The biosemiosis of prescriptive information

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Abstract

Exactly how do the sign/symbol/token systems of endo- and exo-biosemiosis differ from those of cognitive semiosis? Do the biological messages that integrate metabolism have conceptual meaning? Semantic information has two subsets: Descriptive and Prescriptive. Prescriptive information instructs or directly produces nontrivial function. In cognitive semiosis, prescriptive information requires anticipation and "choice with intent" at bona fide decision nodes. Prescriptive information either tells us what choices to make, or it is a recordation of wise choices already made. Symbol systems allow recordation of deliberate choices and the transmission of linear digital prescriptive information. Formal symbol selection can be instantiated into physicality using physical symbol vehicles (tokens). Material symbol systems (MSS) formally assign representational meaning to physical objects. Even verbal semiosis instantiates meaning into physical sound waves using an MSS. Formal function can also be incorporated into physicality through the use of dynamically-inert (dynamically-incoherent or -decoupled) configurable switch-settings in conceptual circuits. This article examines the degree to which biosemiosis conforms to the essential formal criteria of prescriptive semiosis and cybernetic management.

Keywords: *complexity theory; biocybernetics; biosemiotics; emergence; self-organization; systems theory.*

1. What is prescriptive information?

Prescriptive information either instructs or directly produces nontrivial function at its destination (Abel and Trevors 2005, 2006a). Prescriptive information (PI) does far more than describe. As its name implies,

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PI specifically conceives and prescribes utility. PI either tells us what choices to make, or it is a recordation of wise choices already made (Abel and Trevors 2007). When we buy computer software, we are purchasing PI. PI can extend beyond instruction into the realization of nontrivial, "halting" cybernetic function. It can perform nonphysical "formal work." PI can then be instantiated into physicality to marshal physical work out of formal work. Cybernetic programming is only one of many forms of PI. Ordinary language itself, various communicative symbol systems, logic theory, mathematics, rules of any kind, and all types of controlling and computational algorithms are forms of PI.

PI arises from expedient choice commitments at bona fide decision nodes (Abel and Trevors 2006b; Kaplan 1996). Such decisions steer events toward pragmatic results that are valued by agents. Empirical evidence of PI arising spontaneously from inanimate nature is sorely lacking (Abel and Trevors 2006b). Neither chance nor necessity has been shown to generate prescriptive information (Trevors and Abel 2004). Choice contingency, not chance contingency, prescribes non-trivial function.

The gap between intuitive information and Shannon "information" is widely appreciated (Bar-Hillel and Carnap 1953; Barwise and Perry 1983; Devlin 1991; Dretske 1981; Floridi 2003a, 2003b). Shannon himself disowned all discussion of meaning right from the start in creating his transmission engineering methodology (Shannon 1948: 379). Shannon information can have a very high bit content, but no meaning and no pragmatic value. Shannon uncertainty, even reduced uncertainty (mutual entropy), is a measure of mere probabilistic combinatorialism. Probabilistic combinatorialism alone is completely inadequate to explain the computational proficiency of PI.

Intuitive information is semantic information. But both the terms "intuitive" and "semantic" are vague. They imply meaning, certainly a step above Shannon information. But what exactly is meaning? It presumably has worth or value to "agents." This meaning and worth are very nonspecific, however.

In exploring the meaning of information, it quickly becomes clear that Shannon uncertainty and freedom of selection are both essential components. Griffiths and Sterelny state that the notion of misrepresentation must make sense when talking about information (Griffiths and Sterelny 1999). In other words, the possibility of error must exist for meaning to be possible. They also argue that the semantic content of information, including genetic information, may or may not be expressed and utilized in the present tense. It can be stored and expressed at a later time. Stegmann points out that smoke expresses information about a fire, but does not store it (Stegmann 2005).

Adami rightly argues that information must always be *about* something (Adami 1998). "Aboutness" is a common point of discussion in trying to elucidate what makes information intuitive (Bruza et al. 2000; Hjorland 2001). But the biggest problems with aboutness are our inability to measure and generalize aboutness into any law-like regularity. Aboutness is always specific to the particular situation. No fixed units of aboutness exist with which to measure and generalize.

Aboutness is abstract, conceptual, and formal. Efforts to define aboutness in purely physical terms, as in molecular biology, have frustrated bioinformationists for decades (Maynard Smith 1999, 2000; Szathmary 1996, 2001). Even the newer field of biosemiotics continues to struggle with the question of whether PI can be reduced to physicality (Barbieri 2006, 2007a). The difficulty of defining and understanding semantic information is especially acute in genetics. Oyama points to the many problems trying to relate semantic information to biology (Oyama 2000). Some investigators attempt to deny that genes contain meaningful information and true instructions (Boniolo 2003; Kitcher 2001; Kurakin 2006; Mahner and Bunge 1997; Salthe 2005, 2006; Sarkar, 1996, 2000). Their arguments strain credibility.

Jablonka argues that Shannon information is insufficient to explain biology (Jablonka 2002). He points to the required interaction between sender and receiver. Jablonka emphasizes both the function of bioinformation and its "aboutness," arguing that semantic information only exists in association with living or designed systems. "Only a living system can make a source into an informational input" (Jablonka 2002: 588). Perhaps Jablonka's intuition here stems from his sensing the *formal* nature of semantic and intuitive information. Formalisms of all kinds involve abstract ideas and agent-mediated purposeful choices. Inanimate physics and chemistry have never been shown to generate life or formal choice-based systems.

Any exploration of semantic information is inseparable from an investigation of semiosis. Wittgenstein and Peirce played prominent early roles in shaping the field of semiotics (Favareau 2006; Jämsä 2006). Wittgenstein in 1922 felt that a name meant an object, and that the object constituted the meaning of that word (Wittgenstein 2001 [1922]: 3.203). Later, Wittgenstein defined meaning as simply our use of a word (Wittgenstein 1964: 69, 1999 [1953]). Peirce's triad of Object, Representamen, and Interpretant is also classic (*CP* 1.564). Sign, meaning, and interpreting subject are constant focal points in semiotic literature. Serious problems arise in the field of naturalistic primordial biosemiotics, however, where the "interpreting subject" must be replaced somehow by inanimate, unconscious, unsteered physical process (Hoffmeyer 2006; Kull 2006). Plausible models are lacking for a purely physicalistic molecular evolution to generate the equivalent of not only an interpreting subject (interpretant), but also representational and meaningful signs (representamens).

2. Descriptive versus prescriptive information

Semantic information has two major subsets: Descriptive (“DNA is a double helix”) and Prescriptive (“Here is how to amplify DNA using PCR”). Both have semantic properties. Unfortunately, most semiotic research has tended to center around descriptive information in a search for the essence of the meaning of messages. Except in cybernetics, the exact nature of instructions and the means of control have been neglected. All forms of PI far exceed descriptive information in capability and significance. PI does not just convey meaning, it *generates* meaning and function. PI provides recipe, instruction, programming, and computational halting (Abel and Trevors 2005, 2006a).

Nontrivial design and engineering require prescription. Steering and control are involved. PI provides specific purposeful choices at true decision nodes that collectively contribute to larger integrative goals (organization). These formal choices are usually recorded into a physical medium in one of two ways: (1) Clusters (modules) of purposefully selected physical symbol vehicles can be used to represent meaning in a material symbol system (MSS) (Rocha 1995, 2000, 2001). (2) A circuit of deliberately configured physical switch-settings can also be used to record these formal choices (Turing 1936; von Neumann 1961; Wiener 1961).

The mere description of a machine does not produce that machine. Each part, and the integration of those parts, must be prescribed in a highly specific way. One slightly mis-prescribed part can jam the entire machine’s function. The programmer of operating systems and software does not just describe. She prescribes new computational reality with every carefully considered binary choice. She may incorporate huge modules of prior programming. But they too are the product of choice contingency, not chance contingency or law. One less-than-ideal choice can produce a “fatal bug” to the entire system or program. Expedient formal choices at true decision nodes alone make non trivial function a reality. These integrated choices are what comprise prescriptive information.

3. Sign/symbol/token systems

Semiosis typically utilizes a sign/symbol/token system to formally represent meaning. The first problem encountered by semiotics is the nature of symbols. Few problems arise in understanding our arbitrary assignment of meaning to abstract mental symbols. Most branches of semiotics have already presupposed a cognitive environment. Great confusion arises, however, when those symbols are carved into physical tokens. Once physical, naturalists are easily tempted to regard both the tokens and the semiotic system of which the tokens are a part as being purely physical. We forget the abstract input that went into the assignment of meaning to each physical token. We lose track of the formal nature of the entire semiotic system that merely utilizes physical tokens or electrical impulses to achieve semiosis. The problem becomes especially acute in the field of Biosemiotics (Barbieri 2003, 2006, 2007a, 2007b). The inadequacy of materialism to explain semiosis reaches crisis proportions in *primordial* biosemiotic research (Abel 2000, 2002, 2006; Abel and Trevors 2004, 2005, 2006b, 2007).

Sign systems technically employ pictograms whereas symbol systems use more abstract, representational, alphanumeric characters (Sebeok 1991). Tokens are typically physical symbol vehicles used to instantiate a nonphysical formal symbol system into a material symbol system. A physical object or cluster of physical objects is assigned nonphysical formal meaning. Once assigned formal meaning, signs, symbols and tokens outside of human minds then become representational physical entities in appropriate hardware and software. As mentioned very briefly above, any system of communication using physical symbol vehicles in a representational sense is a material symbol system (MSS) (Rocha 1995, 2000, 2001). MSS's allow recordation and transmission of nonphysical linear digital PI into a physical world (Hoffmeyer and Emmeche 2005; Sebeok 1976, 1994; J. von Uexküll 1928; T. von Uexküll 1982).

The setting of configurable switches is a second means of prescribing function and conveying instructions into physicality (Turing 1936; von Neumann 1961; Wiener 1961). The switch itself may be physical, but the purposeful selection of each switch-setting is purely formal (nonphysical). Physicodynamics alone cannot set each switch to achieve pragmatic function. Formal integrative selections are required. The purposeful choice is then instantiated into each physical switch-setting. This is a form of MSS.

When we wish to represent each chosen switch position, we resort to a second separate MSS. "On/Off," "Yes/No," "1/0" are all symbolic representations of the first MSS of actual switch *settings*. A formal symbol is chosen to represent the formal choice of switch position. A printed computer program (a string of "1's" and "0's") is simply one MSS representing another MSS. The printed symbols are physical, just as the configurable switches are physical. But neither the chosen switch positions nor the symbols chosen to represent those switch positions are physicodynamic.

Both MSS's are fundamentally formal. We must never confuse formalism with its secondary instantiation into physicality. This is a major blind spot in many fields of science.

If it were true that each token and the token system were nothing more than physical, it would be impossible to communicate meaning using that system. Token "selection" would be forced by prior cause-and-effect determinism. The token sequence would be devoid of motivation, assignment of arbitrary specific meaning, and pragmatic preference. Natural process has no mechanism for pursuing or steering toward sophisticated formal function. It is blind to even elementary function. Some primordial trivial function could conceivably arise spontaneously. But inanimate nature possesses no motivation to generate, preserve or build upon sophisticated formal function. Differential survival and reproduction (natural selection) does not occur until the phenotypes of living organisms are already incredibly prescribed by libraries of sophisticated genetic instruction, regulation, and epigenetic factor contributions.

4. Prescriptive Information is formal, not physical

Programming is formal, not physical. Sophisticated processes must be steered toward functional goals and away from non functional dead-ends. All applications of Decision Theory and Systems Theory require steering and control. The creation and refinement of algorithmic processes requires more than mere inanimate physicodynamic constraints. At the very least, *particular constraints must be deliberately chosen* and others rejected to steer a cause-and-effect chain towards formal pragmatic worth.

Algorithmic processes (e.g., genetic algorithms) require optimization. The false claim is made of stochastic generation of "candidate solutions." No explanation is provided as to why or how inanimate nature would prefer a solution over a non solution. Optimization is goal-oriented and formal. Neither chance nor necessity problem-solves. Physicodynamics cannot generate "chromosomes" of abstract representations known as "candidate solutions." "Solution space" does not exist in a logically consistent metaphysical materialism that excludes formalism as a fundamental category of reality. The illusion of wonderfully pragmatic Markov chains and spontaneous rugged-landscape-climbs to mountain peaks of optimization can be shown in every case to have behind-the-scenes hidden investigator involvement. The iterations are steered toward formal pragmatic success artificially by agents. A critical review of Materials and Methods exposes the hidden experimental design. The investigator pursues a goal. Evolution has no goal.

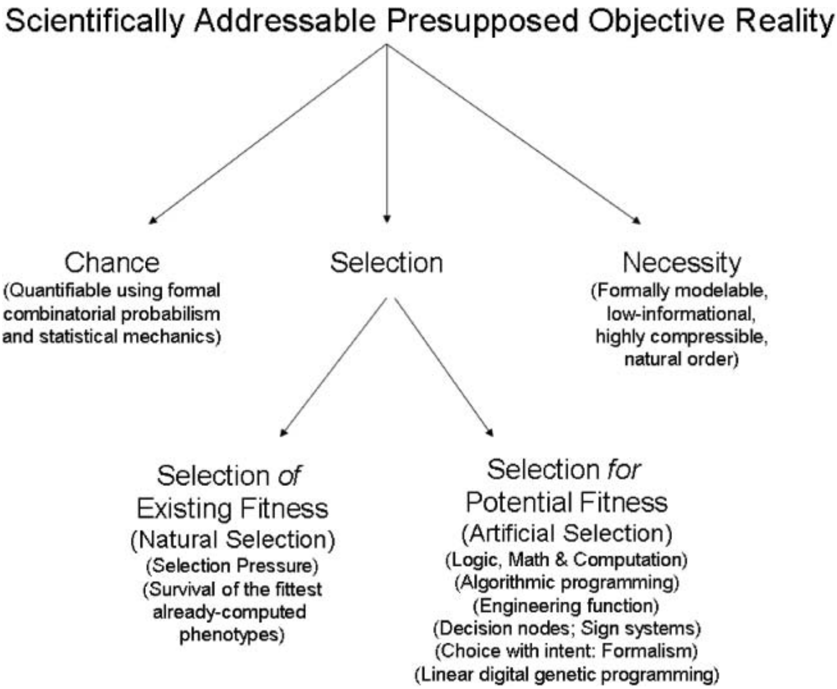

Figure 1. *The scientific method itself pre-assumes the reality and reliability of choice-contingent language, formal rationality, mathematics, cybernetic programming, and predictive computations. In addition, biological science presupposes natural selection as its most fundamental paradigm. Science, therefore, must acknowledge the validity of Selection as a fundamental category of reality along with Chance and Necessity.*

Science suffers when we confuse selection *of* existing fitness (natural selection) with selection *for* a fitness at the genetic level that does not yet exist phenotypically (Figures 1 and 2). Physicochemical dynamics unaided by agent-steering has never been observed to generate formal organization. Natural selection can only favor already-prescribed phenotypic superiority. It cannot program at the linear digital level of nucleotide selection.

Just as pragmatic control cannot be reduced to spontaneously occurring physicodynamic constraints, arbitrarily-written rules cannot be reduced to the "necessary" laws of physics and chemistry (Abel and Trevors 2006b). Whether we are talking about specific prescriptions or the system rules that govern those prescriptions, to talk about prescription is to talk about choice with intent at objective decision nodes. Any attempt to deny "choice with intent" at real decision nodes will doom

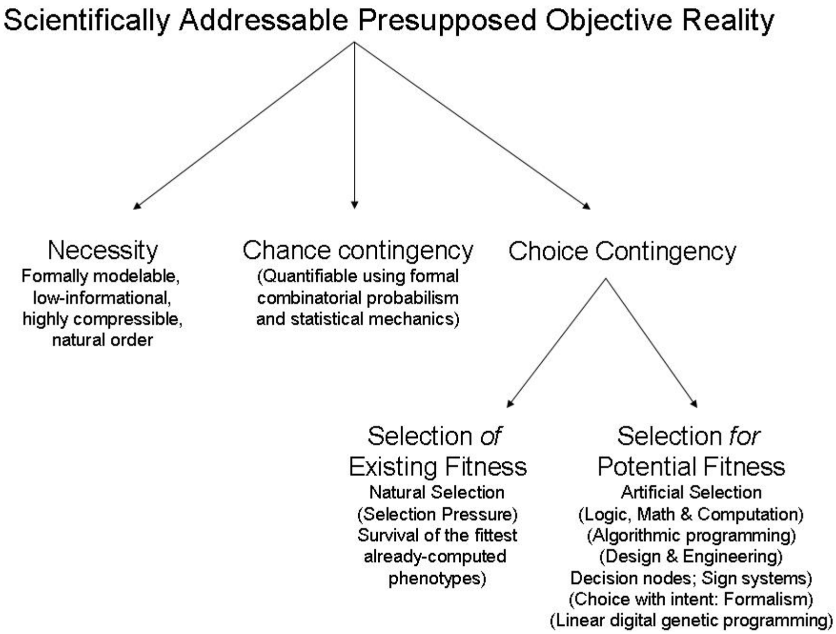

Figure 2. *Contingency has two subsets: Chance Contingency and Choice Contingency. It is widely acknowledged that Chance Contingency is inadequate to explain natural selection. Selection of any kind, including biological selection pressure, must be categorized under Choice Contingency. Natural selection lies in the Selection of Existing (phenotypic) Fitness category. The sign/symbol/token systems employed by language, logic theory, mathematics, cybernetics, engineering function, and linear digital genetics all reside in the category of Selection for Potential Fitness.*

prescription to rapid progressive deterioration. Noise will increase. Formal function at the destination will decrease. The message will become progressively corrupted with nonfunctional gibberish.

We might be tempted to include bad choices in the category of noise. But technically, noise resides solely in the physical world. Choices, including bad ones, reside solely in the formal world. Noise has no effect on the specific efficacious choices that are originally assigned to each physical symbol vehicle or syntax of vehicles. The Second Law comes into play only after instantiation of specific choices into a physical medium. Bad choices are exactly what the name implies. They are less than ideal formal choices at formal decision nodes. Like physical noise, however, bad choices produce no sophisticated formal function. But bad formal choices must not be confused with physicodynamic noise. Choices are always deliberate, whether wise or not. Noise has no motive.

Noise arises from multiple *physical* tendencies. Second Law tendencies rob the physical matrix of the stability of its uniqueness. The same is true of physically instantiated messages traveling within transmission channels. Their unique structure is far from equilibrium because it was generated by formal controls rather than redundant law. This uniqueness is required to record specific formal choices into a physical world. Yet the specificity is lost through the relentless tendency toward physical equilibrium. This loss of uniqueness occurs both at the level of each individual physical symbol vehicle (e.g., monomeric instability), and also at the level of physically recorded syntax (e.g., the denaturization of proteins). Deterioration of utility ultimately results. It is only the physical matrix of the formally-assigned recordation that is subject to the Second Law, not the formal assignment itself. PI is purely formal. Formalism is not subject to the Second Law because formalism it is not physical. Untold confusion exists in literature in both semiotic and cybernetic fields because of failing to understand this objective dichotomy.

PI typically employs and depends upon symbol systems to achieve linear digital semiosis. For the moment let us lay aside any index or analog system of possible prescription. If a symbol system is fundamentally formal, the PI that utilizes it to convey its message (e.g., instructions; cybernetic programs) is also formal. In addition, the very essence of prescription itself is choice-contingent. Intent is required at each successive decision node to choose configurable switch-settings and to steer events toward pragmatic results.

Sign/symbol/token systems utilize different types of symbols and symbol alphabets to represent purposeful choices. We *arbitrarily* assign meaning to small syntactical groups of alphabetical characters, the equivalent of words. By arbitrarily, we do not mean randomly. We mean not only (1) uncoerced by determinism, but (2) deliberately chosen according to voluntarily obeyed rules, not forced laws. But how can a physical symbol vehicle, or a group of such physical symbol vehicles in an MSS, *represent* an idea in a purely materialistic world? Physicalism has never been able to answer this question. The Mind-Body problem prevails. No physical object can take on representational meaning apart from formal arbitrary assignment of abstract meaning by agents. Physicality itself cannot generate a sign/symbol/token semiotic system. Assignment of representational meaning to symbols is formal. This includes MSS's where symbols are instantiated into physical symbol vehicles, or tokens.

Contingent and arbitrary choices are governed by rules, not laws. Rules can be broken "at will." Physicodynamic "necessity" cannot. Both rules and the decisions to follow those rules are mediated through voluntary choices rather than by physicochemical determinism. Choices are uncoerced. Controls are chosen, not "necessary."

5. Constraints versus controls

Constraints are often confused with controls. Constraints stem ultimately from prior cause-and-effect determinism. But this determinism is unrelated to pragmatic goals. Constraints offer no options other than slight statistical variation. No empirical evidence exists of unchosen constraints producing nontrivial formal function. Only our metaphysical commitment to the current Kuhnian paradigm rut (Kuhn 1970) sustains faith in a spontaneous physical generation of formalism.

The choice of particular constraints, on the other hand, does qualify as a means of control. Upon selecting what constraints we wish to use in an experiment, those physicodynamic constraints *at the moment of selection* become *formal controls*. This is the precise point where so-called "directed evolution" experiments become examples of artificial selection rather than natural selection. Choice *for* function at decision nodes, prior to the realization of that fitness, is always artificial, never natural (Figures 1 and 2). Inanimate physicodynamics cannot purposefully choose pragmatism over non pragmatism. In molecular biology, this is called the *GS (Genetic Selection) Principle* (Abel and Trevors 2005, 2007). The Principle states that natural selection (after-the-fact differential survival and reproduction of the fittest phenotypes) does not and can not explain the genetic programming prowess that *produces* that phenotype and its superior fitness. Nucleotide selections are covalently (rigidly) bound into linear digital strings of prescription prior to the realization of any organism, fit or unfit. While Lamarckism has some legitimacy in certain areas such as immunology (Koenig 2000; Taylor 1980), it cannot explain the formal genetic programming that precedes organismic existence.

We call freedom from law-like necessity *contingency*. But there are two kinds of contingency: (1) chance contingency and (2) choice contingency. Mere bifurcation points are not necessarily true *decision* nodes. A path can be taken randomly at these bifurcation points, but only with likely failure to reach the desired destination. Rapid deterioration of function occurs. If "selection" is made randomly at bifurcation points, it has the same effect as noise pollution on a transmission of meaningful instructions. Random selections lack purpose, with predictable results.

In a formal process, however, bifurcation points become true decision nodes when choice with intent determines the selected path. Anticipation and planning are involved prior to the commitment. Deliberate choice of path makes possible unlimited design and engineering successes. Non trivial function is only achieved through selection *for function* (Figures 1 and 2). When purpose, goal, and intent are removed from the equation, "choice" becomes the equivalent of random number generation. No one has ever observed a nontrivial computational program arise from a random number generator. This is all the more significant given that not even the so-called "true random number generators" can be proven to be technically random. Atmospheric noise and even the points in time at which a radioactive source decays continue to be subject to the critique of hard determinists.

Thus neither randomness (if it exists at all) nor the cause-and-effect determinism of nature has ever been demonstrated to generate nontrivial algorithmic utility. Physical generation of nonphysical formalism is a logical impossibility. Cause-and-effect determinism produces highly ordered sequences of events containing almost no uncertainty or information. These sequences of events can be described using a compression algorithm much shorter than the sequence of events being described. The latter ability is the very definition of sequence order, low uncertainty, and minimal information content (Chaitin 1988; Kolmogorov 1965; Li and Vitanyi 1997; Yockey 1992, 2002).

Algorithmic optimization, on the other hand, typically produces highly informational instructions and control. Any physical matrix capable of retaining large quantities of PI must offer high degrees of Shannon uncertainty and high bit content (Abel and Trevors 2005, 2006a; Chaitin 2001). High bit content refers only to combinatorial possibilities within the physical matrix. But it is an essential requirement of any physical medium if PI is to be instantiated into that medium.

As Pattee has pointed out many times (Pattee 1972, 1973, 1995a, 1995b, 2001), even initial physical conditions must be formally represented within the laws of physics. An epistemic cut has to be traversed. Initial conditions cannot measure or symbolically represent themselves. A dichotomy exists that categorizes physicodynamic reality from its formal representation. Physical conditions themselves cannot be plugged into equations. Representational symbols of initial conditions (measurements) must be used. Without formal equations using formal representations of initial conditions, no physicist could predict any physical outcome. In another manuscript currently in peer review, I extend Pattee's epistemic cut to *The Cybernetic Cut*. The Cybernetic Cut emphasizes that laws do not just describe physical interactions. Laws *control* their outcome. More properly stated, the formal structure of reality controls physical mass/energy relationships. Non physical mathematical formulae (laws) could only predict physical interactions to the degree that they prescribe them. Description of mass/energy relationships could otherwise not extend into the future. Physicality is formally prescribed, not just formally described.

What does all this have to do with semiosis? Just as non physical, formal laws govern physicality, non physical formal choice contingency governs semiosis in any MSS. Neither physics nor MSS's can be reduced to physicality. Both the equations of physics and the rules of communication are formally prescribed. They are formally organized, predicted, and governed. They transcend and control physical reality in general, and the messages instantiated into physical media. Any attempt to deny formalism results in the immediate collapse of physics, chemistry, science in general, and all MSS semiosis (including biosemiosis).

6. Source and destination must share an arbitrary formal convention

For prescription to be realized, the destination of any message must have knowledge of the source's alphabet, rules, and cipher. The destination must also possess the ability to use the cipher. Interpreting the meaning of linear digital strings and decoding the encryption are themselves formal functions — as formal as mathematics and the rules of inference. Benefiting from the source's instruction and deciphering the source's code cannot be done by the chance and necessity of physicodynamics. An abstract and conceptual "linguistic" handshake must occur between source and destination. Shared rules of lexicographical meaning must exist between the two. Source and destination must be in sync with arbitrary syntactical meaning assignments. Otherwise, the destination cannot realize the utility intended by the source's prescription.

Shannon "information theory" has from the beginning isolated syntax from semantics and pragmatics (Shannon 1948). These three categories comprise the classic subsets of semiosis (Morris 1946; *CP*; Sowa 1995). Even in the current semiotics field, the dichotomy between syntax and semantics is maintained (Rocha 1995). From the standpoint of signal transmission engineering and "communication theory," this is entirely appropriate. But when it comes to PI, syntax, semantics, and pragmatics are intimately interrelated (Abel and Trevors 2005).

In any materialistic genetic theory, source code is usually viewed as the product of a finite stationary Markov process (Yockey 2005). In PI theory, however, source code is always a function of deliberate choice contingency, not chance contingency or law (Figures 1 and 2). A single alphabetical character can have meaning (e.g., the "H" or "C" on water taps, "X" marks the spot on a map, or the mathematical symbol π). But most often semantics is achieved through syntactical combinations of alphabetical symbols. *Agents* assign meaning to words according to arbitrarily assigned rules for that particular language system. A progressive hierarchical meaning arises out of lexical ascription by agents of message value and meaning to phrases, clauses, sentences, and paragraphs. In short, when it comes to messages, instructions, recipes, and cybernetic programs, syntax cannot be isolated entirely from semantics (message meaning) or pragmatics (message function). Syntax without meaning also lacks function. Thus PI requires all three categories of semiotics to communicate shared meaning and function between source and destination (Sowa 1995).

Both messaging and control require formal decision-node choices that precede their recordation into a physical matrix. Choices are then instantiated into physicality by selecting arbitrarily-assigned representational tokens. Configurable switch settings can also be used to integrate electrical impulses into conceptual circuits. Still other mediums of instantiation into physicality exist. But all physical instantiations without exception record formal *choices made with intent*. The minute we disallow purposeful choices, computation and sophisticated function within the physical world begin to erode. Utility usually plummets off of a steep cliff of formally achieved pragmatism.

7. The role of Prescriptive Information in biosemiosis

When we look at physical semiotic systems, it is so tempting to view them as purely physical. We immediately see the folly of this illusion when it comes to various cybernetic and artificial life systems. We know full well that they exist only because of formal controls that are instantiated into hardware and software physicality. But when it comes to biopolymeric syntax, semantics, and pragmatics, we fanatically insist for metaphysical reasons that the system is purely physical. No empirical, rational, or prediction-fulfillment support exists for this dogma (Luisi 2007). The error seems to be reinforced when we observe loss of function with the deterioration of the syntax of those physical-symbol-vehicle strings (e.g., the denaturization of proteins and DNA into shorter nonfunctional strings). But the inference is fallacious. The deterioration of the physical matrix says nothing about the source of its message. If we burn this paper, we cannot conclude its thesis was merely physical. Despite the loss of physical matrix, nonphysical formal prescription of function had nonetheless been instantiated into that burned physical matrix. The thesis may well remain perfectly intact in someone's mind, or in a different physical matrix such as the email from which it was printed, or from a back-up medium.

The role of folding of these linear digital strings into functional three-dimensional structures further confuses us. Lock-and-key binding draws our attention to physical structure. We forget that protein globule shapes are prescribed primarily by linear digital semiosis (the protein's primary structure — its sequencing [syntax] of monomers with their specific R groups ["alphabetical symbols"]). Even regulatory proteins and chaperone-like molecules that assist in the folding process are themselves prescribed by linear digital semiosis.

We can temporarily circumvent the Second Law by formally introducing conceptual redundancy coding (Hamming 1986, 1998). Groups of symbol choices can be used to represent a single binary choice. As physical symbol vehicles and their syntax deteriorate in any transmission channel, the meaning and utility of the message can be preserved through redundancy coding. As many symbols as desired can be used to represent each single binary choice. But this requires the source and destination agreeing on a redundancy-coding cipher. The ladder is an arbitrary and conceptual cipher. It is formal, not physical. The Second Law has no bearing on programming choices or on a formal deciphering scheme.

In the case of DNA, the functional sequencing of triplet codons is also formal. Genes are strings of Hamming "block codes" (Hamming 1986). Three nucleotides are used to prescribe each amino acid. No physicochemical explanation exists for such sophisticated triplet codon sequencing and encryption (Abel and Trevors 2005, 2007). Physicodynamics cannot explain the dynamically-inert (dynamically decoupled or dynamically incoherent) syntax of monomers. Once sequenced, however, the physical primary structure does become a physical template. That template then becomes the major physicodynamic causal factor in determining shape, binding and catalytic function of the protein prescribed by the complementary string. But what determined the monomeric syntax, the sequencing, of its positive-strand template? Not chance, and not necessity (Trevors and Abel 2004). Like physical configurable switches in a circuit board, physicodynamics does not and cannot explain the functional integration and computational halting achieved by the device.

Metaphysically disallowing formalism in one's model of reality precludes not only redundancy coding, it precludes semiosis. A purely physical semiotic system cannot exist or function as a messaging system. Representationalism requires both combinatorial uncertainty and freedom of deliberate selection. Naturalistic physical ISness cannot generate representationalism. Formalism alone can send and interpret linear digital messages. This remains true even when a material symbol system with physical symbol vehicles is used by formalism. Polynucleotide genes are such an MSS.

Physicodynamics cannot write genetic prescription any more than physicodynamics can write scientific theses. No observational, rational, or prediction-fulfilling evidence exists of physicodynamics producing brain or mind. We cannot conclude that mathematics is physical just because it is instantiated into computer hardware or human brains. The same is true of genetic instruction and the PI management of life at the cellular level. Both mathematics and life are fundamentally formal. Even most epigenetic factors can be shown to be formally produced and integrated into a conceptual, cooperative, computational scheme of holistic metabolism. Life cannot exist without sophisticated, formal, genetic PI.

8. Summary and conclusions

PI either instructs or directly produces nontrivial function at its destination. PI either tells us what choices to make, or it is a recordation of wise choices already made. PI requires deliberate selection at bona fide decision nodes. Such decisions are formal, not physicodynamic. Formal choice contingency alone steers physical events toward nontrivial pragmatic results and the organization valued by agents. Physical symbol vehicles (tokens) can be used to represent formal choices in a material symbol system (MSS) (Rocha 1997, 2000, 2001). Alternatively, dynamically-inert configurable switches can be used to record formal choices into physicality.

What sense can we make, then, of the PI found in nature and particularly in any theorized primordial biosemiosis? Random coursing through a succession of bifurcation points has never been observed to lead to prescription of function, computational halting, sophisticated circuitry, or system organization. The self-ordering events described by chaos theory cannot generate conceptual formal organization. Semiosis, cybernetics, and formal organization all require deliberate programming decisions, not just self-ordering physicodynamic redundancy. Self-ordering phenomena are low-informational, highly redundant, unimaginative, and usually destructive of organization (e.g., tornadoes and hurricanes). No prediction fulfillments have been realized of spontaneous natural events producing formal algorithmic optimization. No empirical support or rational plausibility exists for blindly believing in a relentless natural-process assent up the foothills of a rugged fitness landscape toward mountain peaks of formal functionality. Investigator involvement creates this illusion usually through the hidden artificial steering of experimental iterations.

Falsification of any of the following three null hypotheses is invited in peer-reviewed scientific literature:

Null Hypothesis 1: PI cannot be generated from/by the chance and necessity of inanimate physicodynamics.

Null Hypothesis 2: PI cannot be generated independent of formal choice contingency.

Null Hypothesis 3: Formal algorithmic optimization, and the conceptual organization that results, cannot be generated independent of PI. Here "conceptual organization" must be distinguished from mere self-ordering redundancies such as crystallization and Prigogine's dissipative structures.

A single observation to the contrary would falsify any of the above three null hypotheses. A single prediction fulfillment of spontaneous formal self-organization (independent of agent/investigator involvement and experimenter control) is all that would be necessary to falsify any of these hypotheses. Until such empirical evidence is documented, the concept of spontaneous emergence of formal self-organization in nature should be viewed with strong scientific skepticism (Abel and Trevors 2006b).

The bold scientific prediction is made in this paper that none of these three null hypotheses will ever be falsified.

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