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1. What is ProtoBioCybernetics?

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Abstract: Cybernetics addresses *control* rather than mere constraints. Cybernetics incorporates Prescriptive Information (PI) into various means of steering, programming, communication, instruction, integration, organization, optimization, computation and regulation to achieve formal function. "Bio" refers to life. "Proto" refers to "first." Thus, the scientific discipline of ProtoBioCybernetics specifically explores the often-neglected derivation through "natural process" of initial control mechanisms in the very first theoretical protocell. Whether an RNA World, Peptide World, Lipid World, or other composomal Metabolism-First model of life-origin is pursued, selection for biofunction is required prior to the existence of a living organism. For gene emergence, selection for *potential* biofunction (programming at decision nodes, logic gates and configurable switch-settings) quickly becomes the central requirement for progress.*

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*Sections from previously published peer-reviewed science journal papers [1-9] have been incorporated with permission into this chapter.

Introduction: Exploring the birth of Control

Explaining the scientific discipline of ProtoBioCybernetics first requires defining control and differentiating it from mere constraints [7]. Controls steer events, usually toward formal function and utility. Controls are the subject of cybernetics. The spontaneous orderliness of nature described by the laws of physics and chemistry are blind to formal function and utility.

Inanimate nature constrains events; it does not control events. Nature constrains events without regard to utility. Physicodynamics (mass/energy interactions) have never been observed to foster function at the programming, computational, or linguistic level.

Establishing bona fide control first requires at least one bit of Shannon uncertainty. A bit of uncertainty corresponds to one binary *choice opportunity* at a decision node, *not a choice.* Controls must be chosen. Control requires programming freedom from fixed law. Controls are thus a product of "free-will" determinism, not cause-and-effect physicodynamic determinism. Controls integrate events and objects into a functional state known as "organization." The reader is invited to try to falsify the following null hypothesis, *"Controls alone, not constraints, cause formal function and utility to come into existence."* Without controls, self-ordering can occur in nature, but not bona fide organization. As explained later in this anthology, purposefully chosen constraints are a form of formal control, and do not serve to falsify the above null hypothesis.

Perhaps the earliest historical demonstration of control in the study of physics, thermodynamics and kinetics is the thought experiment known as Maxwell's demon [10] (see Chapter 2 and 4). The demon *chooses* when to open and close a trap door to separate hotter, faster-moving ideal gas molecules from cooler, slower moving molecules. The free-will selective operation of this trap door by the demon alone creates an energy differential and work potential out of physicodynamically inert molecules. The demon's choices constitute the first instance of formal *control*. An agent's purposeful choices control the physical state. Maxwell's demon was the first naturalistic "engineer," except that the demon is not naturalistic, but is a choosing agent that has no place in naturalistic physics texts. Of course, constraints limit behavior too, but without any consideration or pursuit of formal function and utilitarian goal. Physicodynamic constraints are blind to the notions of function, usefulness, formal work, utility, and pragmatism.

Controls are provided to physical systems through Prescriptive Information (PI) [2, 6, 8, 11, 12]. "Prescriptive information either tells us what choices to make, or it is a recordation of wise choices already made." [6] Carrying this idea further, "Prescriptive information either instructs or directly produces nontrivial function at its destination." [2, 8] Externally provided algorithmic processing is usually needed to realize utility from a Turing-tape-like linear digital source of PI such as DNA. But, ribozymes provide exception to this. The PI in ribonucleotide sequencing in ribozymes can act directly to catalyze without any externally applied algorithmic processing. This is the appeal of the preRNA and RNA World models of life origin.

Symbol systems and configurable switch-settings allow recordation of purposeful choices into physicality. PI instructs or produces nontrivial function through control choices originating with each decision-node selection. PI, the use of symbol systems, and the various mechanisms of instantiating control into physicality will all be explained more thoroughly in the chapters that follow in this anthology.

1. What does "formal" mean?

Most academicians readily agree that language, mathematics, programming, and logic theory are formalisms. Few realize exactly why. The word "formal" relates to Plato's forms and Aristotle's appreciation of general classes of form and function that transcend particular physical structure and shape.

Formalisms typically employ representationalism (e.g., math and letter symbol systems, words and language)—something that physicality cannot generate or participate in. Formal choices can be represented within linear digital prescriptions using sequences of "1" vs. "0" to represent each switch-setting to "on" vs. "off," "Yes" vs. "No," or "Open" vs. "Closed." Symbol systems are governed by arbitrary rules, not laws. The rule could just as easily be that "1" represents "Closed." Laws describe the invariant deterministic behavior of inanimate nature. Rules can be readily broken, and govern voluntary, choice-contingent behavior. All formalisms arise out of uncoerced choices in the pursuit of function and utility.

A "formalism" is a concept or idea like the category and generalization known as a "paper clip." (See Figure 1) There are many different kinds of paper clips. But when we say "paper clip," everyone knows what we mean without knowing the details of which specific kind of paper clip we are talking about. The general "form" of a paper clip comes to our mind as both a formal *representation* of meaning (which physics and chemistry cannot participate in) and as a *generalization* of that form that transcends the mass, energy and structure of each specific kind of paper clip. Formalisms make generalizations and categorizations possible.

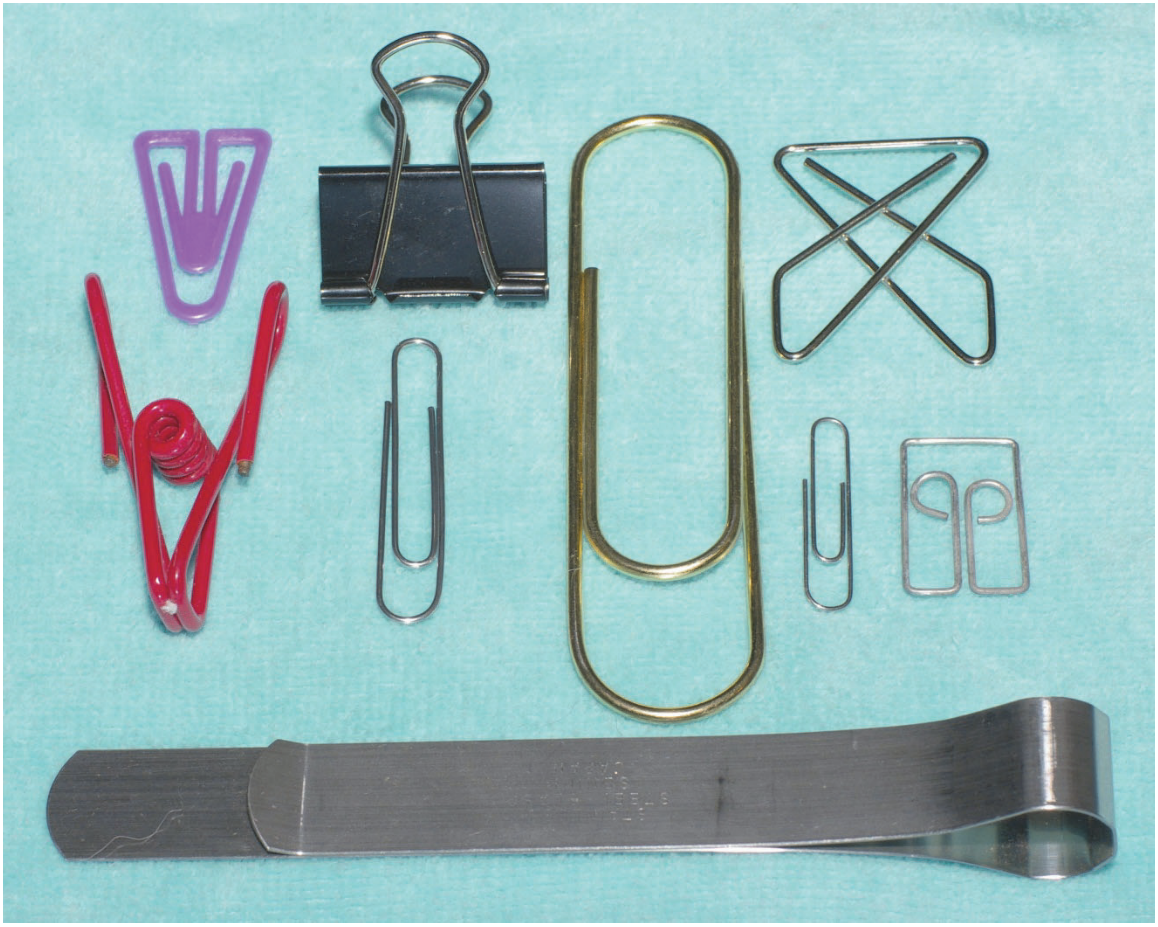

Figure 1. The idea of "paperclip" transcends any unique physical structure, shape, or scale, and it also transcends any particular type or style of paper clip. It is a conceptual category, not a particular physical entity. In this sense, "paperclip" is an abstract representational formalism rather than a physical object.

Listed below are aspects of reality that are all formalisms. None of these formalisms can be encompassed by a consistently held naturalistic worldview that seeks to reduce all things to physicodynamics:

- Mathematics
- Language
- Inferential and deductive logic theory
- The sign/symbol/token systems of semiosis

- Decision theory
- Cybernetics (including computer science)
- Computation
- Integrated circuits
- Bona fide organization (as opposed to mere self-ordering in chaos theory)
- Semantics (meaning)
- Pursuits of goals
- Pragmatic procedures and processes
- Art, literature, theatre, ethics, aesthetics
- The personhood of scientists themselves—the ultimate formalism

All of the above formalisms depend upon *choice contingency* rather than chance contingency or necessity. To hypothesize various theories of evolution, we substitute selection pressure for choice contingency. But whether we are talking about natural selection or artificial selection, the bottom line is still *selection* of the fittest or most pragmatic from among real options.

Nontrivial formal systems have never been observed to arise from "coin flips" at successive bifurcation points. Decision nodes must be true to their descriptive name. If guesses are made at decision nodes, both reason and empirical experience teach us that little or no utility will be generated. Wise choices must be made with intent to achieve logical, cybernetic, computational, and linguistic function. "Garbage in, garbage out," programmers quip. The criterion of wise choices from among real options is incorporated into the generation of any kind of nontrivial organized system.

"Paper clip" can be a single physical entity. But it can also be a formal generalization, a category, or a representation of *a class of entities*, all of which have the same basic function even though no two physical structural descriptions are the same. Three paperclips in Figure 1 vary only in scale; but different scale of the same entity represents still another kind of formalism. The collective descriptive category of "paper clip" is an idea—a formalism. This aspect of formalism was recognized by Plato when he thought about general or universal "form."

2. Physicality vs. Nonphysical Formalisms

Physicalism cannot address or deal with this kind of formal reality. It's like saying "genome" to address the entire class of all specific genetic sequences. Genes and the supposedly "non-coding" DNA sequences are responsible for *prescribing* each specific protein's amino acid sequencing and all of the microRNA controls—not mere physicodynamic constraints—that regulate genes and holistic metabolism. And of course the phenomenon of "regulation" is also formal rather than physical. Controls cannot be reduced to the chance and/or necessity of mere physical constraints.

Aristotelian "formal" and "final" causes cannot be reduced to mere mass/energy interactions. Certainly physicodynamics pursues no "final causes." Physicality has no desires, goals or aspirations. Inanimate physicality has no sensation of or motivation to pursue utility. Physicality is blind to pragmatism.

Formalisms alone generate nontrivial function and utility. Language, mathematics, inferential logic theory, computer programming, knowledge, the "aboutness" of information, and the scientific method itself are just a few examples of formalisms that cannot be reduced to physicodynamic interactions. Formalisms are nonphysical (Table 1). Formalisms always require abstract, conceptual choice contingency. Formalisms can be instantiated (recorded) into a physical medium or matrix. But the formalism itself remains nonphysical despite its instantiation into physicality.

Why is it possible to commit errors in mathematical manipulations, but not possible for gravity, electromagnetism, the strong or weak nuclear force to commit errors? The answer is that the cause-and-effect determinism of inanimate (nonliving) physicodynamic orderliness contains no decision nodes, logic gates or configurable switch-settings (Table 1). Since it is impossible to choose, it is impossible to err. Physicodynamic effects are forced by physical law. The only freedom that exists is a standard deviation bell curve stemming from the uncertainty of heat agitation and complex interactions of known physical forces. Yet-to-be-discovered forces and invariant physicodynamic laws would offer no programming freedom.

What about the "form" of a pattern in beach sand left by wave action? Isn't that formal? No! Such patterns can be explained by a chain or sequence of purely physical events. The pattern has regularity, but it does not result from "formal causation." The pattern has nothing to do with choice contingency and control. It has only to do with constraints and low-informational law. The same is true of the dissipative structures of chaos theory. They are self-ordered, not self-organized. What causes the confusion here is failing to ask whether these phenomena are controlled or merely constrained. We must differentiate between redundant, oscillating, low-informational physicodynamic patterns (similar to pulsar-like signals) vs. formal phenomena that invariably involve choice contingency, not chance contingency or law. Pulsar signals cannot generate meaningful messages because they are merely self-ordered by fixed law (necessity).

Table 1. ***Comparison of Formalisms to Constrained Physicality.***		
Attribute	**Formalisms**	**Constrained Physicality**
Physicodynamic	No. Utterly nonphysical	Yes. Entirely physicodynamic
Options/Possibilities	Many	Few
Uncertainty	High prior to choices	Little
Constrained	No	Yes
Controlled	Yes	No
Limited by forced, fixed laws	No	Yes
Limited by voluntary rule obedience	Yes	No
Chance contingent	No	Some
Choice contingent	Yes	No
Decision nodes	Yes	No
Logic gates	Yes	No
Configurable switch-settings	Yes	No
Abstract or tangible	Abstract	Tangible
Conceptual	Yes	No, except the mathematical nature of the laws themselves
Caused by	Choice determinism	Law-like necessity
Nontrivial function-producing	Yes	Never once observed
Goal oriented	Yes	Never
Which side of The Cybernetic Cut	Far side	Near side
Symbols/Representationalism used	Yes	Never
Meaning generated	Yes	Never
Sophisticated utility generated	Yes	Never
Useful and Pragmatic	Yes	Blind and Indifferent

When we hear the word "formal," we need to *stop* thinking "order" or "pattern." We need to think *"choice contingency."* Physicality cannot participate in formalisms such as language, mathematics, coding, translations, programming, logical inference, circuit integration, engineering, ethics, aesthetics, and the scientific method itself. All of these formalisms require "arbitrary" choices. Arbitrary does not mean random. It means choices uncoerced-by-law. Necessity would program every logic gate the same way every time, by law. If inanimate nature did the programming, it would generate a computer program consisting of all 0's, or a program consisting of all 1's.

Mere coin flips at decision nodes will not work either to explain formalisms. No computationally successful program was ever generated by a random number generator. To generate nontrivial functional Markov chains always involves behind-the-scenes steering. So-called "evolutionary algorithms" (a

Self-contradictory nonsense term), if they produce any formal function, are always artificially controlled. Optimization of genetic algorithms is always choice-contingent, and therefore formal rather than physical.

3. Intuitive, Semantic, Functional Information (FI)

The Prescriptive Information (PI) mentioned at the start of this chapter is a subset of intuitive or semantic (meaningful) information. Semantic information conveys meaningful and functional messages (semiosis) from a source that can be understood by a receiving agent at its final destination—at the far end of a Shannon channel. Adami rightly argues that information must always be *about* something [13]. "Aboutness" is a common focus of attention in trying to elucidate what makes information intuitive [14, 15]. But aboutness is always abstract, conceptual, and formal. Efforts to define aboutness in purely physical terms have frustrated bioinformationists for decades [16-19]. The difficulty of defining and understanding semantic information is especially acute in genetics [20, 21]. Oyama points to the many problems trying to relate semantic information to cellular biology [22]. Some investigators attempt to deny that genes contain meaningful information and true instructions [23-30]. Their arguments strain credibility.

Jablonka rightly argues that Shannon information is insufficient to explain biology [31]. She 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" [31, pg. 588]. Jablonka correctly senses 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.

Semantic information, unlike Shannon "information," is Functional Information (FI). Shannon "information" is a misnomer. What is usually called "Shannon information" is in fact either Shannon "uncertainty" or "reduced uncertainty" (poorly termed "mutual entropy"). Neither can prescribe or generate formal function. Shannon uncertainty is nothing more than a measure of combinatorial probabilism [32]. Bits of Shannon uncertainty can measure "binary choice opportunities." Under no circumstances can bits ever measure actual specific choices. *Yet specific choices at bona fide binary decision nodes alone generate semantic information*—choosing from among two real options: either "On" is picked, or "Off" is picked. A logical "excluded middle" prevails. Indecision is not allowed at programming nodes except to deliberately provide end-user programming options. In computer science this is formally represented symbolically by the programmer's choice of either a "1" or a "0" at each logic gate. At every decision node, either a "1" or a "0" must be picked to generate both Functional Information (FI) and its subset of Prescriptive Information (PI) at that node.

The reason bits cannot measure specific choices is that no standard fixed unit of measure exists to quantify specific choices made at each unique position in the programming string of decision nodes. To generate bits of "reduced uncertainty" requires a great deal of cognitive background knowledge independent of the "before" or "after" bit measurements themselves. To reduce negative uncertainty requires the accrual of positive knowledge that reduces and counterbalances that negative uncertainty. The "after" measurement of bits must be educated by gained certainty before it can be compared to the "before" measure of uncertainty to establish "reduced uncertainty." Even then, reduced uncertainty is a very limited form of knowledge. Shannon uncertainty cannot progress to becoming FI without smuggling in positive information from an external source. Only then is Shannon uncertainty (bits) reduced.

Even though bits cannot measure FI, it is important to remember that to record FI does require 1) Shannon uncertainty (contingency: events could have occurred differently despite physical constraints), 2) freedom of selection (the ability to choose), and 3) intent (goal and/or purpose). No system can contain FI that is fully physicodynamically determined. The necessity of law-like physical behavior disallows contingency and freedom of selection. What is forced by law cannot offer choice, goal or purpose. In addition, for FI to be generated, the possibility of error and symbolic misrepresentation must exist [33]. Sterelny and Griffiths also argue that the semantic content of information, including genetic information, can be stored and expressed at a later time. Immediacy of cause-and-effect is not required. Finally, choice contingency is a form of determinism. Determinism is not limited to physicodynamics. Choice contingency, when instantiated into physicality, can become a true cause of physical effects.

4. Descriptive Information (DI) vs. Prescriptive Information (PI)

The source of the external positive background information needed to reduce uncertainty (discussed above) can come in the form of Descriptive Information (DI). Intuitive semantic information (Functional Information, or FI), technically has two subsets: Descriptive (DI) and Prescriptive (PI). Unfortunately, many semantic information theorists make the mistake of thinking of functional information solely in terms of human epistemology and specifically description (DI). This in effect limits the meaning of "function." DI provides valued common-sense knowledge to human beings about the way things already are. *Being* can be described to provide one form of function. But this subset of intuitive and semantic information, while highly functional, is very limited and grossly inadequate to address many forms of *instruction and control.* Prescriptive information (PI) does far more than describe. We can thoroughly describe a new Mercedes automobile, providing a great deal of DI in the process. But this functional DI might tell us almost nothing about *how to design, engineer and build* that Mercedes. The term "functional information" as used in peer-reviewed naturalistic biological literature by Nobel laureate Jack Szostak et al in 2003 [34] [35, 36] can be a completely inadequate descriptor of the "how to" information—the instructions—required to organize and program sophisticated utility. *Potential* formal function must be *prescribed* in advance by Prescriptive Information (PI) via decision node programming, not just described after the fact. As its name implies, PI specifically conceives and prescribes utility. PI programs computational success in advance of halting. While it is true that halting must be empirically verified (the halting problem [37, 38]), *computational success still must be prescribed in advance of its realization.* PI either tells us what choices to make, or it is a recordation of wise choices already made [12]. When we install computer software, we are installing PI. Yet PI is not just limited to instruction. PI can also indirectly generate nontrivial computational success and cybernetic function in conjunction with external algorithmic processing.

PI can perform nonphysical "formal work." PI can then be instantiated into physicality to marshal physical work out of nonphysical formal work [6, 10]. 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 [6, 9, 39]. Such decisions steer events toward pragmatic results that are valued by agents. Empirical evidence of PI arising spontaneously from inanimate nature is sorely lacking [1, 9]. Neither chance nor necessity has been shown to generate prescriptive information [1, 3, 4, 6-9, 12, 40, 41]. Choice contingency, not chance contingency, prescribes nontrivial function.

PI typically is recorded into a linear digital symbol system format. Symbols represent purposeful choices from an alphabet of symbol options. Symbol selection is made at bona fide decision nodes. Selection of particular sequences of symbols (syntax) must follow prescribed arbitrary rules. It is only when these rules are followed by both sender and receiver that a meaningful/functional message can be successfully conveyed to its destination (semiosis). A meaning*less* message (another self-contradictory nonsense term) would fulfill no purpose and provide no functionality. It would therefore not qualify definitionally as a "message." It would in fact be nothing more than a signal. Signals are not necessarily messages. A consistently repeating pulsar signal is not a meaningful message, and therefore not a message at all. Yet a pulsar signal contains high order and pattern.

It is common for non-specialists in biocybernetics and biosemiotics to try to define messages erroneously in terms of "patterns." The patterns in the sand caused by wave action of the sea, for example, convey no meaningful message or cybernetic programming. As we shall see in later chapters, neither order nor patterns are the key to meaning, regulation, control or function. *Selection for potential function* at bona fide decision nodes and logic gates is. more conceptually complex PI is needed to compute and organize metabolism and life than is needed to generate our most advanced computer systems. Life is the most sophisticated of all integrated meta-systems. Prescriptive Information is much more than intuitive semantic information. PI requires anticipation, "choice with intent," and the diligent pursuit of Aristotle's "final function" at successive bona fide decision nodes. PI either instructs or directly produces formal function at its destination through the use of controls, not mere constraints [6, 11]. Once again, PI either tells us what choices to make, or it is a recordation of wise choices already made.

Decision node choices can also be recorded or instantiated into physicality via logic-gate and configurable switch-settings. When mental symbols are recorded onto physical objects, they are called "tokens." The small blocks of wood with letters written on them in a Scrabble game are tokens. When physical tokens are *chosen* to spell words, the symbol system is called a Material Symbol System (MSS) [42, 43]. Although the tokens are physical, the selection of each token to spell meaningful syntax is not physical. Each selection is abstract, conceptual, nonphysical, choice-based, rule-guided, and formal. The same is true of the symbol meaning itself. Meaning is arbitrarily assigned to each representational symbol. The latter is a purely formal control function, not a physicodynamically constrained interaction.

The prior selection of each nucleotide and syntactical nucleotide sequencing is a form of linear digital programming of potential function. Transcription and mRNA editing must be completed by additional algorithmic processing. The "messenger molecules" are rigidly bound with covalent bonds before that biofunction is ever realized phenotypically. Protein primary structure (linear digital sequence) must be completed in the ribosome before folding into molecular machines begins. All of this linear digital prescription must take place long before any fittest living organisms can be favored by the environment (The GS Principle) [5]. Later we will look at the incredible additional layers and dimensions of PI that are instantiated into both DNA and other parallel nanocomputers systems in the cell.

Definitions of information that are limited to human epistemology are not helpful when it comes to gene and functional small RNA emergence. Genetic and genomic PI was instructing the organization of metabolism long before Homo sapiens arrived on the scene to ponder it. Humanity's knowledge and definitions of information are irrelevant to the question of how protocells could have objectively prescribed biofunction and self-organized in a prebiotic environment. We need to cultivate a less anthropocentric and less subjective understanding of PI and its MSS coding in the genome to make any progress in life-origin science. Molecular biological encryption/decryption cannot be reduced to a product of human consciousness. Linear digital prescription using a material symbol system, its coding and decoding, its error-correction mechanisms, and its noise-reducing Hamming redundancy block coding produced not only cellular metabolism, but human brain function with its consciousness. Our knowledge of these phenomena is secondary, not primary. Our consciousness and epistemology is not the center of biological and cosmic reality. No room exists for solipsism within a consistently held naturalistic and evolutionary worldview. Naturalism metaphysically presupposes an external-to-mind literal objective history of real physical transitions from objective simple one-celled organisms to primate brains. Consciousness is secreted by the brain (just as liver secretes bile) in a naturalistic worldview. Consciousness is not ultimate as envisioned by solipsism, and the derivation of consciousness from physicodynamics must be fully elucidated before equating naturalism with science.

5. The focus of ProtoBioCybernetics

ProtoBioCybernetics seeks to study the source and derivation of Prescriptive Information (PI) in inanimate nature. PI is the "how to" information that we call "instructions." Genomes were giving instructions and computing long before *Homo sapiens* existed. Belief in chemical/molecular evolution presupposes that physicodynamics alone generated formal instructions sufficient to organize a protometabolism in a structural protocell that spontaneously came to life. The sharp focus of the discipline of ProtoBioCybernetics addresses questions of how inanimate nature could have:

1. Chosen wisely from among physicodynamically indeterminate options
2. Valued and pursued formal function to which physicodynamics is blind
3. Anticipated what would "work" before that utility came into existence

4. Wrote formal rules governing behavior not forced by fixed laws
5. Programmed, measured and computed formally controlled systems
6. Generated the very first Prescriptive Information (PI)
7. Generated the first material symbol system with which to record and replicate PI.
8. Organized both protocell structure and protometabolism.
9. Programmed specific reaction sequences, pathways and cycles.
10. Integrated all those specific reactions into a cooperative protometabolic system
11. Established protometabolic control and regulatory mechanisms.
12. Selected the syntax of "alphabetical characters" (nucleotides) so as to "spell" and "encode" meaningful (biofunctional) messages that prescribe amino acid sequence
13. Devised a noise-reducing Hamming "block code" (triplet codons)
14. "Foreknew" which nucleotide sequences would prescribe (only upon later translation) the needed amino acid sequences.
15. "Foreknew" which sequences of amino acids (primary molecular structure) would only later fold according to minimum Gibbs free-energy dictates to produce thousands of needed three-dimensional molecular machines and computers.
16. Devised a formal codon table and bijective 3-to-1 translation system
17. Devised a representational heritable symbol system "independent" of phenotype that could evolve, but still retain already achieved progress so that the wheel didn't have to be completely re-invented with each new phenotypic reproduction.
18. Overcame the various well-known chicken-and-egg problems of life origin research.
19. Isolated out only homochiral nucleic acid and peptides.
20. Employed only 3'5' phosphodiester bonds in nucleic acid
21. Employed only peptide bonds in polypeptides
22. Achieved dehydration synthesis of heteropolymers, not just homopolymers, in aqueous environments
23. Synthesized exceedingly hard-to-make building blocks such as cytosine.
24. Overcome molecular instability of many key components of life over vast periods of time while life was slowly getting organized supposedly by small increments.

How did unaided physicodynamics accomplish any one of these *formal* feats of control? How did physicodynamics integrate all of these individual formal feats into a utilitarian metasystem called "metabolism"? Formalisms are abstract, conceptual, choice-contingent, organizational, nonphysical, mentally steered constructions. Physicodynamics does not practice the fine arts of purposeful choice, language, mathematics, logic theory, algorithmic optimization, programming, computation, and the pursuit of formal function and utility. What possible physicodynamic mechanisms could have existed in a prebiotic environment for inanimate physicality to generate such formalisms—such PI, organization, control and regulation?

The standard contention of naturalistic life-origin science is that almost none of these *conceptual* complexities of current life were needed or present in the first protocells. The composome and micelle to vesicle model of life-origin seems to circumvent the steep vertical cliff of Mount Improbable, providing the gradual back-side slope to that vertical cliff [44]. But the nagging problem for the scientific discipline of ProtoBioCybernetics is that a critical mass of minimal integration, cooperation and control is required even for the simplest of theoretical protocells to self-organize. No motivation, reason or mechanism seems to exist for accumulation through gradualism of any one, let alone *all*, of the above formal integrations needed even for the simplest conceivable protometabolism. A punctuated equilibrium approach to abiogenesis is statistically prohibitive by hundreds of orders of magnitude, and is definitively falsified with sound application of the Universal Plausibility Metric and Principle [45].

The very existence of bona fide "self-organization" has been called into question despite thousands of peer-reviewed papers and books that simply presuppose its reality [1, 6, 7, 9, 12, 46, 47]. Often low-informational spontaneous self-ordering phenomena (e.g., Prigogine's dissipative structures of chaos theory) are confused with imagined "self-organization." [9] The two have little in common. Self-ordering phenomena perform no formal functions that could be organized into sustainable utility, let alone a cybernetic protometabolic metasystem.

Thus the subjects of study within the discipline of ProtoBioCybernetics, and this anthology of peer-reviewed works, include:

A. The three fundamental categories of reality: chance, necessity, and selection
B. The three subsets of sequence complexity, Random Sequence Complexity (RSC), Ordered Sequence Complexity (OSC), and Functional Sequence Complexity (FSC)
C. Physicodynamics (physicochemical mass/energy interactions) vs. nonphysical

D. formalisms
E. Constraints vs. Controls
F. Law vs. Rules
G. The formal nature of function, work and utility
H. Physicodynamic determinism vs. programming determinism
I. Decision nodes, logic gates and configurable switch-settings
J. The Cybernetic Cut and one-way nature of the Configurable Switch Bridge
K. Order and Pattern vs. Complexity and Noise
L. Self-ordering vs. self-organization
M. Mere combinatorial complexity vs. bona fide organization
N. Shannon uncertainty vs. semantic information
O. Description vs. Prescription
P. Functional Information transcends mere Shannon reduced uncertainty
Q. Prescriptive Information (PI) transcends mere Descriptive Information (DI)
R. The instantiation of nonphysical formalisms into physicality
S. Moving far from equilibrium
T. Chaos theory vs. Systems theory
U. Material Symbol Systems cannot be reduced to physicality
V. Can composomes (which include ribozyme complexes) evolve?
W. The GS (Genetic Selection) Principle
X. The highly selective nature of membrane active transport
Y. What might be a protocell’s minimal genome?
Z. The Formalism > Physicality (F > P) Principle

In summary, we might ask, “To what degree do the PI, biocybernetic and biosemiotic aspects of cellular metabolism conform to the cognitive and psychological criteria of these formalisms?” How did inanimate physical nature generate such nonphysical formalisms sufficient to organize life? Do the biological controls and messages that integrate metabolism have conceptual meaning? If not, how can meaning be divorced from such exquisite genomic and epigenomic instructions, metabolic integration and organization? Is anything more goal-directed than the holistic metabolism needed to be and stay alive? This is the subject matter of ProtoBioCybernetics.

References

1. Abel, D.L. 2009, The capabilities of chaos and complexity, Int. J. Mol. Sci., 10, (Special Issue on Life Origin) 247-291 Open access at http://mdpi.com/1422-0067/10/1/247
2. Abel, D.L.; Trevors, J.T. 2006, More than metaphor: Genomes are objective sign systems, Journal of BioSemiotics, 1, (2) 253-267.
3. Abel, D.L. 2007, Complexity, self-organization, and emergence at the edge of chaos in life-origin models, Journal of the Washington Academy of Sciences, 93, (4) 1-20.
4. Abel, D.L. 2008, 'The Cybernetic Cut': Progressing from description to prescription in systems theory, The Open Cybernetics and Systemics Journal, 2, 234-244 Open access at www.bentham.org/open/tocsj/articles/V002/252TOCSJ.pdf
5. Abel, D.L. 2009, The GS (Genetic Selection) Principle, Frontiers in Bioscience, 14, (January 1) 2959-2969 Open access at http://www.bioscience.org/2009/v14/af/3426/fulltext.htm.
6. Abel, D.L. 2009, The biosemiosis of prescriptive information, Semiotica, 2009, (174) 1-19.
7. Abel, D.L. 2010, Constraints vs. Controls, Open Cybernetics and Systemics Journal, 4, 14-27 Open Access at http://www.bentham.org/open/tocsj/articles/V004/14TOCSJ.pdf.
8. Abel, D.L.; Trevors, J.T. 2005, Three subsets of sequence complexity and their relevance to biopolymeric information., Theoretical Biology and Medical Modeling, 2, 29 Open access at http://www.tbiomed.com/content/2/1/29.
9. Abel, D.L.; Trevors, J.T. 2006, Self-Organization vs. Self-Ordering events in life-origin models, Physics of Life Reviews, 3, 211-228.
10. Abel, D.L. 2012, Moving 'far from equilibrium' in a prebitoic environment: The role of Maxwell's Demon in life origin. In *Genesis - In the Beginning: Precursors of Life, Chemical Models and Early Biological Evolution* Seckbach, J.Gordon, R., Eds. Springer: Dordrecht.
11. Abel, D.L. Prescriptive Information (PI) [Scirus Topic Page]. http://www.scitopics.com/Prescriptive_Information_PI.html (Last accessed November, 2011).
12. Abel, D.L.; Trevors, J.T. 2007, More than Metaphor: Genomes are Objective Sign Systems. In *BioSemiotic Research Trends*, Barbieri, M., Ed. Nova Science Publishers: New York, pp 1-15 http://books.google.com/books?id=GvRmYbN3n6UC&pg=PA1&lpg=PA1&dq=%22The+GS+Principle%22&source=bl&ots=-ZK4mRBvqw&sig=52lPn3HuWpfD095dHEidlXr4cBM&hl=en&sa=X&oi=book_result&resnum=6&ct=result.
13. Adami, C. 1998, *Introduction to Artificial Life*. Springer/Telos: New York.
14. Bruza, P.D.; Song, D.W.; Wong, K.F. 2000, Aboutness from a common sense perspective, JASIS, 51, (12) 1090-1105.
15. Hjorland, B. 2001, Towards a theory of aboutness, subject, topicallity, theme, domain, field, content . . ., and relevance, Journal of the American Society of Information Systems and Technology, 52, (9) 774-778.
16. Maynard Smith, J. 1999, The 1999 Crafoord Prize Lectures. The idea of information in biology, Q Rev Biol, 74, (4) 395-400.
17. Maynard Smith, J. 2000, The concept of information in biology, Philosophy of Science, 67, (June) 177-194 (entire issue is an excellent discussion).
18. Szathmary, E. 1996, From RNA to language, Curr Biol, 6, (7) 764.
19. Szathmary, E. 2001, Biological information, kin selection, and evolutionary transitions, Theoretical Population Biology, 59, 11-14.
20. Johnson, D.E. 2010, *Probability's Nature and Nature's Probability (A call to scientific integrity)*. Booksurge Publishing: Charleston, S.C.
21. Johnson, D.E. 2010, *Programming of Life*. Big Mac Publishers: Sylacauga, Alabama.
22. Oyama, S. 2000, *The Ontogeny of Information: Developmenal Systems and Evolution (science and cultural theory)*. Duke University Press: Durham, N.C.
23. Sarkar, S. 2000, Information in genetics and developmental biology: Comments on Maynard Smith, Philosophy of Science, 67, 208-213.
24. Sarkar, S. 1996, Biological information: a skeptical look at some central dogmas of molecular biology. In *The Philosophy and History of Molecular Biology: New Perspectives*, Sarkar, S., Ed. Kluwer Academic Publishers: Dordrecht, pp 187-231.
25. Boniolo, G. 2003, Biology without information, History and Philosophy of the Life Sciences, 25, 255-73.
26. Salthe, S.N. 2005, Meaning in nature: Placing biosemiotics within pansemiotics, Journal of Biosemiotics, 1, 287-301.

27. Salthe, S.N. 2006, What is the scope of biosemiotics? Information in living systems. . In *Introduction to Biosemiotics: The New Biological Synthesis* Barbieri, M., Ed. Springer-Verlag New York, Inc.: Dordrecht, The Netherlands; Secaucus, NJ, USA
28. Kurakin, A. 2006, Self-organization versus Watchmaker: molecular motors and protein translocation., Biosystems 84, (1) 15-23.
29. Mahner, M.; Bunge, M.A. 1997, *Foundations of Biophilosophy*. Springer Verlag: Berlin.
30. Kitcher, P. 2001, Battling the undead; how (and how not) to resist genetic determinism. In *Thinking About Evolution: Historical Philosophical and Political Perspectives*, Singh, R. S.; Krimbas, C. B.; Paul, D. B.Beattie, J., Eds. Cambridge University Press: Cambridge, pp 396-414.
31. Jablonka, E. 2002, Information: Its interpretation, its inheritance, and its sharing, Philosophy of Science, 69, 578-605.
32. Shannon, C. 1948, Part I and II: A mathematical theory of communication, The Bell System Technical Journal, XXVII, (3 July) 379-423.
33. Griffiths, P.E.; Sterelny, K. 1999, *Sex and Death: An Introduction to Philosophy of Biology*. Univ. of Chicago Press: Chicago.
34. Szostak, J.W. 2003, Functional information: Molecular messages, Nature, 423, (6941) 689.
35. Hazen, R.M.; Griffin, P.L.; Carothers, J.M.; Szostak, J.W. 2007, Functional information and the emergence of biocomplexity, Proc Natl Acad Sci U S A, 104 Suppl 1, 8574-81.
36. Sharov, A. 2009, Role of utility and inference in the evolution of functional information, Biosemiotics, 2, 101-115.
37. Davis, M. 1958, *Computability and Unsolvability*. McGraw-Hill: New York.
38. Turing, A.M. 1936, On computable numbers, with an application to the *entscheidungs problem*, Proc. Roy. Soc. London Mathematical Society, 42, (Ser 2) 230-265 [correction in 43, 544-546].
39. Kaplan, M. 1996, *Decision Theory as Philosophy*. Cambridge Univ. Press: Cambridge.
40. Trevors, J.T.; Abel, D.L. 2004, Chance and necessity do not explain the origin of life, Cell Biology International, 28, 729-739.
41. Abel, D.L. 2002, Is Life Reducible to Complexity? In *Fundamentals of Life*, Palyi, G.; Zucchi, C.Caglioti, L., Eds. Elsevier: Paris, pp 57-72.
42. Rocha, L.M. 2000, Syntactic autonomy: or why there is no autonomy without symbols and how self-organizing systems might evolve them, Annals of the New York Academy of Sciences, 207-223.
43. Rocha, L.M. 2001, Evolution with material symbol systems, Biosystems, 60, 95-121.
44. Dawkins, R. 1996, *Climbing Mount Improbable*. W.W. Norton & Co: New York.
45. Abel, D.L. 2009, The Universal Plausibility Metric (UPM) & Principle (UPP), Theor Biol Med Model, 6, (1) 27 Open access at http://www.tbiomed.com/content/6/1/27.
46. Abel, D.L. 2008 The capabilities of chaos and complexity, Society for Chaos Theory: Society for Complexity in Psychology and the Life Sciences, International Conference at Virginia Commonwealth University, Richmond, VA., Aug 8-10.
47. Overman, D.L. 1997, *A Case Against Accident and Self-Organization*. Rowman and Littlefield Publishers, Inc.: New York.

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