustainability is imposed, through the appropriate social institutions and their associated implements, upon microlevel or individual purposes so that these achieve compatibility with sustainability and therefore survive into the future through consequent semiotic hysteresis.

Sustainability, as defined above, clearly has a core element of justice conceived of as fairness. Dyson's physics of resource mobilization upholds it. Justice as fairness, however, was also the position arrived at by the purely philosophical investigations of the philosopher, John Rawls. As we shall see, chronological time through the irrevocable choices made in semiotic hysteresis and even nonlinear dynamical hysteresis (both cases of historical contingency), also played a key role in Rawls' determination of justice as fairness. To complement the findings of Dyson's

physics of resource mobilization that sustainability demands justice as fairness, we now turn to Rawls' philosophical investigations to further impress the convergence of ethics and technics when sustainability is concerned. In so doing, Dyson's and Rawls' investigations receive reciprocal support from one another and bolster the mutual security of their foundations.

It is to John Rawls, in his *A Theory of Justice* (Harvard University Press, 1971) that we owe the first systematic inquiry of our obligations to future generations.[42] (Subsequently, inevitably, Rawls would further qualify his thoughts in *A Theory of Justice* through such books as *Political Liberalism* [Columbia University Press, 1993] and *Justice as Fairness* [Harvard University Press, 2001]). Of Rawls achievement, philosopher, Daniel Dennett, had this to say: "Rawls' theory has received, and deserved, more attention than any work of ethics in this [20th] century." Of the nature of Rawls' theory, Dennett tells us this: "Rawls presents a thought experiment about what, if it did happen, would be right. Rawls' project … is an entirely normative project: an attempt to demonstrate how ethical questions ought to be answered, and, more particularly, an attempt to justify a set of ethical norms".

The though experiment Dennett adverts to is termed the original position (OP).[43] The OP is a hypothetical, ahistorical meeting of all generations possible to the human species.[44] In Rawls' own words as he concludes *Theory of Justice*, to see our place in society from the OP " 'is to see it *sub specie aeternitatis*: it is to regard the human situation not only from all social but also all temporal points of view' ".[45] Elsewhere in *Theory of Justice*, Rawls writes: "Each aspect of the original position can be given a supporting explanation. Thus, what we are doing is to combine into one conception the totality of conditions which we are ready upon due reflection to recognize as reasonable in our conduct towards one another." (It may seem ironic that an ahistorical meeting of generations is required to address problems of historical contingency; however, a little thought suffices to persuade that, in fact, only by stepping out of history, as it were, could we make adjustments to contingencies or accidents of circumstance constituting history.) Thus, Rawls' OP, as with Dyson's calculations, demands consideration of the entire sequence of generations possible to the human species, albeit Dyson's calculations, on a purely pragmatic level and not on the level of justice as an *idealization*, considers only all future generations.

In this OP, the members of every generation are to operate behind what Rawls calls a " 'veil of ignorance' ". This veil of ignorance obscures from the members of each generation their historical, social, and genetic circumstances. Thus, they do not know to which generation they belong or what their social status is within each generation; nor do they know their genetic gifts or afflictions. Only behind this veil of ignorance, Rawls argues, could and would we truly care about what features human society is to exhibit if it is to render justice.

Among those features that Rawls considers are the social means (e.g. political and legal rights, leisure and independence, wealth and income) and resources that each generation would have to work with in their pursuit of the worthwhile life, however that life is conceived.

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42. Lukas Meyer, "Intergenerational Justice", *Stanford Encyclopedia of Philosophy*, 2008, section 4.4. http://plato.stanford.edu/entries/justice-intergenerational/

43. Daniel C. Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. New York: Touchstone, 1996 [1995], p. 456.

44. See Meyer, "Intergeneration Justice", section 4.4.

45. Samuel Freeman, "Original Position", *Stanford Encyclopedia of Philosophy*, 2008, section 8.

(Such pursuit is a major motive in the decisions of the parties to the OP.) In the ideal case as to the allocation of those social means and resources, Rawls concludes (in subsequent qualifications of his thoughts in a *A Theory of Justice*) that it would have to be a conservation or savings principle such that " 'the members of any generation (and so all generations) would adopt as the one their generation is to follow and as the principle they would want preceding generations to have followed (and later generations to follow), no matter how far back (or forward) in time' ". Accordingly, this principle of just savings thus agreed on is to be binding for all previous and future generations.

To implement his just savings principle, Rawls envisions two stages of social development. There would first be an accumulation stage in which the allocation of resources to the current generation compatible with just allocation to future generations is achieved. (This resonates with the disclosed recommendation in the previous section that Daly's SSE institutions only be instructed with Dyson's calculations after we have achieved Type II status in the Kardashev nomeclature of civilization types.) The next stage is what Rawls calls the steady-state stage. This stage is attained when the appropriate social institutions are established. The previous section discloses that Rawls was in error here: What Rawls should have said was the pulsing-mode stage in the sense described in the section.

Rawls stresses in his theory the minimum amount of available resources (along with other primary social means) if the parties to the OP are to be able to make rational choices: Although, they may not even have knowledge, in the OP, of the good that they want to pursue in life, guided by the available resources and primary social means that are available to them or which they possess, they can still make rational choices.[46] That those rational choices are likely to be just is underscored by comparing Rawls' thick veil of ignorance and the utilitarians' thin veil of ignorance. (Mainstream, neoclassical economics, it should be noted, is utilitarian in its thrust.)

For utilitarians, the particulars of everyone's circumstances are known and are taken as givens. The justice of these particulars is not questioned. Rather, what happiness is possible from these particulars is to be maximized in the aggregate or in the average because we do not know our particular identities (this ignorance then constitutes the thin veil of ignorance). By contrast, Rawls' thick veil of ignorance deprives one of knowledge of both one's personal identity and personal circumstances (e.g. as to social status, historical situation, genetic gifts). These particular circumstances are therefore not taken as givens we have to work with. They may be questioned as to their justice. Deliberations behind Rawls thick veil of ignorance on the justice of these particulars may then aid in the construction of the appropriate social institutions that would indeed guarantee justice relative to particular circumstances for everyone in every generation (or at the least, all remaining generations) by ameliorating the injustice of those particular circumstances.

Rawls argues above that for rational behavior operating towards justice behind the thick veil of ignorance in the OP to be possible, a minimum of resources and primary social means must be available to each member of each generation. What is the decision procedure for deciding that minimum that Rawls advocates? Without benefit of Dyson's seminal calculations,

46. Freeman, "Original Position", section 3.

Rawls advocated a maximin decision rule.[47] That is to say, he wants to ensure that the least advantaged members of society, in whatever generation, should have the resources and primary social means available to them maximized. The maximin rule is to be chosen because the exercise of choice (behind the thick veil of ignorance in the OP) concerning what the nature of society is to be, is not subject to renegotiation or repetition; further, that choice determines all future prospects for the individual (i.e. semiotic hysteresis achieved through cognitive semantic closure embodied in the appropriate social institutions).

How does one defend the choice of the maximin decision rule for the OP against the Bayesian statistical charge of its irrationality for most scenarios involving uncertainty? It is true that, for most decision contexts involving maximal uncertainty, the maximin decision rule is irrational since statistical independence of circumstances counsels equiprobability of contingent personal circumstances. One would, therefore, logically favor maximizing average utility (i.e. happiness, satisfaction) over minimum utility. However, those decision contexts involve "future opportunities to recoup potential losses and choose gain." Those opportunities are absent from the OP because the moral choices involved from that position are irrevocable (they hold in perpetuity). To put it another way, the Bayesian statistical objection is only valid if we operate in an atemporal or dynamical time rather than in temporal or chronological time. Therefore, the necessity of the maximin rule if justice is to be served and responsibility discharged. As the physical chemist and Nobel laureate, Wilhem Ostwald, eloquently put it: " 'The responsibility for every act has sense only if the act cannot be repeated, if what is done is done forever.'"[48]

That the distinction between historical and dynamical time must be made absolutely clear to instruct one's arguments about intergenerational justice is revealed in the work of another philosopher, Derek Parfit, eminent in this sphere of inquiry. I refer in particular to what Parfit has called the *repugnant conclusion* (RC). The RC holds that any decline in the quality of life of population could and would, other things remaining equal and supposing that the decline in quality of life still leaves life worth living (even though barely), be compensated for by an increase in population.[49] In other words, Parfit is arguing that the increase of total utility in a population (i.e. number of people multiplied by their satisfaction), supposing his presuppositions are granted, would compensate for decline in quality of life. As the description itself suggests, the RC is a conclusion that Parfit (as well as many others scholars and academics) do not like.

The most natural way to avoid the RC is, of course, simply to challenge the assumption of "all other things remaining equal" (i.e. to recall, this is the ceteris paribus assumption of the neoclassical economists in their destructive affirmation of dynamical time). The distinction between historical and dynamical time certainly authorizes this challenge. Historical time means irrevocable qualitative transformations, as the discussion on strong sustainability in the previous section implied. Strong sustainability therefore demands quantitative restrictions be imposed on natural and man-made capital. Such restrictions, through the appropriate social institutions instructed by Dyson's resource mobilization physics (Daly's SSE institutions, for ex-

47. Freeman, "Original Position", section 6.1.

48. Jeremy Rifkin and Ted. Howard, *Entropy: Into the Greenhouse World*, New York: Bantam Books, 1989, p. 288.

49. Jesper Ryberg, Torbjorn Tannsjo, Gustaf Arrhenius, "Repugnant Conclusion", *Stanford Encyclopedia of Philosophy*, 2006, section 1.

ample), should avoid Parfit's RC.

If, as argued above, the maximin decision rule is to be implemented to secure justice, then certainly an important aspect that decision rule must address is the limitation of income differentials within each generation (therefore, the importance of inheritance taxes, at least initially): Purchasing power for the individual is more a function of relative rather than absolute income.[50] Thus, if your neighbor earns four times as much as you do, increasing both your incomes by a factor of three would leave your relative purchasing powers unaltered. If an improvement in your purchasing power is to transpire, it is required that the factor increase in your income exceed that of your neighbor's. Thus, your income might increase by a factor of three whereas your neighbor's increases only by a factor of two. Accordingly, the prescription in section 3 of a social institution for limiting income differentials, initially in the context of a steady-state economy (SSE) as conceived by Daly, which SSE is subsequently switched to pulsing mode according to Dyson's calculations.

In this regard of limiting income differentials, minimum income should be able to afford food, clothing, shelter, basic health and education. Maximum income might be placed at ten times minimum income since evidence from the military and the civil service shows that this income differential is able to generate sufficient incentive such that all jobs are filled voluntarily.[51] Limiting income differentials through minimum and maximum limits is also likely to lessen wealth accumulation: Why accumulate and maintain wealth (if this is at all possible from the limited income) from which you are unable to derive income anyway? Still, limitations on wealth might deserve further study.[52]

The salutary effects of limiting income differential to fostering justice and community is articulated by Daly amplifies as follows:

> Unlimited inequality is inconsistent with community, no matter how well-off the poorest are. Even relative poverty breeds resentment, and riches insulate and harden the heart. Conviviality, solidarity, and brotherhood weaken with economic distance. Political power tends to follow relative income and cannot be allowed to concentrate too far in either a theocracy or a democracy without leading to plutocracy.[53]

Achieving a limitation of income differential might be had through a combination of negative income taxes (i.e. subsidies to low incomes, say, from progressive and resource transformation taxes) and/or a universal basic income (UBI).[54] A UBI (advocated by Van Parijs, among others) is "an income paid by a government, at a uniform level and at regular intervals, to each adult member of society." It is income fixed at a certain level that is paid "whether the person is rich or poor, lives alone or with others, is willing to work or not." It may apply (indeed, in most versions it does) to include, not only citizens, but permanent residents as well. The characterization "basic" does not mean that the UBI is necessarily expected to meet "basic needs" (the UBI may be well below subsistence or well above it); all it means is that it is income that a person can rely upon whatever his circumstances.

50. Robert H. Frank and Philip J. Cook, *The Winner-Take-All Society*, New York: The Free Press,1995, p.14.
51. See Daly, *Beyond Growth*, p.210.
52. Daly, *Beyond Growth*, p.212.
53. Daly, *Beyond Growth*, p.214.
54. Philippe Van Parijs, "A Basic Income for All", *Boston Review*, October/November, 2000.

The fundamental authorization for the UBI as being due to the operation of historical (rather than dynamical) time is given by Van Parijs in his answer to those who object that the UBI is "undeserved good news for the idle surfer": As Van Parijs retorts, providing the idle surfer with a UBI

> is ethically indistinguishable from the undeserved luck that massively affects the present distribution of wealth, income, and leisure. Our race, gender, and citizenship, how educated and wealthy we are, how gifted in math and how fluent in English, how handsome and even how ambitious, are overwhelmingly a function of who our parents happened to be and of other equally arbitrary contingencies. Not even the most narcissistic self-made man could think that he fixed the parental dice in advance of entering this world. Such gifts of luck are unavoidable and, if they are fairly distributed, unobjectionable. A minimum condition for a fair distribution is that everyone should be guaranteed a modest share of these undeserved gifts. Nothing could achieve this more securely than a UBI.[55]

Van Parijs wants to make clear that he does not mean to deny "the importance of work and the role of personal responsibility" with his advocacy of the UBI. His motive, rather, is to provide reasoned, ethical defenses against (thanks to the Anglo-Saxon economic hegemony) "a fashionable political rhetoric that justifies bending the least advantaged more firmly under the yoke." In so doing, he wishes to persuade us that there is more justice to "everyone being entitled to an income, even the lazy" than to "everyone being entitled to a vote, even the incompetent."

The limitation of income differential by the UBI and negative income taxes in a pulsing-mode economy that does not grow (i.e. increases production or consumption) but develops (improves the nature of the capital stock towards serving the public good) is indispensable because, not being a growing economy, paying jobs will likely not be available for all, perhaps even the majority. Is this something to be lamented, however? A growing economy is one that sacrifices equity and maximizes profit. As Daly argues:

> If automation and offshoring of jobs results in more of the total product accruing to capital (that is, the businesses and business owners profit from the product), and consequently less to the workers, then the principle of distributing income through jobs becomes less tenable. A practical substitute may be to have wider participation in the ownership of businesses, so that individuals earn income through their share of the business instead of through full-time employment.[56]

Additionally, the enforced leisure imposed by a pulsing-mode economy should give people the incentive to become more civilized in the sense astutely discriminated by Clarke as the ability to be happily occupied for a lifetime even if one did not work for a living.[57]

5. MEANING AND SEMIOTIC HYSTERESIS

The role of chronological time, in the sense of semiotic hysteresis initially achived by non-

55. Philippe Van Parijs, "A Basic Income for All", *Boston Review*, October/November, 2000.

56. Daly, Herman E. 2005. "Economics in a Full World." *Scientific American*, September, pp. 100-106, p.106.

57. Arthur C. Clarke, Profiles of the Future: An Inquiry Into the Limits of the Possible, London: Pan books Ltd. ISBN: 0030697832,1973, p. 177.

cognitive semantic closure and subsequently by cognitive semantic closure, in the sustainable propagation of indefinitely evolving complexity and justice was discussed in the preceding three sections. In this section we see that semiotic hysteresis is also intimately related, nay, sine qua non for the possibility of meaning to life.

To assemble the argument for this thesis, it may be well to begin with the varieties of happiness that positive psychology has discriminated.[58] These are three: a pleasant life; eudaemonia; and meaning. A pleasant life simply corresponds to acquiring as many of the positive emotions as you can manage, along with the skills for amplifying them. "There are a half dozen such skills that have been reasonably well-documented." This is the "Hollywood view of happiness" as exemplified by a giggling Debbie Reynolds. That this is not the only kind of happiness is readily disclosed by even a superficial reading of history: Thinkers "from Aristotle through Seneca through Wittgenstein" looked upon a mere pleasant life as rather vulgar. As stated above, at least two other kinds of happiness (with "very good intellectual provenance") are possible that would be more welcome to these thinkers.

Eudaemonia, the good life, is the sort of happiness that Thomas Jefferson and Aristotle would have advocated. Eudaemonia does not consist in copious smiles and giggles or refer to "thrills", visceral feeling uninstructed by thought, or "orgasms". Rather, eudaemonia consists in such things as "Aristotle talks about": such things as "the pleasures of contemplation and the pleasures of good conversation". When one is in a state of eudaemonia, it is as if "time stops" and you merge with the music. There is a liberation from self-consciousness and a feeling of being "completely at home."

To achieve eudaemonia, one wants flow. This means identifying "what your signature strengths are and then recrafting your life to use them more." That is to say, you want "your work, your romance, your friendships, your leisure, and your parenting to deploy the things you're best at." When you do this, the result is not more giggles in your life but more flow.

In connection with the signature strengths to be identified to achieve eudaemonia, Seligman (the originator of positive psychology) and his colleagues conducted "a 70-nation study" which yielded "a classification of strengths and virtues". This classification disclosed "six virtues …endorsed across cultures, and these break down into 24 strengths." The six virtues included the following: "first, a wisdom and knowledge cluster; second, a courage cluster; third, virtues like love and humanity; fourth, a justice cluster; fifth a temperance, moderation cluster; and sixth a spirituality, transcendence cluster." The study suggests that these six virtues are about as fundamental to "human nature as walking on two feet are."

An example of "recrafting your life" to achieve flow and eudaemonia is afforded us by Seligman. He relates that he worked with a bagger at a store. She didn't like her job. Seligman asked her to take the signature strengths test and it emerged that her highest strength was social intelligence. Accordingly, she consciously "recrafted her job to make the encounter with her the social highlight of every customer's day." Obviously, many of her customers didn't see it as she intended it. However, "by deploying the single thing she was best at, she changed the job from one in which time hung heavy on her hands into one in which time flew by."

58. Martin Seligman, "Eudaemonia, The Good Life", 2004. http://www.edge.org/3rd_culture/seligman04/seligman_index.html

How truly fundamental eudaemonia is to a happy life or even simply, to life itself, is also impressed upon us by Seligman when he relates to us a story involving one of his undergraduate teachers, Julian Jaynes—who he characterizes as "a peculiar but wonderful man." He was a research associate in Princeton when Seligman was an undergraduate there. According to Seligman, some people characterized Jaynes as a genius, but Seligman didn't know him well enough to be able to judge. As for the story, Jaynes was "given a South American lizard as a laboratory pet." Jayne's problem was that "no one could figure out what" the lizard ate. Accordingly, the lizard was dying.

So, as the story goes, Jaynes came in one day. The lizard lay in the corner, in torpor. Jaynes was having ham on rye for lunch and he offered some of it to the lizard. The lizard would have none of it. Jaynes read the *New York Times*. Without thinking about it, he put the first section down on top of the ham on rye. Seeing "this configuration", the lizard "got up on its hind legs, stalked across the room, leapt up on the table, shredded the New York Times, and ate the ham sandwich." So we see that even "lizards don't copulate and don't eat unless they go through the lizardly strengths and virtues first." If creatures as relatively simple as lizards have to experience eudaemonia to lead a healthy and happy life, then this argues so do we.

As for the third type of happiness—meaning—this may be considered an extension of eudaemonia to the social sphere. That is, you want to deploy your strengths in the service of a collective larger than yourself that serves not only your interest (achieving flow) but others as well. Seligman gives the example of a lawyer. A lawyer can either be in his profession just to make money; or he can be in it to further "good counsel, fairness, and justice."

A problem with meaning as a form of happiness, Seligman, concedes is that it doesn't distinguish between good and evil. As Seligman instructs us, if meaning simply consists in "joining and serving in things larger than you that you believe in while using your highest strengths", then there is no distinction between suicide bombers and the firemen who try to save the victims of the suicide bombers. Both lead meaningful lives, albeit one may be characterized as evil and the other as good.

Clearly, if the concept of a meaningful life cannot distinguish between good and evil deeds, then there is something objectionable about it. A possible way of resolving this problem, as suggested by the previous sections would be the imposition of an indefinite time horizon to instruct our present interests. That indefinite time horizon would encompass, at the least, all future human generations, or, as in Rawls' OP, deployed as a normative artifice for distilling universally valid principles of justice (in conjunction with his "veil or ignorance"), all human generations.

How merely extending our time horizon to the unlimited future may temper our decisions and actions towards expunging evil and malice is suggested by this argument from Daly: The further we look into the future, then the more likely it is that we, in the present generation, are potential co-progenitors of a common descendant according to the retroactive algorithm 2^n (where n is the number of previous generations). Accordingly, to the extent that we care about our remote descendants, then we should also care for our contemporaries. This fact, Daly argues, gives us an additional reason to care for our contemporaries and gives the lie to the common charge that "concern for the future" weakens ethical concern for more pressing

problems of present injustice.[59]

Daly points out, however, that caring for our remote descendants, due to increasing anonymity of kinship, is in the nature of a public good and must therefore be addressed through collective arrangements or institutions. He also points out that because care for our remote descendants is a public good, the conclusion reached by mainstream economists that "the revealed public will" is "that the future beyond two generations should carry no weight in present decisions" because "people usually take no action and show little interest in their own descendants beyond their grandchildren" is a fallacious one.

Rawls' OP and his veil of ignorance should also exert a restraining influence in the investment of meaningful lives with evil intent. To recall, the OP is an imagined ahistorical meeting of all human generations and the veil of ignorance may be taken to mean as the unpredictable and irrevocable hand of contingency in assigning to us to the conditions of our lives (including which generation we live in). The conjunctive operation of these two conditions means that we do not know our fate in life. Accordingly, it would be hard to harbor evil intent against others because the consequences of those evil intent might well fall on ourselves.

The foregoing discussion clearly shows the literally decisive role played by chronological time in exercising ethical choice. It offers support for and is reciprocally given support by the judgment of the British astrophysicist, Arthur Stanley Eddington, when he wrote: " 'In any attempt to bridge the domains of experience belonging to the spiritual and physical sides of our nature, [chronological] time occupies the key position' ".[60] By contrast, the denial of the ability to exercise any choice at all, let alone ethical choice, by those who reject chronological or historical time in favor of dynamical time is plainly disclosed by this confession from a neoclassical economic theorist:

> [neoclassical economists] naturally tended to think of models in which things settle down to a unique position independently of initial conditions. Technically speaking, we theorists hoped not to introduce *hysteresis* phenomena into our model, [thereby taking] the subject out of the realm of science and into the realm of genuine history.[61]

A technical way chronological time helps to foster meaning in human lives on its largest scale through historical time may be seen through the metaphor afforded us by symbolic dynamics (i.e. the hybrid discipline from the union of information theory and dynamical systems theory) about how meaningful messages are generated from symbols.[62] Symbolic dynamics teaches us that this requires two conditions, at the least: 1.) The symbols involved must exhibit a preferential direction in space. Thus, English only makes sense when read from left to right; Arabic only makes sense when read from right to left; and the genetic code only makes sense when read in a fixed direction from a start point. 2.) It must be impossible, "in all nontrivial cases", to infer the message from a sequence of symbols, however large a segment of the sequence we possess. The message should only emerge after reading the entire sequence. Thus, the books worth reading are those that demand being read in their entirety and not those with

59. Herman E. Daly, "Postscript: Unresolved Problems and Issue for Further Research", in: *Energy, Economics, and the Environment: Conflicting Views of an Essential Interrelationship*, Herman E. Daly and Alvaro F. Umaña (eds), Boulder, Colorado: Westview Press (1981): 165-185, pp. 177-178.

60. See Prigogine, *The End of Certainty*, p.59.

61. See Mirowski, "From Mandelbrot to chaos in economic theory", p.291.

62. See Nicolis and Prigogine, *Exploring Complexity*, p.186.

conclusions we can infer without having read all their pages.

Meaning in our lives therefore requires the predictive opacity imposed by uncertainty over historical time. As the heterodox economist, Nicholas Georgescu-Roegen, has noted of this opacity, it results from the fact that the "needs generated by evolution" are often so subtle that we are seldom aware of their "influence upon our complex activity", if we are even aware of their existence at all. In consequence, only after the fact "do we realize why we labored and what we searched for" and subsequently affirm "with Ostwald Spengler that 'a task that historic necessity has set will be accomplished with the individual or against him' ".[63]

Georgescu-Roegen was therefore entirely correct in praising this predictive opacity and the meaning it affords the human condition when he wrote:

> With a life span amounting to no more than a blink of a galaxy and restricted within a speck of space, mankind is in the same situation as a pupa destined never to witness a caterpillar crawling or a butterfly flying. The difference, however, is that the human mind wonders what is beyond mankind's chrysalis, what happened in the past and, especially what will happen in the future. The greatness of the human mind is that it wonders: he 'who can no longer pause to wonder and stand rapt in awe'—as Einstein beautifully put it—'is as good as dead'. The weakness of the human mind is the worshiping of the divine mind, with the inner hope that it may become almost as clairvoyant and, hence, extend its knowledge beyond what its own condition allows it to observe repeatedly.[64]

It seems therefore that even infinite beings, if there be such (certainly we cannot exclude this possibility as it lies in the realm of theology where, as per the distinctions made by the philosopher, Karl Popper, propositions are unfalsifiable and therefore non-testable and non-scientific), have cause to envy finite beings such as ourselves. It may even be, if they have caused our existence, that the reason they have done so was to experience, in their immanent aspects (through us), what they cannot, in their transcendent aspects: Meaning.

This necessity of historical time if meaningful lives are to be had may be complementary impressed through the resulting existential pain that comes only with preoccupation with present conditions (that is, by being instructed only by dynamical time). This existential pain is certainly attested to by author, Bryan Appleyard, when he writes:

> I am born and I shall die and, in between, these visions are what they most obviously are: mine. This is the only timespan I have and the only one in which my virtue and purpose may be found. I choose not to be written into some history of the future or beguiled by the technological demands of the as-yet unborn. …
>
> Such an avowal means the end of the rule of science because it denies the infinite open-endedness and willingness to change that science needs for the continued invasion of our souls. It also means an insistence that my soul be put back where it belongs—in my body—rather than in the remote realm to which, 400 years ago, science consigned it. This realization alone may not make that soul immortal, nor will it promise me an afterlife or salvation. So you may say it leaves me exactly where I was before—mortal, suffering, and as lost as ever. I will reply that there is one vital difference: I shall not be,

63. See Georgescu-Roegen, *The Entropy Law*, p.27.
64. Georgescu-Roegen, *The Entropy Law*, p.207.

> at the last, alone. [65]

That is bitter and empty solace indeed: "community" in death.

Why preoccupation with present conditions alone should lead to such existential pain is given psychological explanation by Skinner as follows:

> One of the great problems of individualism, seldom recognized as such, is death--the inescapable fate of the individual, the final assault on freedom and dignity…[T]he individualist has a special reason to fear death, engineered not by a religion but by the literatures of freedom and dignity…He has refused to be concerned for the survival of his culture and is not reinforced by the fact that the culture will long survive him. In the defense of his own freedom and dignity he has denied the contributions of the past and must therefore relinquish all claim upon the future.[66]

In other words, the existential pain has to do, as asserted before, with the denial of the affinity of the living condition with chronological or historical time rather than with dynamical time.

6. CONCLUSION

It is an acknowledged commonplace that people whose choices are motivated only by immediate reward (choices often associated with sociopaths) do not prosper and are apt to have lives that are, to quote Hobbes, "short, nasty, and brutish." What is not generally known, let alone acknowledged, is that wider society too, whether capitalist, communist, or socialist, by looking only at finite time spans in the future in their collective aspirations, have been essentially motivated by short term gain as well. In effect, therefore, human affairs on this planet is directed by dynamical time. This is why we find ourselves in our present predicament, with the very ability of the planet to support life impaired and obfuscated from our awareness by its treatment as an external cost (rather than a central cost) by capitalist, mainstream, neoclassical economics (with its global hegemony); as well by the fact that it is in the nature of nonlinear dynamical transitions (as of a beam failing) that we seem to be doing okay until we take that final step, to the point of no return.

If we are to repair this ultimately lethal state of affairs, it will be necessary to embrace the indefinite future through cognitive semantic closure, thereby displacing dynamical time with the chronological time (in the sense of semiotic hysteresis) in which the living condition has evolved (of necessity, initially through non-cognitive semantic closure). The deliberate exercise of cognitive semantic closure through the social institutions described in this paper (with their associated implements and as instructed by Dyson's seminal calculations) may be the first unambiguous demonstration of the superiority of brains over genes since it was brains that uncovered the resource mobilization schedule that permits the perpetuation of life into virtual infinity. Supposing the indefinite perpetuation of life, that superiority would further be bolstered in the quality of life yielded: one of justice and meaning as the claims of the future restrain the claims of the present, thereby shaping and filtering those present claims into choices which, through their selection and consequences, essentially project as non-tautological messages through the communications channels of chronological time: semiotic hysteresis.

65. Brian Appleyard, *Understanding the Present: Science and the Soul of Modern Man*, London: Pan Books Ltd., 1992, pp. 249-250.

66. B. F. Skinner, *Beyond Freedom and Dignity*, New York: Bantam/Vintage, 1972 [1971], pp. 200-201.