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Constraints *vs* Controls

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Abstract: The terms constraints and controls should not be used interchangeably. Constraints refer to the cause-and-effect deterministic orderliness of nature, to local initial conditions, and to the stochastic combinatorial boundaries that limit possible outcomes. Bits, bifurcation points and nodes represent "choice opportunities", not choices. Controls require deliberate selection from among real options. Controls alone steer events toward formal pragmatic ends. Inanimacy is blind to and does not pursue utility. Constraints produce no integrative or organizational effects. Only the purposeful choice of constraints, not the constraints themselves, can generate bona fide controls. Configurable switch-settings allow the instantiation of formal choice contingency into physicality. While configurable switches are themselves physical, the setting of these switches to achieve formal function is physicodynamically indeterminate—decoupled from and incoherent with physicodynamic causation. The mental choice of tokens (physical symbol vehicles) in a material symbol system also instantiates non physical formal Prescriptive Information (PI) into physicality.

Keywords: Autonomy, biocybernetics, biosemiotics, biosemiosis, complexity, configurable switches, decision nodes, genetic code origin, logic gates, self-assembly, self-maintenance, self-organization, self-replication, sign systems, symbol systems.

1. INTRODUCTION

Great confusion has resulted from sloppy interchangeable use of the terms "constraints" and "controls" [1-4]. Science emphasizes precise definitions for good reason. In the case of constraints *vs* controls, however, contributors to scientific literature have often been grossly negligent. As a result, numerous fallacious inferences have been propagated. Sloppy definitions often cause "category errors" in particular. Varying contexts, hierarchical levels of application, and subjective word connotations have further blurred the dichotomy. Proper definitions of these two terms hold the key to understanding whether life is truly unique from inanimate physics and chemistry.

But before we can examine the difference between constraints and controls, we need first to clarify the dichotomy between "necessity" and "contingency" [5-7]. The orderliness of nature exists in fixed mass/energy relationships and constants described by "laws". These best-thus-far generalizations describe highly probable cause-and-effect chains of behavior. Despite our quantum world enlightenment, determinism in the macroscopic world is still a highly useful and reliable concept. "Necessity" refers to this highly predictable determinism. Since the probability of law-like cause-and-effect chains approaches 1.0, the uncertainty of outcome is therefore very low. Under conditions of such low uncertainty (low Shannon bits), the prescription of sophisticated organization becomes impossible [5, 6, 8].

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The laws of physics and chemistry are basically compression algorithms for reams of experimental data. The laws themselves contain very little information (F = ma). We celebrate the parsimony and universality of these low-informational laws. Life, on the other hand, is highly informational. Metabolic organization and control is highly programmed. Life is marked by the integration of large numbers of computational solutions into one holistic metasystem. No as-of-yet undiscovered law will ever be able to explain the highly informational organization of living organisms. The latter would be a mathematical/logical (deductive) impossibility that cannot be overturned by any amount of future observation, abduction or induction. There are simply not enough bits of uncertainty in any law, nor enough "information" (reduced uncertainty, "mutual entropy" in applying a law to the data) to *prescribe* the integration of so many complex pathways, cycles and regulation schemes into a holistic metabolism.

We contrast chance from deterministic necessity to refer to such phenomena as the heat agitation of molecules and normal distributions. Chance is a form of contingency. Contingency means that events can unfold in multiple ways despite the local and general constraints of cause-and-effect determinism. But chance is not a physical entity and therefore cannot be a physicodynamic cause [9]. Chance is a formal, mathematical, statistical, mental construct. Nothing is "caused by chance" because chance is not a physical cause of physicodynamic effects. Brownian movement is caused by mass/energy physical factors, heat and kinetics that are so complex, interactive and regularly irregular that probability distribution curves (formalisms) provide description and relative predictability.

Relative degrees of interaction between cause-and-effect determinism and the chance contingency of quantum

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indeterminacy, heat agitation, and complex causation exist. These interactions require weighted means in Shannon theory to measure the relative uncertainty and partial order. But even the combination of these factors has never once been observed to produce formal algorithmic optimization, integration of circuits, computational halting, sophisticated utility, or true organization of any kind. The third category of choice contingency alone achieves sophisticated formal utility.

Often overlooked is the fact that two subsets of contingency exist: Chance and Choice contingencies. A succession of "fair" coin flips provides an example of independent *chance contingency* events with unweighted means. Physicodynamic constraints exert no bias on whether the outcome is heads or tails. Physical constraints act equally on both possibilities. Chance contingency allows the outcome to be statistically predictable because of the absence of both law-like necessity *and* controls (choice contingency). The coin toss is said to be "fair" because the mean is not weighted by physicodynamic influence *or* experimenter preference. The statistical outcome is not prejudiced or biased.

Whereas chance contingency cannot cause any physical effects, *choice contingency* can. But choice contingency, like chance contingency, is formal, not physical. So how could non-physical choice contingency possibly become a cause of physical effects? The answer lies in our ability to *instantiate* formal choices into physical media. As we shall see below, formal choices can be represented and recorded into physicality using purposefully chosen physical symbol vehicles in an arbitrarily assigned material symbol system. Choices can also be recorded through the setting of configurable switches. Configurable switches are physicodynamically indeterminate (inert; decoupled from and incoherent with physicodynamic causation) [10, 11]. This means that physicodynamics plays no role in how the switch is set. Physicodynamic factors are equal in the flipping of a binary switch regardless of which option is formally chosen. Configurable switches represent decision nodes and logic gates. They are set according to arbitrary rules, not laws. Here arbitrary does not mean random. Arbitrary means "not physicodynamically determined" [12-14]. Rules are not constrained by physical nature. Arbitrary means "freely selectable"—choice contingent.

Below are listed the necessary and sufficient criteria for differentiating constraints from controls. Somewhat related to this dichotomy is the difference between *laws* and *rules*, the subject of a separate manuscript.

2. WHAT ARE CONSTRAINTS?

The best-thus-far generalizations known as "laws" discussed above typically are represented as mathematical equations. The laws of motion are formal, not physical. Such non-physical formalisms describe and predict physical interactions with amazing accuracy. Forces act physicodynamically with great regularity upon initial state conditions. Quantum indeterminism at the microscopic level does not prevent the reliable mathematical prediction of nature's macroscopic orderliness. Events are said to be caused by physical forces and their resulting mass/energy interactions. The force constants and the regularity of natural force interactions constitute a form of constraint. Thus, not only are the local initial conditions viewed as constraints, but also the high dependability (orderliness; regularity) of physicodynamic interactions.

The roles of quantum indeterminacy and the statistical variations of complex causation are often hotly debated. Even the strictest metaphysical naturalism and cause-and-effect determinism never seem able to totally obliterate chance contingency [9]. Again, both chance and choice contingencies mean that events could unfold with multiple outcomes despite constraining initial conditions and the law-like regularities of nature.

Probabilistic combinatorialism measures chance contingency. It cannot measure choice contingency. But even probabilistic combinatorialism has its boundaries that limit possible outcomes. These too are a form of constraint.

Initial conditions (when not chosen by experimenters) are usually viewed as the result of prior cause-and-effect physicodynamic chains. Initial conditions in combination with the high dependability of precise physical interactions severely constrain outcome space. No local intent or purpose is involved in these constraints. The constraints just ontologically exist. Our various epistemological and metaphysical slants of interpretation are irrelevant to the fact of these objective constraints.

Nature has no goals, including evolution. The use of the term "constraints" to refer to any formally *steered* utilitarian process is therefore erroneous. Likewise, referring to a pragmatically blind physicodynamic causal chain or to the spontaneously self-ordering dissipative structures of chaos theory [15] as a "process" is technically incorrect.

"Natural process" proceeds without regard to formal function or any goal of pragmatic outcome. This raises the question of the legitimacy of using the term "process" in the commonly used phrase "natural process". A certain wish fulfillment emerges from our naturalistic metaphysical presuppositions that uncontrolled physicodynamic phenomena will spontaneously self-organize into extraordinary degrees of formal ingenuity. Empirical support, logic, and prediction fulfillment evidence is sorely lacking for this blind, unfalsifiable belief.

The etymology of "process" traces back to "processus" and relates to "procedure". A procedure is a *formal* undertaking involving decision nodes, directionality, purpose, and goal. Processes are undertaken to achieve Aristotelian "final" function. Processes require wise anticipatory programming decisions. Utility is desired and sought after in any bona fide process.

Mere physicodynamic constraints and cause-and-effect deterministic chains cannot prescribe formal goals or generate cybernetic processes and procedures. They can only generate ordered sequences of physicochemical cause-and-effect chains with no orientation toward utility. Mere cause-and-effect chains may lead to self-ordering phenomena such as bathtub drain vortexes and the shapes of a candle flame. But unselected constraints and physicodynamic cause-and-effect chains have never been observed to steer events toward, let alone through, formal utilitarian processes, procedures, algorithmic optimizations, circuit integration, or computational solutions.

Unfortunately, it has become all too common to refer to mere physicodynamic causal chains like star formation as a "process". General scientific concepts and terms were sometimes poorly defined originally (e.g., "work", "system", "constraints" used erroneously to refer to "controls"). Fundamental confusion resulted. Over the last 100 years this same confusion has extended into multiple specialized fields (e.g. solid state physics, weather forecasting, astronomy, information theory, cybernetics). Once incorporated into the many branching specialized fields of science, the linguistic confusion only evolves independently into ever worsening varieties of nonsense in each specific field. Even when fundamental definitional errors are finally corrected, it becomes almost impossible to undo the damage in each specialized field. Astronomers are not going to stop using the word "process" to refer to the uncontrolled, merely constrained chain of deterministic physicodynamic events that cause star formation. But this does not change the fact that star formation is not a cybernetic process. It is just a cause-and-effect physicodynamic chain with some degree of statistical variation. All we can do is to call attention to some of the errors in fundamental scientific thought and terminology, and hope that the correction eventually filters down to each scientific specialty. Until then, the terminology advocated in this paper will seem idiosyncratic and at odds with long established use in multiple fields of science. During the long reign of Ptolemaic astronomy, Copernican concepts and terminology were also initially idiosyncratic.

In the mean time, we must remain clear that bona fide processes are technically controlled, cybernetically guided (programmed), goal-oriented, and organized. They are not merely ordered by the fixed, low-informational, unimaginative orderliness and cause-and-effect chains of nature.

3. WHAT ARE CONTROLS?

Controls involve *steering* events toward some *useful* end. Controls circumvent, "outsmart", and even make use of constraints in order to achieve formal (choice-based) utility. Constraints are purely physicodynamic—physical. Controls are formal and non-physical, although as mentioned briefly in the Introduction, controls can be instantiated into physicality using physicodynamically indeterminate configurable switch-settings [10, 11]. Configurable switches are highly unique physical entities that are specifically designed to record non-physical formal decisions into physical reality. The switches are themselves physical. Physicodynamic action is required to flip the switch. But with respect to *which switch option is chosen,* they are physicodynamically inert. Cybernetic function requires freedom of selection. Configurable switches constitute the one-way bridge (The CS [Configurable Switch] Bridge) across the great chasm known as The Cybernetic Cut [1, 16]. The Cybernetic Cut delineates perhaps the most fundamental dichotomy of reality. The Cybernetic Cut is a vast ravine. The physicodynamics of physicality ("chance and necessity") lie on one side. On the other side lies the ability to choose with intent what aspects of ontological being will be preferred, pursued, selected, rearranged, integrated, organized, preserved, and used (cybernetic formalism) [1, 16]. Through configurable switch-settings, formal choice contingency can become a source of physical causation. The setting of these switches and the selection of physical symbol vehicles in a material symbol system constitutes the building of the one-way CS Bridge (Configurable Switch Bridge [1, 16]) across the vast ravine of The Cybernetic Cut.

Wise programming requires choice contingency at bona fide *decision nodes*. Nonphysical formal choices made with intent at these decision nodes can determine the course of physicodynamic events. Such decisions instantiate purposeful choices (e.g., programming choices) into physicality.

No more energy is required to flip the quaternary (four-way) switch knob to the right than to the left, or away from than towards the choosing agent. Initial conditions, physical forces, energy requirements, and rate constants are equal for all options afforded by a well-designed quaternary configurable switch. Physicodynamics offers no help in elucidating why a quaternary switch knob was set to one of four possible positions, or why a combination of successive switch-settings achieved correlated formal function.

Fig. (**1**) shows the three fundamental categories of outcome given various kinds of events. Only selection for potential function (choice contingency, not chance contingency or law) has been observed to generate controls. Controls alone, in turn, prescribe bona fide organization (as opposed to mere self-ordering phenomena) and formal function and utility.

4. CONTROL THROUGH CHOICE OF CONSTRAINTS

Initial conditions can be chosen by investigators as the starting point of their experimentation. Under these circumstances, the *chosen* constraints rightly can be considered controls [14, 17, 18]. But these constraints become controls only because those constraints were deliberately selected to steer events toward the experimenters' desired results. The constraints themselves do no steering toward any formal utilitarian goal. Choice contingency alone achieves non trivial integration, organization, and function.

No matter how well a bridge is designed, the river bottom must have adequate physical conditions at the foundation of the main bridge supports. Thus controls cannot be divorced from physicodynamic reality. But no matter how ideal the physical rock bed at these points is, no bridge will spontaneously form from physicodynamics alone. The engineers must either work around or make use of existing physical constraints when they make their design choices according to the formal *rules* (not laws) of safe bridge-building. Engineers must even make choices in view of their anticipation of future circumstantial constraints. Thus

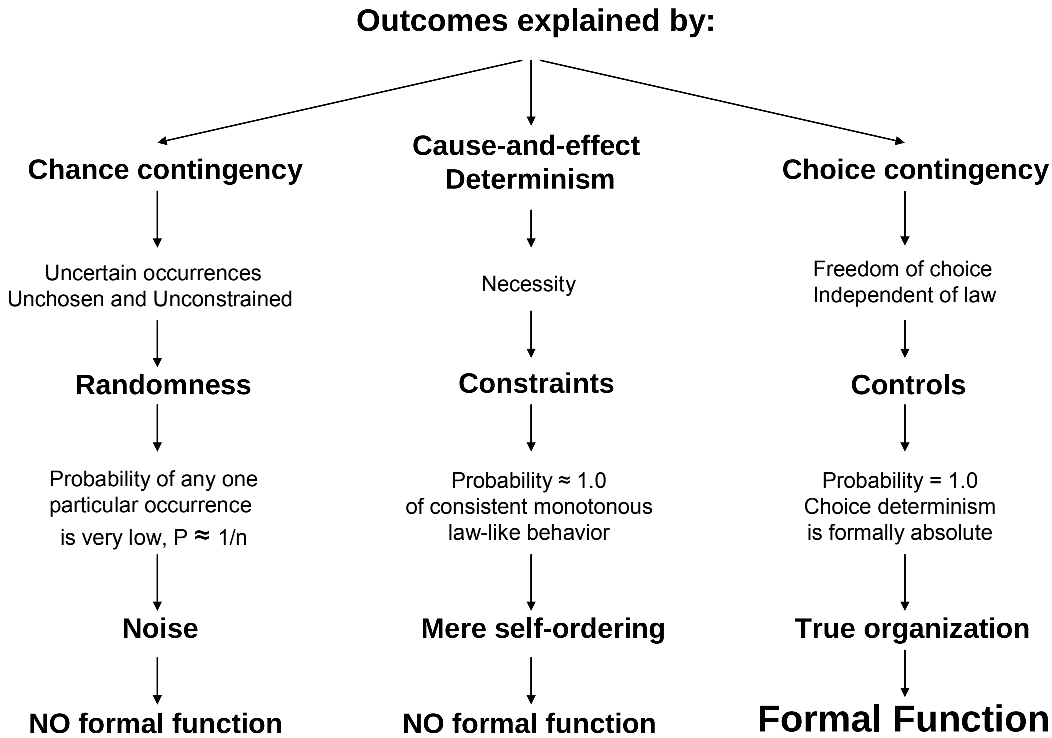

Fig. (1). The three major categories of outcome/behavior.

engineers might design a bridge to survive a 100-year flood. But the dichotomy between anticipated environmental constraints (infrequent floods) and controls remains intact.

The choice of constraints, the choice of tokens, the choice of which iterative product to proceed with in an optimization process, and the selection of logic gate settings to achieve potential integrated circuits—all of these are functions of choice contingency even though they utilize physical entities. Such formal choice contingency allows us to make use of physical objects to design and engineer physical manifestations of formalisms.

Purely physicodynamic air flow, force and friction cause airplane lift. But the chosen aspects of airplane wing design and engineering are alone what harness those physical factors into airplane flight (formal utility). Lift is ultimately prescribed and produced through physicodynamically indeterminate configurable switch-settings. Every individual design enhancement in the wing and fuselage comes in the form of a formal decision-node choice. Flight is not optimized by "bifurcation points" (choice *opportunities*). Flight is optimized by wisely choosing which path at each bifurcation point to take. Logic-gate settings must be ideally programmed to optimize the formal utility of desired flight.

In the same way, Maxwell's Demon [19-21] is only able to dichotomize faster moving gas molecules from slower moving ones through *formal choices* of when to open and close the trap door between compartments [22, 23]. Why else would such a ridiculous cartooned personage ever have been introduced into the scientific literature of physics? The reason is that no physicodynamic explanation could be found to explain the sustained non trivial journey away from equilibrium. Only a choosing agent could generate a sophisticated utilitarian heat engine. The Second Law can only be locally and temporarily circumvented to accomplish *useful* work through formal controls, not through spontaneous physicodynamic constraints. Without choice contingency and its controls and regulations, no local sustained circumvention of the 2nd Law would be possible. Physicodynamic behavior would always quickly revert to obeying the 2nd Law in the absence of formal interventions.

Choosing constraints can constitute a very subtle form of "experimenter interference" ("investigator involvement") in experimental design. Such artificial selection of which products to use from the effluent of each successive iteration creates the illusion of a spontaneous evolutionary pathway. But such so-called "directed evolution" is a classic example of formal control. Directed evolution boils down to the purposeful selection of initial conditions *for each iteration* of a highly integrated experimental plan and goal. Such experiments begin with a highly touted initial random phase space of stochastic ensembles of oligoribonucleotides, for example. But the succession of repeated runs uses only carefully selected candidates from each previous iteration [24-27]. The procedure is anything but random. And it is not just constrained by physicodynamics. It is controlled by the formal choice contingency of the experimenter who pursues his or her own formal "target phrase" [28]. Such a process has absolutely nothing to do with evolution. "Directed evolution" is a self-contradictory nonsense term that has no place in science [1, 5]. If the process is directed, it cannot be evolutionary. If the process is evolutionary, it cannot be directed. The same is true of the term "evolutionary algorithm". If a procedure is algorithmic, it is not evolutionary. If it is evolutionary, it is not a choice-based, optimization-steered, goal-directed algorithm [4]. Evolution has no steering or goal

The fatal flaw in the notions of "drunken walks", "directed evolution" and "evolutionary algorithms" is that each selection made by the experimenter is artificial, not natural. Each selection is made at the programming level *in pursuit of a potential function* that does not yet exist. The GS Principle (Genetic Selection Principle) is only affirmed by such engineering experiments [29, 30]. Natural selection favors only the fittest already-existing function. The inanimate environment possesses no ability to select for potential function. The inanimate environment cannot even select for *existing* isolated functions. Natural selection is nothing more than differential survival and reproduction of the fittest *already-living organisms* [29, 30]. No differential survival of living organisms is involved in ribozyme engineering experiments. Directed evolution is nothing more than a string of purposeful logic gate or configurable-switch settings. Directed evolution is controlled, not constrained. The terms "directed" and "process" are quite legitimate in such laboratory procedures. The term "evolution" is not.

The result of oligoribonucleotide "evolution" experiments (e.g., a self-replicating ribozyme) [31, 32] is typically attributed to trial and error. We fail to realize that "trial and error" is itself a teleological process of investigating and testing for what works (inefficient though it may be). The Markov or drunken-walk "process" is erroneously and illegitimately offered as proof of self-organization. This "evidence" is then used in support of the notion of spontaneous generation of life. In reality, such "experiments" are nothing more than human engineering projects. Remove the hidden experimenter involvement (investigator interference) from Materials and Methods, and nothing of interest has ever been observed to spontaneously evolve. The reason is the loss of formal steering and control. When the experimenter is denied purposeful choices of which iteration to select and utilize at each step, no sustained uphill progress toward non trivial functionality occurs.

Constraints alone simply do not integrate, organize, or optimize algorithmic function. Constraints, including spontaneous initial conditions, forces, and the deterministic cause-and-effect chains of nature, cannot program configurable switches in a manner that leads to computational solutions. Constraints cannot generate representational symbol systems or linear digital prescription of any kind, including the genetic instructions that prescribe regulatory proteins and micro-RNAs. Without formal controls that select and organize physicodynamic constraints, we would have no complex machines, no computers, no buildings, no bridges or any other kind of engineering marvel.

5. FORMAL FUNCTION REQUIRES CONTROL CHOICES

"Useful causation requires control", argues Howard Pattee [33, pg. 68]. Note that "useful" is a formal concept and value judgment, not a merely constrained physical interaction. Spontaneous physicodynamic constraints exist without relation to utility. The most elementary of functions could theoretically "self-organize" happenstantially. But even the simplest utility almost always requires not only multiple steps, but coordination of those multiple steps. Physicodynamic constraints have no orientation toward organizational success. What is usually labeled "self-organization" is in reality merely "self-ordering" [7]. Self-ordering can produce some impressive dissipative structures [15]. But these structures manifest no integrational prowess. Prigogine's low-informational dissipative structures do not produce formal multi-step processes resulting in sophisticated utility. They do not organize non trivial function. They typically destroy highly informational organization (e.g., self-ordered tornadoes and hurricanes).

Formal choice determinism also lies in a different dimension and category from chance contingency. Unlike the probabilistic combinatorialism quantified by Shannon, *choice contingency* deliberately steers events toward desired functionality. Choice contingency, while free, becomes a form of determinism at the moment of choice. *Decision theory* is not subject to direct statistical quantification. No standard unit of measure is possible for pragmatic individual decision-node selections. Each decision-node choice-commitment is unique, especially with relation to other coordinated decision-node choice commitments. Each is made with deliberate cognitive intent. Such formal choices cannot have a constant unit value with regard to general function.

Uncertainty is measurable prior to the setting of any configurable switch. Bits measure the uncertainty of how switches *could* be set. But bits under no circumstances measure specific choices. Binary choice *opportunities* can have a measurable constant unit value (bits), but not the specific choices themselves. This is the reason that quantification of intuitive and semantic information has been so evasive.

Paradoxically, choice contingency (once exercised) precludes the very Shannon uncertainty that is necessary for information generation. At the moment of purposefully opening or closing the logic gate, all uncertainty at that decision-node or configurable switch is erased. We can loosely assign a "probability" of absolute 1.0 to *already-made formal choice commitments* (technically, of course, probability is not really applicable at that point). The reason is that with "operations" we are dealing with deductive reasoning in an abstract and axiomatic thought world. The act of setting a switch removes all uncertainty. In the abstract world of cybernetics, choosing a switch setting is viewed with absolute certainty and specificity. It is a form of deductive and absolute theoretical causation. Choice causation in cybernetics is as formal as logic theory and mathematics. Binary configurable switches are designed to have "excluded middles". The switch is either absolutely on or off. The mathematical laws of physics and the logic gates of cybernetics are themselves both formal—deductively absolute and non physical.

When we attempt to instantiate this absolute choice determinism and mathematical logic into physicality, however, we lose the absoluteness of formal determinism. The same is true with instantiation of ideas into the world of physical symbol vehicles (into a *material* symbol system—MSS [10, 34]). Formal absoluteness is compromised. The probability of choice contingency then only approaches 1.0 asymptotically. Instantiation into a physical matrix introduces physicodynamic factors such as quantum indeterminism, the heat agitation of molecules, unanticipated and complex physical interactions, noise, and general 2nd Law tendencies toward the disorganization of matter. Such physicodynamic realities require data distribution curves to describe. Nevertheless, in a well-designed configurable-switch integrated circuit, the instantiation of choice contingency determinism into a matrix of physical causation can very closely approximate a probability of 1.0.

When the physical matrix of formal prescriptive Information (PI) instantiation decays, the recordation of formal PI is lost with it even though the PI itself is non physical. This is the exact point of major confusion, misleading many investigators into the faulty inference that PI is physical. PI is in fact purely formal. It consists entirely of choice contingency, a category than cannot be merged with the chance and necessity (constraints) of physicodynamics. PI is only instantiated into a physical medium or matrix. The latter instantiation is needed for recordation and messaging between agents of abstract, mental, conceptual, choice-contingent, formal ideas into the physical world.

Choice determinism alone programs sophisticated formal function [1, 16]. Neither chance contingency nor law can match this feat. Algorithmic optimization is a form of *control*, not constraint [6]. Constraints exercise no volition. Constraints have no teleological goals. Constraints are blind to utility [5]. Constraints are themselves the passive effects of prior physicodynamic causation in the larger force field, thermodynamic and quantum context. Natural law, initial conditions, and combinations of the two have no preference for functionality of any kind. The physical world is full of constraints. But these constraints are blind to functional syntax, semantics, pragmatics, cybernetics, and formal utility.

Configurable switches could also be set randomly. But no empirical evidence exists for nontrivial computation arising from random switch settings. Nontrivial integrated circuits have never been organized stochastically. To achieve sophisticated function, switches must be set with the intent of completing a logical process or functionally coordinated circuit.

Physical constraints can and do limit choices, but only upon the instantiation of those formal choices into physicality. The main boundary to choices is arbitrarily-written and agreed-upon *rules,* not laws. Rules govern how the game will be played—what choices and formal goals will be allowed. The rules are often written in view of physical constraints. But the constraints themselves never write the rules. Rules are written by choice, often with the goal of overcoming constraint barriers to achieve a formal goal. Sometimes rules are written to actually make use of physical constraints. But rules themselves exist in the category of abstract conceptual Controls, not in the category of inanimate physical Constraints. *The word "constraint", therefore, cannot be appropriately applied to any formal control function* unless the specific constraints were chosen by an experimenter.

Secondary selection pressure can control in the sense of preferring already existent small groups of living organisms. But selection pressure cannot program polynucleotide sequencing for eventual function (The GS Principle [29, 30]). Natural selection is nothing more than the differential survival and reproduction of small groups of already-living, already-programmed organisms. Controls do not arise from the categories of chance contingency and necessity addressed by thermodynamics, kinetics and physics in general. Physics can address constraints. Physics cannot address bona fide controls without acknowledging the reality of non naturalistic engineering. Life is wholly dependent upon tight regulation and controls. For this reason, physics and chemistry alone cannot adequately address and explain life any more than physics and chemistry alone can explain engineering.

Under the conditions of a well-designed integrated circuit, choice contingency determinism and its instantiation into physicality results in nearly zero Shannon uncertainty in that physical medium (e.g., a pre-set circuit board). There is therefore almost no information *potential* left in a system produced by already-exercised choice determinism. The only bits of uncertainty remaining in well-designed circuit boards and programs are its provisions for software user-designed choices. Yet paradoxically, such circuits and programs contain extraordinary intuitive, semantic, and Prescriptive Information (PI) [5, 35]. As good as Shannon theory is for communication engineering, it is fundamentally flawed in its ability to deal with Prescriptive Information (PI).

The resetting of any one configurable switch restores Shannon uncertainty at that switch for a moment in time only during the re-switching process. The moment the re-setting of a configurable switch is considered, Shannon uncertainty is revived from the theoretically absolute certainty that existed prior to formal switch re-setting. Once reset to a new formal choice, uncertainty once again disappears. Choice determinism corresponds to $p = 1.0$, which in turn leaves 0 bits of uncertainty.

Physical constraints are equal for all re-switching options in well-designed user-defined systems. A specific decision to change the switch position is unconstrained by physicality (physicodynamically inert). But to effect the choice into physicality does require mass/energy interaction and involves physical constraints. A quaternary (four-way) switch knob does have to be physically pushed in one of four directions. The vector of that push, however, is physicodynamically inert. The vector is determined by formal choice alone. Neither the setting of the switch in the first place, nor the resetting of the switch for further optimization of the circuit, has anything to do with chance contingency or necessity. It is a function of wise programming choice contingency alone.

Bits of Shannon uncertainty are often erroneously equated with "information." Shannon information is defined epistemologically as *reduced* uncertainty. The measure of uncertainty after a message is received is subtracted from the measure of uncertainty that existed before the message was received [36]. This is called "mutual entropy," a very unfortunate and misleading terminology. Reduced uncertainty is regarded as gained knowledge. Notice that reduced uncertainty and gained knowledge are both purely formal. Epistemology is not a physical entity. Neither reduced uncertainty nor Prescriptive Information (PI) can be generated by inanimate physicodynamics. See Section 8 on Prescriptive Information (PI) [5, 35]. See also Table **1** below which compares and contrasts mere physicodynamic Constraints from formal Controls.

Choice contingency does not constrain physicality; choice contingency controls physicality. But choice contingency causation can *select* dynamic constraints. When constraints are chosen (as in controlled experiments), constraints are transformed (not transduced) into formal controls. Controls do not lie in the physical domain of physicodynamics. Phase transitions cannot generate formal controls. Phase transitions are devoid of choice contingency. Hoping to find a source of controls in physical phase changes, spontaneous energy transductions, and necessity (highly ordered law-like behavior) constitutes a *category error* of logic theory. Controls lie in the formal category of choice contingency. This is why we have always recognized mathematics, logic theory, language, algorithmic optimization and computation solutions to be "formalisms". The optimization of genetic algorithms is a form of control, not constraint. Constraints are blind to goals and utility. Chance, laws and constraints cannot steer or control physical events toward utility.

6. THE REALITY OF CHOICE CONTINGENCY IS "BEYOND PHYSICS"

Physics cannot address the phenomenon of choice with intent. The particular setting of configurable switches to achieve formal function is beyond physics to explain — literally metaphysical. The answer to the riddle of *cybernetic causal determinism* lies only in the arena of *formal choice contingency* — of *control,* not the arena of physicodynamic constraints, fixed forces and highly ordered relationships. Until naturalistic science is willing to acknowledge this fact of reality, progress will be thwarted in many investigative specialties. A Kuhnian paradigm rut prevails: "Physicality (e.g., the cosmos) is all there is, ever was, or ever will be". The scientific method itself cannot be practiced with such a naïve and misguided metaphysical pontification governing science. In opposition to this religious materialistic belief system is the supervening role of formal mathematics, logic theory, language, and cybernetics so universally employed and required by science. "Information is information, not matter or energy", said Norbert Wiener. "No materialism which does not admit this can survive at the present day". [37, pg. 132]

"Biological information is not a substance", say Hoffmeyer and Emmeche [38, pg. 39]. "Biological information is not identical to genes or to DNA (any more than the words on this page are identical to the printers ink visible to the eye of the reader). Information, whether biological or cultural, is not a part of the world of substance" [38, pg. 40].

One cannot even argue for a purely materialistic perspective without violating materialism's most fundamental premise. The defense of materialism is itself abstract, conceptual, choice-contingent, formal and non physical. Materialism/Naturalism is a metaphysical faith system. It is not only a philosophic formalism, but it is an exercise in self-contradiction.

One of the reviewers of this manuscript suggested replacing 'Paradigm rut" with "metaphysical presupposition of normal science". But what Kuhnian paradigm rut hasn't been considered (for all too long) to be a "metaphysical presupposition of normal science"? That is the very reason inferior models continue as paradigm *ruts*. They are all too easily pre-assumed to be "normal" science. The scientific community can pontificate a metaphysical presupposition to be "normal science" sometimes for over a century (e.g., Ptolemaic astronomy) with no questions asked. Sometimes metaphysical presuppositions and mathematical axioms, even though thoroughly entrenched in scientific theory, need to be reconsidered in view of a great deal of inconsistent evidence.

A hill does not become the simple machine of an "inclined plane" until *agency chooses to use the hill* to assist in overcoming the formal challenge of outsmarting the agent-perceived problem of gravity. Such choice to pursue and achieve formal function is a form of control, not natural constraint. Physicodynamics cannot choose with intent at a single decision node, logic gate, or configurable switch-setting. Formally organized utility has never been observed to occur spontaneously from naturalistic constraints alone. Mere constraints cannot organize anything, including our thoughts or any form of non trivial utility (useful work). Without the reality of formal choice contingency, physics cannot even distinguish "work' from "wasted energy". The mere transfer of energy from one entity to another often has nothing to do with utility. Work must be defined and pursued formally. That definition must be related to other formalisms such as "value", "economy", "usefulness", and "efficiency". Such formalisms arise only in the minds of agents.

7. CYBERNETIC SYMBOLS REPRESENT CONTROL CHOICES

Symbol systems allow representation, recordation and transmission of formal choices [38-43]. Symbols represent specific selections from among real options. Symbol selection is not made randomly or physicochemically [44]. Symbol selection, if it is to have sophisticated utility at the message's destination, is made freely and deliberately [45, 46].

Representationalism (e.g., "0" and "1" for "off" and "on") is abstract, conceptual and formal, not physical.

Table 1. The Contrast Between Physicodynamic Constraints and Formal Controls

Constraints	Controls
Physical/Dynamic	Nonphysical/Formal/Conceptual/Abstract
Naturally-occurring initial conditions	Agent-chosen initial conditions
The fixed orderliness of nature itself constrains	Dynamically-inert configurable switch-settings control
Necessity/Chance contingency statistical bounds	Choice contingency
No goal, directionality, or intent	Purpose-driven
Non pragmatic; *any* cause-and-effect chain prevails	Pragmatic intent and results
Bifurcation points only; No bona fide decision nodes	Decision-node choice commitments
State-based	Deliberately engineered
A string of dissipative structures momentarily occur on a unidirectional physicodynamic time vector	Time-independent programming choices can be symbolically represented and instantiated into switch-settings at any time
Simple/highly-ordered/regular monotonous/redundantly structured	Cybernetically Complex Algorithmically optimized and conceptually organized
Unimaginative	Imaginative
A natural state in physical state space	Choice contingency engineers formal function
Blindly constrains fixed law-like behavior. Deterministic without regard to formal pragmatic benefit.	Deliberately steers toward sophisticated utility through particular settings of configurable switches that are decoupled from deterministic laws.
Constraints are not capable of measuring initial conditions or manipulating formal equations	Formalism measures (*represents)* initial conditions and controls manipulate mathematical equations (e.g., F = ma)
Can not compute	Can compute
Cannot steer toward or pursue pragmatic goals	Steers, integrates circuits, and pursues formal goals
Blind to formal function	Formally prescribes function into physicodynamic reality
Differential survival/reproduction of the fittest organisms *only secondarily constrains* the population	Linear digital prescription/regulation computes into existence all organisms *prior to* natural selection of the fittest phenotypes

Constraints come into play only after formal symbols are instantiated into physical symbol vehicles in a material symbol system (MSS). Physical symbol vehicles (tokens such as Scrabble pieces) are of course physical entities. But the decision-node choice commitment that selects each particular token is beyond physics to address. It is a control function. The constraints of nature are irrelevant to the selection of both tokens and configurable switch positions. Tokens and configurable switches are designed to have no constraints to free-will choice.

Selection of the symbol "1" or "0" represents the simplest binary control decision. Each such purposeful choice is the fundamental unit of Prescriptive Information (PI) [5, 35] or instruction. If the "1" or the "0" is selected randomly, one bit of *potential control* is immediately lost. Or, if the "1" or "0" is determined by prior cause-and-effect chains of physicodynamic necessity, one bit of potential control is also immediately lost. The ability to steer events through many decision nodes toward computational success quickly deteriorates and dies with each new denied binary control choice. When every "choice" is determined the same way by "necessity", the resulting "program" consists of all "1's" (OR all "0's"). Neither chance nor constraints can select the path with greatest function potential. Neither chance nor constraints can program or compute. Constraints exert their physicodynamic influence independent of formal pragmatic considerations. Controls, on the other hand, program pragmatic success at the rock-bottom binary decision-node level of "Yes, No", "Open, Closed". Controls select each ideal configurable switch-setting prior to the realization of any function. The biological scientific community often seems blind to the fact that selection *for potential* function is something that natural selection cannot do [1, 5, 16, 29, 35]. Absolutely no selection pressure exists at the genetic/genomic programming level. The GS (Genetic Selection) Principle reigns at the level of nucleotide selection in forming positive informational strands of nucleic acid [29, 30].

To communicate a meaningful or functional true message, first we must arbitrarily assign an alphabet of usable symbols. Next, we must again arbitrarily assign meaning to small groups of alphabetical characters, the equivalent of words. This is done according to arbitrarily defined rules, not constraints or laws. The rules are freely selectable, not constrained by physicodynamics. In short, symbol systems are entirely formal.

The term MSS for Material Symbol Systems was first used by Rocha in his Ph.D. thesis [10, 34]. Signs, symbols and tokens outside of human minds are representational physical entities called physical symbol vehicles. Any system of communication using these physical symbol vehicles is a material symbol system. But how can a physical symbol vehicle, or group of such physical symbol vehicles in an MSS, *represent* instructions in a purely materialistic world? The Mind-Body problem is closely related to the symbol-matter problem. These problems are in turn closely related to the measurement problem not only in quantum physics, but in Newtonian physics as well. As physicist Howard Pattee has pointed out in many publications, the measurements used in the laws of physics are formal representations (mathematical symbols) of physicality, not physicality itself [47].

The first problem encountered by semiotics in a material symbol system (MSS) is the nature of symbols. Charles Sanders Peirce proposed the triadic interpretation of signs. Meaning is created mentally through consideration of recursive relationships [48]. Peirce's interpretation of signs and semiotics involving representamen, object and interpretant is inseparable from human cognition and agency. Representations are necessarily abstract, conceptual and formal. Peirce's triadic relation work incorporates abundant human psychological and epistemological components. Under no circumstances are such representations "natural" (purely physicodynamic). Representations are never physical. Representations can be arbitrarily assigned to physical tokens in a material symbol system. But the representations assigned to those physical tokens are always agent-chosen according to formal rules, not physical laws.

No justification exists for trying to circumvent the fact of "volition" using Peirce's category of thirdness (mere "habit formation") [49]. Habits are nothing more than redundant patterns of volitional social behavior. If a pattern does not originate out of true behavior choice tendencies (volition), then that pattern is simply reflective of physicodynamic necessity (ordered by the regularities of nature described by physical law as further refined by statistical distribution curves).

We must clearly distinguish between *symbols* and *physical symbol vehicles (tokens)*. Symbol vehicles are physical. Symbols are not. Symbols are *conceptual representations of meaning*. The symbol π represents a formal mathematical idea in our minds. We can instantiate this symbol with its meaning into a physical symbol vehicle through handwriting π onto paper with physical ink, typing it onto a computer hard disc, speaking it into a telephone receiver, or emailing it. But the recordation and transmission of physical symbol vehicles does not change the fact that the symbols being represented are abstract ideas with arbitrarily assigned meaning. No physicodynamic constraints or causation can explain cognitive representationalism and symbolization. Cybernetic function requires deliberate selection. First, the actual uncoerced and non random selection must be made. Then that choice must be formally represented using a mental symbol. Finally, that cognitive symbol can be instantiated into physicality by selecting a certain symbol vehicle in a material symbol system (MSS). Alternatively choice contingency can be instantiated into the setting of a physical configurable switch to achieve formal pragmatism.

Semiotic and cybernetic functions both require formal symbolization according to previously agreed-upon arbitrary rules (not physical laws) in order to convey meaning. Neither cybernetics nor semiosis can be reduced to the mere physicality of its switches or physical symbol vehicles. The uncoerced choice contingency that selects those symbols or that sets those configurable switches is the key.

To ascribe semantic value to physical entities requires both *contingency* and *volition*. Neither necessity (forced law-like behavior) nor chance contingency can generate meaning. Choice contingency is required [1, 4, 5]. Semantics entails "aboutness". Aboutness and meaning are absent from the category of inanimate physicodynamic interactions.

Rosen [50] regarded sign systems as "anticipatory". He argued that conventional physicodynamic theory cannot possibly model sign system's descriptive behavior. But the problem extends far beyond having to explain the phenomenon of description. Far more important is the function of symbol systems to *prescribe*—to indicate *determinative choices and controls* that will be efficacious in producing utility *in the future* [5]. Natural selection cannot select for not-yet-existent function. Yet sophisticated utility only comes into existence *via* integrated pre-programmed decision nodes, logic gates, and configurable switch-settings. Choice contingency's unique ability to generate pragmatic controls alone accomplishes this.

8. PRESCRIPTIVE INFORMATION (PI) PROVIDES CONTROLS

Abel [6, 44, 46] has championed use of the term *Prescriptive Information (PI)* to distinguish instructions, algorithms and programming from mere Shannon uncertainty [51], reduced uncertainty [36, 52], mutual entropy [12, 13, 53, 54], and Kolmogorov algorithmic complexity [5, 35, 55-60]. Bennett's "logical depth" presupposes PI [61]. PI either instructs or directly produces formal function at its destination. The meaning of prescriptive information is the *function* that prescriptive information organizes and institutes.

Prescriptive information (PI) [6, 44, 46] is unique from descriptive information in that PI provides *determinative controls* (bona fide causes of real formal effects). Once those formal (non physical) control choices are instantiated into a physical medium, the effects of those choices can become physical effects. The CS Bridge (The Configurable Switch Bridge [1, 16] is crossed as part of the one-way traffic from formalism to physicality. Wise programming decisions provide instruction for eventual formal function leading to physical utility (e.g., engineering decisions). Prescriptive information is truly cybernetic (controlling). Computer programs, integrated circuits, and computational success must be prescribed with choice contingency. Typically a symbol system is used to represent the decision-node choices that program such utility.

Adami rightly argues that meaningful information must be *about* something [54, 62]. But attempts to define and quantify this *aboutness* in purely physical terms have failed miserably. Prescriptive information (PI) [5, 35] goes a step beyond aboutness, embodying pragmatic instruction and achievements. PI also extends beyond the quantitatively elusive and epistemologically nebulous "intuitive information". Both "meaningful" and "instructive" messages are found only in the choice determinism of PI. Neither combinatorial probabilism nor algorithmic compression of syntactic patterns offers the physicalist any help in understanding the programming choices of cybernetic control. In addition to meaning and description, PI programs computation and three-dimensional practical function.

Reduced uncertainty has nothing whatever to do with statistical mechanics. Knowledge is in a different category entirely from thermodynamics. Although Shannon's famous H equation looks almost identical to the S equation of thermodynamics, the probability spaces are non isometric. A long list of reasons is provided in previous publications as to why not only PI cannot be measured using statistical mechanics, but not even Shannon uncertainty [6, 7].

What is the mysterious ingredient of Prescriptive Information (PI) [5, 35] that elevates it above not only Shannon uncertainty, but even reduced uncertainty (mutual entropy), semantic information, description and measurement? The *prescription* of controlling algorithms enters at the point of each individual decision-node choice-commitment for *potential* (not-yet-existent formal function). Every time a binary physical configurable switch is set that contributes to a potential specified function, nonphysical prescriptive information is instantiated into that physical state and process [6].

Prior to 2007, information theory had no means of measuring specific choices. No fixed unit of measure could quantify particular choices for each unique function. But in a milestone paper [63] a method was devised for the first time to actually quantify the Functional Sequence Complexity (FSC) [6] of the most highly informational linear digital strings known to science—nucleic acid and proteins [63]. Evolutionary transitions toward or away from specific binding functions and holistic metabolic contribution can now be quantified at the level of each configurable switch setting (each amino acid selection that is added to the polyamino acid string). Although developed for measuring the FSC of nucleic acid and protein strings, the method is readily adaptable to measuring most forms of linear digital prescription. The firm prediction is made that random mutations of existing functional proteins will consistently demonstrate a progressive decrease, not a progressive increase, in measured "fits" of FSC in these already functional polyamino acid strings. As cited in a previous publication, abundant evidence already exists of a decrease in genetic information with evolution, not an increase, across a number of different species' genomes [4].

The destination of any message must have knowledge of the cipher and possess the ability to use it. Deciphering is a formal function—as formal as mathematics and the rules of inference. Deciphering of the source's code and prescriptive intent at the destination cannot be done by the chance and necessity of physicodynamics. An abstract and conceptual handshake must occur between source and destination. Shared rules of lexicographical meaning must exist between source and destination. Source and destination must be in sync regarding pragmatic significance of the arbitrarily chosen language system. Mere physicality cannot establish the formal handshake.

So-called "information theory" has from the beginning isolated syntax from semantics and pragmatics [51]. These three categories comprise the classic subsets of semiosis [64]. Even in the current semiotics field, a strict dichotomy is argued between syntax and semantics [65]. From the standpoint of signal transmission engineering and "communication theory", this is entirely appropriate. But when it comes to prescriptive information [46], syntax, semantics, and pragmatics are intimately interrelated. In particular, syntax is purposely chosen to create lexical meaning and to prescribe function.

The nature of symbolization is not so clear at the linear digital genetic level of control and regulation. In the application of Shannon theory to linear digital biological messages, source code has been viewed as the product of a finite stationary Markov process [12]. For purposes of transmission engineering, this may be fine. But finite stationary Markov processes cannot program the integrated computational solutions so evident in the metabolic organization of all known life. In addition, Markov processes contain hidden steering. The drunken walk is subtly guided behind the scenes towards a goal by the experimenter, then claimed to be spontaneous. Because steering is involved, the term "process" is legitimate. The term "evolution" is not.

In prescriptive information theory, source code is always a function of choice contingency, not chance contingency or law. A single chosen 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 symbols and symbol sequences (e.g., words, phrases, clauses and sentences) 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 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. Prescriptive information requires all three categories of semiotics to communicate shared meaning between source and destination. Not only are semantics and pragmatics formally instituted and controlled, but in the case of Functional Sequence Complexity (FSC)[6], even syntax must be formally established.

9. THE KEY TO LIFE IS CONTROLS, NOT CONSTRAINTS

The need for "semantic closure" between natural physicodynamics and the seemingly very unnatural (abstract, conceptual, formal) control functions employed by life has been widely known for some time [18, 47, 66-77]. The hope for a naturalistic semantic closure or "code duality" [38, 78-80] is usually pursued along the lines of blurring the clear distinctions between categories of constraints *vs* controls. Despite decades of trying to bridge the gap, The Cybernetic Cut [1, 16] remains untraversed except by the unidirectional CS (Configurable Switch) Bridge [1, 16]. Traffic flow across this bridge has thus far been observed to be one-way-only. Formalism can be instantiated into physicality. But physicality cannot reverse the traffic flow across the CS Bridge to invade the world of formal controls. The reason is that physicality offers nothing but constraints and chance contingency with which to attempt programming controls, computation, circuit integration, complex machine generation, algorithmic optimization, organization, and sophisticated utility of any kind. Neither chance nor necessity can generate non trivial formal function.

Gregory Bateson [81, 82] failed to succeed in his lifelong quest to elucidate the emergence of creatura (life) from pleroma (the inanimate physical realm). Many since have tried to realize Bateson's goal to naturalize life origin [71, 83-119]. But these models and many others consist more of poetic, mystical, magical phrases (e.g., "the adjacent possible;" "self-organizing criticality") rather than demonstrated spontaneous naturalistic mechanisms and biochemical reality. Life-origin models typically lack empirical verification, prediction fulfillment, linguistic clarity, sound logical inference, and falsification potential. Can anyone explain how science could possibly falsify "the adjacent possible" [109]? What a wonderfully inviting, imaginative phrase. It is offered in explanation of anything and everything related to life-origin. But it has nothing to do with science. Exactly what mass/energy interactions in inanimate nature selectively "ratchet" away from entropy towards algorithmic optimization, computational success, ever-increasing formal utility and organization far from equilibrium? Mere "possibilities" don't consistently ratchet toward any goal, let alone conceptual integration, cooperation, and holistic metabolism. Seemingly more fruitful life-origin experimentation typically incorporates artificial selection to unnaturally steer iterations towards experimenter-desired, out rightly engineered results. *Controls* not common to ordinary mass/energy interactions are provided through investigator involvement in experimental design. If anything, such experiments only provide all the more empirical evidence of the complete inadequacy of mere constraints to organize life.

Biological evolution is rightly seen as *non* intentional. "Evolution has no goal". But if evolution has no goal, why is peer-reviewed evolutionary literature replete with analogies of intention in virtually every explanation and defense? Second, what empirical evidence can we provide from the entire history of human observation of a single non-simple machine that accomplishes sophisticated work ever having arisen spontaneously from inanimate nature? Our major organizing biological paradigm may dictate belief in the spontaneous generation of life; but not a single observation or prediction fulfillment has ever falsified the null hypothesis that "life cannot spontaneously generate from non life". After 160 years of extensive yet unsuccessful life-origin experimentation attempts to falsify this null hypothesis, some would argue more than ever that this null hypothesis deserves provisional acceptance (as with all laws of science) as The First Law of Biology—"All life comes from previously existing life" [120]. Said Leslie Orgel, "In my opinion, there is no basis in known chemistry for the belief that long sequences of reactions can organize spontaneously---and every reason to believe that they cannot" [121].

No logic justifies believing in the abstract, formal, conceptual capabilities of mere mass/energy interactions. "Differential survival" of already living organisms cannot write new programming language at the genetic level (The GS Principle [29, 30]). But we choose to deny this universal experience in order to maintain our prior presuppositional commitment to belief in philosophic physicalism. Biological evolution is nothing more than the differential survival and reproduction of already-computed, already-living organisms. Natural selection cannot select for the best configurable switch-settings at the level of nucleotide polymerization (programming) of single, positive, information strands [29]. Neither chance nor necessity has ever been observed to program computational success, engineer circuit integration, optimize algorithms, or organize physical entities into holistic conceptual pragmatic schemes [1, 4]. Yet we continue to believe blindly in the mystical capabilities of spontaneous mass/energy interactions. "Constraints did it", we proclaim. We believe this nonsense because we have no choice given our prior presuppositional/metaphysical commitments to naturalism. We are forced by this philosophic imperative to believe that undirected physicality (mere constraints) can self-organize into the most exquisite conceptual organization and utility known to science (holistic metabolism and life itself). Rather than to reconsider the possibility of a long-standing Kuhnian paradigm rut, we choose instead to hunker down in obstinate, fanatical physicalism. "Don't trouble we with the evidence, my mind is made up: undirected physicodynamics did it".

The game of Scrabble cannot be isolated from the constraints of its physical tokens and playing board. But winning at Scrabble cannot be isolated from the formalisms of word recognition, anticipation of needed tokens, correct spelling, and the goal of earning the most points. All these factors are choice-contingent, not physicodynamically constrained by mass energy interactions. Constraints will never win a game of Scrabble.

Formal controls are an observational reality not only in Scrabble, but life itself. All known life is undeniably cybernetic. Both engineering and life are controlled, not merely constrained. Appreciation for the critical role of "regulation" grows in worldwide molecular biological literature by the day. Regulation is formal control, not mere physicodynamic constraint.

Volition (choice contingency) is every bit as repeatedly observable, predictable (given any form of true organization), and as potentially falsifiable as any naturalistic hypothesis. Volition and control are no more metaphysical than acceleration, wave/particle duality, weight, height, quarks, and light. We cannot label volition and control "metaphysical", and quantum mechanics and statistical mechanics "physical". Mathematics and the scientific method themselves are non physical. Volitional controls (as opposed to mere constraints) are a fact of objective reality. If this fact does not fit within the perimeter of our prized lifelong worldview, perhaps it is time to open our minds and reconsider the purely metaphysical presuppositions that shaped that inadequate worldview. Philosophic naturalism cannot empirically or logically generate organizational bona fide controls. It can only generate self-ordering, low-informational, unimaginative constraints with no formal cybernetic capabilities. Metaphysical naturalism is too small a perimeter to contain all of the pieces. Naturalism is too inadequate a metanarrative to be able to incorporate all of the observable scientific data. And it cannot explain the integration and cooperation of so many physicochemical interactions into the holistic metabolism and true organization of life. Mere constraints are simply not up to the task, starting with the fact that constraints cannot pursue *any* task.

10. CONCLUSION

The word "constraint" cannot be appropriately applied to any formal control function. Instituting controls requires choice contingency. Neither chance contingency nor low-informational, highly-ordered (or highly-patterned) law-like behavior can generate bona fide controls. Sophisticated functions must be instructed or actually computed by prescriptive information (PI). PI most often presents as a linear digital string of symbols representing decision node, logic gate, or configurable switch-setting choices. PI arises not only out of high Shannon-bit uncertainty, but also out of high "Fit" (functional bit) content found in Functional Sequence Complexity [6, 63] and PI [5]. Once choices are made at decision nodes, no Shannon uncertainty remains. Yet the prescription is often highly informational within that matrix. The notion of reduced uncertainty has severe limits in biological PI, for example, where objective function is not dependent upon the subjective knowledge of any human knower. Biological PI is the most ingenious form of instruction known. Yet it predates vertebrates, their consciousness, and their epistemologies. Any definition of PI that attempts to reduce it to human knowledge is laughable. PI not only stands alone on its own objective merits, PI ultimately produced human brains, consciousness and knowledge that allow us to ponder it.

Physicodynamic constraints exist only in the physical world. Within formalisms, choices are limited by arbitrary rules, not by physicodynamic constraints. Rules written with the intent to instantiate formalisms into physicality are often written with physical constraints in mind. Formal controls frequently even make use of physical constraints. Physical constraints limit non physical formal choices only upon instantiation of those formal choices into physical media of retention and transmission.

The purposeful selection of constraints, not the physicodynamic constraints themselves, constitutes controls. It is only when we manipulate initial conditions or purposefully steer iterations to achieve a desired experimental result that constraints can be considered controls.

All known life is cybernetic. The key to understanding life is controls, not constraints. Both linear digital genetic prescription using a material symbol system and epigenetic "regulation" in molecular biology are aspects of formal control.

Great care should be taken not to use the terms "constraints" and "controls" interchangeably.

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ABBREVIATIONS

FSC	=	Functional Sequence Complexity
Fits	=	Functional bits
PI	=	Prescriptive Information
The GS Principle	=	The Genetic Selection Principle

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