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MORE THAN METAPHOR: GENOMES ARE OBJECTIVE SIGN SYSTEMS

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ABSTRACT

Genetic cybernetics preceded human consciousness in its algorithmic programming and control. Nucleic acid instructions reside in linear, resortable, digital, and unidirectionally read sign sequences. *Prescriptive information* instructs and manages even epigenetic factors through the production of diverse regulatory proteins and small RNA's. The "meaning" (significance) of prescriptive information is the function that information instructs or produces at its metabolic destination. Constituents of the cytoplasmic environment (e.g., chaperones, regulatory proteins, transport proteins, small RNA's) contribute to epigenetic influence. But the rigid covalently-bound *sequence* of these players constrains their minimum-free-energy folding space. Weaker H-bonds, charge interactions, hydrophobicities, and van der Waals forces act on completed primary structures. Nucleotide selections at each locus in the biopolymeric string correspond to algorithmic switch-settings at successive decision nodes. Nucleotide additions are configurable switches. Selection must occur at the genetic level *prior to* selection at the phenotypic level, in order to achieve programming of computational utility. This is called the *GS Principle*. Law-like cause-and-effect determinism precludes freedom of selection so critical to algorithmic control. *Functional Sequence Complexity (FSC)* requires this added programming dimension of freedom of selection at successive decision nodes in the string. A sign represents each genetic decision-node selection. Algorithms are processes or procedures that produce a needed result, whether it is computation or the end products of biochemical pathways. Algorithmic programming alone accounts for biological organization.

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ABBREVIATIONS

RSC: Random Sequence Complexity;
OSC: Ordered Sequence Complexity;
FSC: Functional Sequence Complexity;
MSS: Material Sign Systems;
OEE: Open-Ended Evolution;
GS Principle: Genetic Selection Principle

INTRODUCTION

DNA's instructions are instantiated into a linear, digital, resortable physical matrix (Yockey, 1973, Yockey, 1992, Yockey, 2004). Genetic algorithmic optimization accounts for metabolic homeostasis (Abel, 1997, Abel, 2000, Abel, 2002). Natural genetic algorithms inspired the artificial modeling techniques called by that same name (Chambers, 2001, Mitchell, 1998).

Sign systems are fundamentally cybernetic (von Neumann, 1950a, von Neumann, 1950b, von Neumann, 1956, von Neumann, Aspray and Burks, 1987, von Neumann and Burks, 1966). Signs/symbols invariably *represent* decision-node *selections* from among real contingent options. In cybernetics, choice with intent at each binary decision node is symbolized with a "0" or "1". These signs *mean* "off" and "on" respectively. They represent a physical switch setting. The circuit is either open or closed with an excluded middle. "Open" cannot mean "closed" at the same time and in the same sense. Logic begins with such "logic gates." Logic proceeds not by law, but by *rules*. It is not constrained, but *controlled. Choice contingency* makes logic, mathematics, language, and science possible. Neither chance nor necessity can explain *formality* (Abel and Trevors, 2005, Trevors and Abel, 2004). Formality (e.g., mathematics) is nonphysical—nondynamic. Even categorization of any kind is impossible without *selecting* the subset into which an entity should be placed.

Von Neumann (von Neumann, Aspray and Burks, 1987) drew his inspiration from biology, and specifically from genetics. Had he known what we know today about the details of molecular biology, he would have been all the more inspired. Von Neumann's "threshold of complexity" is *description-based* complexity. Description is symbolic. Pattee rightly argues that description is not contrary to physicality. It is just complementary to physicality (Pattee, 1982, Pattee, 1995b).

In order for signs/symbols to represent physical configurable switch-settings, an "*epistemic cut*" must be traversed (Pattee, 1977). Nonphysical description must somehow be translated into dynamic realization. Pattee calls this *semantic closure* (Pattee, 1982, Pattee, 1995b, Pattee, 2000, pg. 74, Umerez, 1995). Contributions from both symbolic description and material modes are required in a certain *complementarity* (Pattee, 1978, pg. 191). Pattee

has also pointed out the necessity of a sign system for Open-Ended Evolution (OEE): “A necessary condition for hereditary transmission is a classification process or a many-one mapping.” (Pattee, 1967, pg. 410). OEE is impossible under any conditions other than semantic closure (Pattee, 1982, Pattee, 1995b). Symbols and matter must interact. But in what sense? Physical instantiation can feed back dynamically onto its own physicality, but not onto symbol meaning assignment. The latter is fundamentally nonphysical. Physicality cannot dynamically affect non physicality (e.g., formality).

The symbol selections at each decision node of nucleic acid formation is isolated from final physicality and utility by what Rocha calls a *dynamic discontinuity* (Rocha, 2001). Rocha points out that cognitive science relegates the notion of a material sign system (MSS) to a functionalist approach (Rocha, 2001). The functionalist approach deems the physicality of the MSS to be irrelevant. The materialistic biophysics of life-origin science has difficulty relating to such a purely functionalist approach. Yet genetic code clearly represents a sign system, coding encryption/decryption, and functional meaning at the destination of its biomessages.

Switches must be set in a certain way to achieve computational function. The assignment of representational meaning to a physical sign in a MSS must be arbitrary (Yockey, 1992, Yockey, 2004). That is, the occurrence of a certain sign at any functional decision node must be unconstrained by natural law. The decision of which switch-setting is to be made must be dynamically inert. The logic gate must be freely configurable. Signs/symbols are fundamentally a representation of which switch setting is being set. “Yes, No,” “On, Off,” “Open, Closed,” “O, 1” are all variants of the same binary mode of *choice contingency* that alone makes computational function possible. Language, mathematics, and logic can all be expressed using this binary expression of successive decision-node selections. Indeed, so can successive nucleotide selections.

Although arbitrary with reference to law-like constraints, the occurrence of a certain sign at any decision node is anything but arbitrary in the sense of being random. No empirical evidence exists of randomly generated sign sequences producing even modest cybernetic computation. No observational support exists to justify the belief that stochastic ensembles in sequence space can spontaneously self-organize into a physical sign *system.* Only metaphysical imperatives and paradigmatic commitments maintain such a notion, not empiricism, reason, or predictability. The latter three provide the very foundation of science.

“System” is a loaded word. We use the words “system” and “organize” loosely to refer to *self-ordered* dissipative structures such as hurricanes and tornadoes. But these phenomena are not truly organized or bone fide systems. Organization and systems are more appropriately reserved to refer to algorithmically and computationally coordinated utility. Sign systems do not arise spontaneously from highly-ordered, low-informational, law-like behavior. In addition, sign systems do not arise from the heat agitation of molecules. Sign systems in human experience arise only from *choice contingency* at successive decision nodes, not chance contingency or necessity (Trevors and Abel, 2004).

Genomic instructions are a form of what Abel (Abel, 2002, Abel and Trevors, 2005) calls *prescriptive information*. Such a clarifying descriptor of information is necessary to distinguish mere Shannon combinatorial uncertainty and Kolmogorov complexity from functional algorithmic strings. Algorithms steer events and behavior toward organized, predictable usefulness. Prescriptive information utilizes a sign system to either instruct or to directly compute utility.

MUST SIGN SYSTEMS BE SUBJECTIVE?

When we hear the terms "semiotics" and "cybernetics," we tend to think in cognitive terms. To whatever degree we ascribe meaning and purpose to a message, to that same degree we tend to associate it with the cognitive function of humans. This is because our naturalistic perspective precludes meaning and purpose from natural process. It is widely agreed, for example, that even evolution has no goal.

At some point surprisingly early on in life's history, the pre RNA, RNA, and perhaps concomitant Protein Worlds had to slowly evolve into the current DNA/RNA/Protein transcription/translation world. It is at this point where tension arises between our naturalistic metaphysical presuppositions and our semiotic sensibilities. Stochastic ensembles of ribonucleotide analogs in a preRNA World had no meaning. They just happened to possess the property of self-replicative catalysis. These same self-replicative sequences are believed to have also possessed the capability to catalyze productive protometabolic reactions. Given enough time and a large enough sequence space, many of these happenstantial "dual-purposed" stochastic ensembles are believed to have cooperated together—to "self-organize"—into an algorithmic, genetically described/instructed protometabolism.

Evolutionary history mandates that sign systems had to have predated humans by at least three billion years (Hayes, 1996, Mojzsis, Arrhenius, McKeegan, Harrison, Nutman and Friend, 1996, Parsons, Lee and Smith, 1998, Schopf, 1993, Van Zuilen, Lepland and Arrhenius, 2002, Yockey, 2000). Sign systems and biocybernetic function were busy instructing and computing invertebrates and vertebrates long before *Homo sapiens* arrived on the scene. We cannot reduce biosemiotics and biocybernetics to human epistemology. Genetic control is objective rather than humanly subjective. Genetic cybernetics produced our cognition and subjectivity. Mentation is seen by naturalistic science as an epiphenomenon of physical brain. If this assumption holds, objectivity precedes subjectivity. *Objectivity gives birth to subjectivity,* not the other way around.

We can retreat into the epistemological problem and into various versions of antirealism/solipsism if we wish. But in doing so we will not make much progress elucidating a literal evolutionary history. Such a history is presumed to be physical. This is the essence of philosophic naturalism and evolution theory. At some point in pre human history functional sign systems had to *objectively* arise in the material world. No cell, let alone central nervous system, could have organized without controlling sign systems. The notion of homunculi died out not only because of a growing understanding of linear digital genetics, but also because of the realization that any three-dimensional physical information system could not possibly fit spatially into a zygote.

THE ROLE OF NATURAL SELECTION

For good reason the terms "natural selection" and "environmental selection" both include the term "selection." Selection in our naturalistic paradigms replaces the more subjective "choice with intent" of our cognition. The best phenotypes in any environment are selected passively through *differential reproductive success and differential survival*. The fittest phenotypes are *those with the most utilitarian computations and heritable cybernetic control*.

Algorithmic optimization has never been observed apart from selection. The environment selects indirectly for optimal fitness and survival. But natural selection raises new questions. We know that inanimate nature cannot select *for* anything in an active teleological sense. Natural selection is passive. The fittest populations survive. The rest die out. But can such after-the-fact selection of the best phenotypes really explain selection at *genetic* decision nodes? A nucleotide addition to a polynucleotide constitutes a particular configurable switch setting. Genetic prescription of computation precedes and produces phenotypic realization. And this prescription is "written in stone" with covalent bonds. Linear primary structure exists with strong bonding before folding into functional three-dimensional conformation ever begins. Correct selections that ultimately determine conformation must be made at the linear digital level. If genetic "programs" are full of "bugs," the computed phenotypic population will not be the fittest.

THE RELATIONSHIP BETWEEN CYBERNETICS AND PHYSICS

A cybernetic switch is physical. The flipping of the switch is a dynamic process through time. The selection of a certain option from among those options that the switch offers, however, is as formal as mathematics itself. The consideration and choice of switch positions precedes the dynamic action of flipping the switch. Choice contingency has potential and eventually real dynamic effects. But the intent of which choice commitment will be made (using the switch) is nonphysical, nondynamic. And it is not merely descriptive. It is *prescriptive*. Whatever switch position is chosen will determine the degree of utility of the integrated circuit. Function is determined by the formal computational halting of the system. But computational success is accomplished at the individual decision node level. In addition, integration of those individual decisions must be made wisely to bring about holistic success (e.g., metabolism). Coordination of solitary configurable switches into holistic function constitutes even more abstract meta control. The only instantiation into physicality of this higher level organization is found in the circuit board or homeostatic metabolism as a whole.

Thus programming *uses* dynamics to accomplish its ends. But the programming decisions themselves are intangible. The algorithmic computation achieved through the use of any material sign system (MSS) is formal rather than physicodynamic. Failure to acknowledge this reality results in innumerable futile life-origin studies. In experiments limited to pure dynamics, no true algorithmic organization is ever realized. In so-called evolutionary algorithms, human artificial selection is incorporated into the experimental design. The latter is usually through investigator steering of iteration paths toward the desired ribozyme being engineered (Bartel and Szostak, 1993, Conrad, Baskerville and Ellington, 1995, Ekland, Szostak and Bartel, 1995, Ellington and Szostak, 1990, Keefe and Szostak, 2001, Knight and Yarus, 2003, Lehman, Donne, West and Dewey, 2000, Robertson and Joyce, 1990, Robertson, Hesselberth and Ellington, 2001, Tuerk and Gold, 1990, Unrau and Bartel, 1998). Artificial life investigators and most applied biologists accepted this reality early on. Steering is required to achieve sophisticated function of any kind. Much of the life-origin research community, however, continues to "live in denial" of this fact.

Physicist Howard Pattee sees physics and evolution theory as the two great scientific disciplines (Pattee, 1982). But these two great disciplines seem to be disjoint. Constructions and descriptions lie in separate categories of reality. Dynamics (constraints, energy, mass, forces, and laws) are distinct from semiotics (symbols, codes, language, rules, digital information, control). Pattee realized that the frozen accidents of incidental physics and chemistry do not explain the highly algorithmic nature of genetic control (Pattee, 1995a, pg. 3). A threshold of complexity exists that requires a *description phase* for open-ended evolution to be possible (Pattee, 1982) (Pattee, 1995b). A genotype-phenotype threshold exists. For all of the hundreds of papers in the life-origin literature that have pursued the nature of this threshold, few have succeeded as well as Pattee in isolating its essence.

Von Neumann inspired Pattee by distinguishing between active physical dynamics vs. quiescent symbolic descriptions. This process took place parallel to and mostly independent of the formal biosemiotics movement history that began with von Uexküll (von Uexküll, 1928, von Uexküll, 1982). The two histories complement each other, culminating in up-to-date contributions by Howard Pattee (Pattee, 2005), Hoffmeyer and Emmeche (Hoffmeyer and Emmeche, 2005), Kull (Kull, 2005), Nöth (Nöth, 2005), Barbieri (Barbieri, 2005) and many others in the first issue of the *Journal of Biosemiotics.*

TURING TAPES AND MACHINES

The hypothesis that DNA and its transcribed and edited mRNA serve as programmed Turing tapes is not new. Von Neumann (von Neumann, 1961) and Henry Quastler (Quastler, 1958) were among the first. Other researchers followed (Chaitin, 1979, Yockey, 1974). Recent application of the metaphor along with semiotic analogies is abundant (Barbieri, 2005, Benenson, Paz-Elizur, Adar, Keinan, Livneh and Shapiro, 2001, Cristea, 2002, Hood and Galas, 2003, Lenski, Ofria, Collier and Adami, 1999, Noll, 2003, Pargellis, 1996, Pargellis, 2001, Wilke, Wang, Ofria, Lenski and Adami, 2001), to name just a few.

A theoretical Turing tape can be instantiated into a physical tape similar to a computer back-up medium. It can also be instantiated into a physical DNA or mRNA strand. But to concentrate on the dimensions of a physical medium or RNA strand is like concentrating on the dimensions of the molecules of ink on paper. One will never understand the nature of messages studying dynamics alone. The instructions are in a different plane of reality—a different category. Confusion results from committing the logical fallacy of a "category error." The physicality of a mRNA strand is one category. The cybernetic function of mRNA is another category. A back-up DVD, ink and paper, electron flow, sound waves, smoke signals, and mRNA can be different physical instantiations of the exact same succession of *symbolized* selections. We call this a program—a computational algorithm. Instructions of any kind can always be converted into a binary decision-node linear sequence format. We loosely call this “digital” even though digital technically means “base 10”.

In one sense the Turing tape is time-independent. In another sense, the Turing tape has a time vector dimension because the string is read through time. Choices are affected by prior choices. We are forced to symbolize the succession from one finite state to the next using a linear data feed. But the choices represented by each 0 or 1 are otherwise dimensionless. Choices are abstract and non-physical. As Pattee argues, the genetic message is time-

independent (Pattee, 1977, Pattee, 1980, pg. 265). The genome in a bacterial cell or spore can be read tomorrow or fifty years from now. The instructions are still there. Thus a Turing "tape" is not really a physical object. But the choices can be represented using physical symbol vehicles.

Because one idea follows another in the time dimension, we are forced to represent these choices on a linear time vector. From the standpoint of genetic instruction, AUGUUCCCAUGGAUAGCACCC is unidimensional. The three-dimensional physicality of a mRNA strand is not what binds to the destination target. Codons are Hamming redundancy *block codes* that *represent* an amino acid (Yockey, 1992). Nucleotides function as formal signs, not physical reactants. Codons are symbols.

Ideas such as "selection for fitness" have no quantifiable dimensions (Barbieri, 2003, Barbieri, 2004a, Barbieri, 2004b, Barbieri, 2005). The notion of selection at configurable switches (e.g., nucleotide selections) is nonphysical even though the selection is instantiated into a physical medium of memory retention and transmission (nucleic acid).

Programmed Turing tapes are worthless without Turing machines to read them. A Turing machine is a theoretical and conceptual mechanism. But both tape and machine can be instantiated into physical matrices. The translation system of molecular biology functions as a universal Turing machine. A ribosome's digital sensing head moves back and forth reading *prescriptive information*. The symbols recorded in mRNA consist of triplet codons of A,U,C,G that can be expressed using 0's and 1's (2^{NH} bits per codon). Like the tape, the machine requires an operational context which is itself algorithmically programmed. The source, tape, machine, and destination must all operate in the same communication system context. Yet the physicality of the tape has no direct connection to the physicality of the independently produced machine. This suggests a commonality of programmed system design and engineering that cannot be attributed to ordinary physicochemical causation or chance. For the tape and machine to display any utility, they must both be controlled by the same conceptual *rules*, not constraints. They both must cooperate from the beginning in an abstract, nonphysical way. And there must be a handshake of meaning between message source and message destination.

One can hardly recognize a Turing machine in modern day computers. The level of current hardware sophistication obscures the basic principles of how digital computation is accomplished. But all computation can nonetheless be traced back to the basic operation of the Turing machine and tape. As our knowledge of molecular biology grows, the level of sophistication becomes more difficult to explain, especially the origin of genetic instructions. Gene overlapping, gene splicing, post-transcriptional editing, post-translational editing, operons, small RNA interference and regulation, retroviral reverse transcription, and ribozymic intron function are examples of these higher levels of cybernetic complexity. Like computers, the basic principles and operation of genetic control remain the same. Genetic algorithms retain their prescriptive information, and replicate that information, using linear digital bit string segments. Life's most advanced control mechanisms are digital and algorithmic. Epigenetic factors do not undo this reality.

EPIGENETIC EXCEPTION TO GENETIC CONTROL

Post-transcriptional editing is cited often when taking exception to digital genetic programming. But epigenetic context does not occur spontaneously in a vacuum. Editorial cutting and splicing are mediated by restriction enzymes, ligands, and small RNA's. Timing regulation, positive and negative feedback mechanisms, transport proteins, and operon-like systems, are all mediated primarily by biopolymeric sequence. Even with zinc finger-like phenomena, metals must bond at certain locations in the architecture of the folded primary structure. Ultimately, *the covalently-bound sequence of monomers* determines the minimum-free-energy folding space of epigenetic major players. Behind virtually all epigenetic control mechanisms is genetic instruction and ultimate control.

Post-translational polypeptide editing (Bachmair, Novatchkova, Potuschak and Eisenhaber, 2001, Eisenhaber, Bork and Eisenhaber, 2001, Vaish, Dong, Andrews, Schweppe, Ahn, Blatt and Seiwert, 2002) refines proteins to optimize their function. But this too provides still further evidence of the algorithmic nature of life's processes. Post-translational editing of proteins is performed by proteins. These proteins were themselves programmed by independent linear digital genetic instructions. Genetic cybernetics ultimately determines even the epigenetic context. Even the Turing machine itself is algorithmically instructed. Lac operon-like systems and feedback regulatory systems are still fundamentally genetic. Genomes at least indirectly correlate all of these secondary molecular interactions. As Sharov says, "genes determine the choice of developmental trajectories at branching points" (Sharov, 1992). Even though the set of creods (stable trajectories) seem to exist independently from genes, every aspect and level of the metabolism that utilizes creods is orchestrated. This symphony is directed in real time by holistic programming that makes and uses at the proper time transport subsystems. The instructions are smart enough to allow responses to environmental challenges.

IS THE HYPOTHESIS OF OBJECTIVE GENETIC CYBERNETICS TESTABLE?

Our hypothesis in this paper is that the cybernetic function of genomes is not merely metaphoric or heuristic, but is objectively real. In addition, we maintain that the machinery of protein translation can be viewed as an objective Turing machine without anthropomorphizing. We contend that both the Turing tape and the Turing machine predate humans. Genetic instruction utilizes halting computational program strings. The selection of one of four nucleotides at each successive locus in a string functions as a four-way switch-setting. Each monomer is a decision-node selection in the mRNA program tape. *We contend that messenger molecules have real objective meaning, not just analogous subjective meaning to human minds.*

Genomic instructions prescribe objective biofunctions at their metabolic destination. The "meaning" of messenger molecules is realized in the context of the message's contribution to metabolism, differentiation, growth, and reproduction.

The Biosemiotics and Biocybernetics fields are converging in the realization that life is not only responsible for digital semiotics, but is itself cybernetically programmed:

> "There are no sign systems functioning out of touch with living beings, and no living organisms which can function without some sign systems (at least genetic code). This fact gives evidence of common roots of biology and semiotics, and indicates the necessity of the synthesis of these two sciences." (Sharov, 1992)

Null hypotheses are needed to scientifically test and potentially falsify an "*objective* Turing tape/machine" hypothesis. We have reduced these down to four testable null hypotheses:

1) *Stochastic* ensembles of physical units cannot program algorithmic/cybernetic function;
2) *Dynamically-ordered* sequences of individual physical units (physically patterned by natural law causation) cannot program algorithmic/cybernetic function;
3) *Statistically weighted means* (e.g., increased availability of certain units in the polymerization environment of sequence space) giving rise to patterned (compressible) sequences of units cannot program algorithmic/cybernetic function.
4) *Computationally successful* configurable switches cannot be set by chance, necessity, or any combination of the two.

Only one nontrivial algorithmic programming success would be needed to falsify any one of these null hypotheses. But such a success would have to be free of artificial selection. Experimental design cannot itself contribute to selecting for fitness. Investigator involvement is often hidden in the *steering of iterations*. The latter is often incorporated into the experimental design of so-called "evolutionary algorithms." Ribozyme engineering research using SELEX (Ellington and Szostak, 1990, Robertson and Joyce, 1990, Tuerk and Gold, 1990) is a classic example of artificial selection from investigator involvement. Experimenter steering toward a desired goal is hardly "evolution." Evolution has no goal.

The above null hypotheses pertain to the setting of switches to achieve complex function *at the decision-node programming level* where monomers link. This is very different from after-the-fact phenotypic fitness selected by the environment. We are addressing *the generation* of functional genetic algorithms (genotypes) that produce those phenotypes. We concur with Sharov that no known living phenotype exists without a cybernetic genome instructing and controlling its metabolism, development, growth, and replication/reproduction. *Each of our four null hypotheses is scientifically testable.* We offer the prediction that none of these four hypotheses will be falsified in any amount of time.

We further challenge ourselves and the scientific community to falsify the following hypothesis: "Meaningful (functional) messages are invariably algorithmic." Algorithms consist of an integrated sequence of decision-node switch-settings that achieve function. Each of these switch-settings is symbolically represented. The sequence of symbols is integrated into syntactic, semantic, and pragmatic programming instructions. "Instructions" of any kind provide enumeration of the particular sequence of selections that efficiently leads to ideal computational function. Computation is formal, not dynamic. This remains true when the formal system utilizes physical symbol vehicles. Such optimization of formal systems can result only from *bone fide selection at the decision-node level, and from meta selection at the integrative level.*

The decision-node level in biology is the rigid covalently-bound nucleotide selection level. Abel's *GS Principle* (Genetic Selection Principle) states that selection of halting biological computations of fittest phenotypes must occur at the genetic level. After-the-fact selection of the fittest phenotypes is not sufficient to explain genetic programming. Programming can only be accomplished at the decision-node nucleotide selection level. Natural selection favors only finished (halted) computations. Environmental selection does not operate at the decision-node formal level. Natural selection operates at the dynamic phenotypic level. Only after instantiation of cybernetic programming into a material sign system (MSS) (Rocha, 2001) and dynamic realization of those instructed reactions does natural selection contribute. The environment favors the most efficient and successful computational *results*. Natural selection is blind to dynamically inert switch-settings and to the conceptual programming prowess that produces the fittest phenotypes. Phenotypes result from correlated dynamic interactions between three-dimensional folded proteins. Dynamic folding in turn results from minimum-free-energy folding space *controlled by primary structure programming*.

A crucial category is missing from Monod's "false dichotomy" of Chance and/or Necessity (Monod, 1972). Neither chance nor necessity can explain genetic algorithmic optimization (Trevors and Abel, 2004). Only algorithmic programming produces sophisticated function. Abel calls this the "*Cybernetic Cut*," moving well beyond Pattee's "Epistemic Cut." Genes are not merely epistemological "descriptions." Genes are cybernetic *prescriptions* for metabolic success. To the best of our knowledge, such programming has never been observed to arise from stochastic processes or from law-like cause-and effect determinism. The self-ordering phenomena of chaos theory (Prigogine and Stengers, 1984) cannot program switch-settings for biological utility. We invite citation of a single exception that might falsify our null hypotheses.

CONCLUSIONS

Selection/choice contingency cannot be reduced to chance contingency without loss of computational halting and utility. Physicochemical determinism described by the laws of physics precludes both choice and chance contingency beyond thermal agitation. The uncertainty functions upon which information is predicated require contingency. Contingency represents freedom from rigid law. What distinguishes Shannon information from functional/intuitive information is the *selection of options for fitness* at successive decision nodes rather than mere combinatorial probabilities. Neither chance contingency (quantified by Shannon theory) nor any yet-to-be-discovered law of nature can generate selection contingency (Trevors and Abel, 2004). Yet selection contingency is abundantly evident throughout nature.

To generate a plausible naturalistic model of the origin of life, we need first to generate a plausible model of algorithm generation through natural molecular evolutionary processes. The logical fallacy of a "false dichotomy" results from attempts to reduce reality to only two subsets: Chance or Necessity. At least one additional category of reality must exist. Neither Chance nor Necessity is adequate to fully describe what we repeatedly observe in naturally occurring genetic algorithmic/cybernetic biofunction. A real "selection contingency" exists

separate and distinct from the categories of "chance contingency" and "cause-and-effect determinism." Neither chance nor necessity can explain sign systems (Trevors and Abel, 2004). This includes linear, digital, genetic algorithmic programming. Life utilizes representational sign systems and redundancy block-coding for noise reduction in its Shannon channels.

Bioinformation, biosemiosis, and biocybernetics fall into the category of Functional Sequence Complexity (FSC), not Random Sequence Complexity (RSC) or Ordered Sequence Complexity (OSC) (Abel, 2000, Abel, 2002, Abel and Trevors, 2005). Syntax, semantics, and pragmatics all flow from secondary organizational combinations of individual sign selections. Each individual decision node must be real, not imagined, for function to be achieved. Metaphorical and heuristic human consciousness played no role in the rise of biological sign systems. Objective sign systems produced cellular metabolism, intra and inter cellular communication and transport of messages, and tens of millions of central nervous systems prior to the appearance of Homo sapiens. Indeed, if we view human consciousness as an epiphenomenon of physical brain, our every choice traces back to a real, objective, molecular biological cybernetic reality.

If the brain's decision nodes were constrained by natural law, our decisions would not be real. If our choices were constrained by chance or necessity, we should stop holding engineers responsible for building collapses, and stop holding criminals responsible for their behavior. Real selection/choice contingency not only predates the existence of human metaphor and heuristic use of analogy, it produced human mentation. Metaphor is real in human cognition precisely because the natural objective biocybernetics that produced the central nervous system and its thought is real. This fact cannot be reduced to anthropocentrism. Any anthropocentrism is after the fact of already computed physical brain. Anthropocentrism would have to be "secreted" by that physical brain in any naturalistic metaphysical perspective. Only objectively existent decision-node selections can program genetic prescriptive information. Immense advances have been made in molecular biology. The chemical synthesis of oligonucleotides in a prebiotic environment has proven much more challenging than anticipated (Shapiro, 1987, Shapiro, 1988, Shapiro, 1999, Shapiro, 2000). But the origin of sign systems and functional nucleotide sequencing at the covalent level remain an even greater mystery. Biosemiotics cannot be explained in terms of self-ordered dissipative structures or stochastic ensembles.

Science requires honesty and open-mindedness. Its theories must be empirically supportable and subject to both falsification and prediction fulfillment. Scientific progress can be impeded by Kuhnian paradigm ruts (Kuhn, 1962). The science of genetics can better proceed by exploring and acknowledging the algorithmic nature of genomes. It is widely appreciated that mere probabilistic combinatorial Shannon/Kolmogorov complexity contributes little to explaining the birth of biocybernetics and biosemiosis. Biochemical pathways and cycles require computational halting to achieve organizational metabolic efficiency.

No excuse remains for the continued use of the poorly defined generic term "complexity" as a descriptor of biological reality. Life clearly displays *algorithmic/cybernetic* complexity, not just some nebulous, ill-defined complexity. Biocybernetic complexity in turn requires selection at the covalently-bound nucleotide decision-node level, not just at the finished, post-computational-halting, phenotypic selection level known as environmental selection.

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