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The Life/Non-life Dichotomy

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Abstract

What exactly distinguishes life from non-life? Is the dichotomy a black/white absolute, or a slow "gray scale" transition? We don't normally consider life vs. death to be "relative." Genomics and epigenomics continue to amass irrefutable evidence of causes and their effects that cannot be reduced to Monod's Chance and Necessity [1-6]. All known life is formally programmed using physical symbol vehicles in Material Symbol Systems (MSSs). The uniqueness of life is specifically defined by syntaxes of semantic Efficacious Executable Choice Command Controls (EECCCs). Cybernetic processing is accomplished only through agreed-upon conformance by programming, machinery and recipient to arbitrary formal rule conventions. Computation cannot be achieved by physicodynamic laws, forces, constraints, quantum mechanics or irreversible nonequilibrium thermodynamics. The prescription of biofunction successfully traverses Shannon channels across The Cybernetic Cut on the one-way narrow Configurable Switch (CS) Bridge from formalism into physicality[7-9]. The result is formal computational halting within the material world. Hundreds of conceptual integrated circuit components cooperate to achieve homeostatic metabolism far from equilibrium. *What clearly defines life's uniqueness is EECCC*. The Physicodynamic Incompleteness Theorem [10] firmly predicts that no physicalistic model of abiogenesis will ever elucidate the causation of life's EECCC on the near physicodynamic side of The Cybernetic Cut.

Keywords: Life vs. Non-life; Animacy vs. Inanimacy; The Definition of Life; Life Origin; Abiogenesis; Computational Biology; The Universal Determinism Dichotomy (UDD); The Formalism > Physicality (F > P) Principle; The Physicodynamic Incompleteness Theorem (PIT); The Genetic Selection (GS) Principle; Protocellular Metabolomics; ProtoBioCybernetics; ProtoBioSemiotics.

Introduction

The First Law of Biology states that "All life must come from previously existing life." Has Pasteur's and Virchow's First Law of Biology ever been falsified? If empirical evidence exists of purely physicodynamic transition from inanimacy (non-life) to animacy (life), then the answer is yes. But does it? Most abiogenic researchers are still presupposing a spontaneous purely physicodynamic transition from non-life to life. Examples of this include the latest proto-cellular metabolomics research [11-23] and lipid membrane research [24-30]. All of these authors still espouse a slow naturalistic evolutionary transition despite many all-or-none, immediate-need system requirements of life [5, 6, 31-47]. But if the spontaneous generation of life has *never* been observed, even with the aid of human engineering, then the

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question arises, "Are the notions of "protolife," "protocell" and "Protobiont" real, or just theoretical mental constructs?" Imagination is critical to hypothesizing, modeling, and theorizing. Imagination is often the first step to scientific progress. But imagination must have strict limits in science. Firmly entrenched Kuhnian paradigm ruts can exert such profound influence on supposed scientific knowledge as to equate imagination with reality. This is especially true when a purely metaphysical presupposition becomes the most fundamental starting axiom of naturalistic science. Einstein warned against this [48, 49]. Whatever our presuppositions, the latest biological research shows abundant evidence of steering, controls, directives, and regulation at the subcellular level of even the most primitive living organisms. All known life is programmed, cybernetically processed, and literally computed. The definition of all these terms is far more formal than physicodynamic. Consider, for example, the term "regulation" used so commonly in the field of epigenomics.

What do we mean when we talk about "epigenetic regulation" and "switching genes on and off"?

To "regulate" means to purposefully control. But discussion of "purpose," "goal" and "control" are not admissible into naturalistic science. Eyebrows of cynicism are raised. These concepts are just too teleological. Evolution has no goal. Purpose, goal and controls are just too akin to engineering and agency. To be consistent with our metaphysical presuppositions, we prefer to couch causation solely in terms of laws, forces, constraints and probability bounds. These causes are acceptably "natural," meaning psychodynamic. The most fundamental axiom of naturalistic science is basically that "Physicodynamics is sufficient to explain the whole of reality." The problem is, the natural science of Biology is daily confronted with thousands of subcellular empirical examples of *undeniable purposeful controls*. Now what do we do? Excommunicate the science of Biology from the natural sciences the way we did with the science of Engineering? "Control" means ever so much more than mere constraint [50]. Life is controlled, not constrained. From the beginning, both philosophy and science were supposed to be about progressive discovery of all aspects of ontological *being*. Only our metaphysical presuppositions caused us to exclude Engineering from investigating the full spectrum of the "Hows?" of reality. But, are we now going to be able to get away with divorcing Biology from the natural sciences the way we did with Engineering Science? Life is undeniably regulated and controlled. The only answer will be found in *redefining* what science has been defining as "natural."

In genomics, epigenomics and molecular biology, control and regulation refer to steering a biochemical process toward a successful biofunctional endpoint. Life regulates everything for a reason: to be alive and to stay alive. Life is so sophisticated in its programming, it sometimes even deliberately programs its own cell death to protect the well-being of the overall organism (apoptosis, which is also tightly regulated) [51-53].

Life's regulation might be of a seemingly isolated biochemical pathway. It might be of what started out as a spontaneous hypercycle, of a positive or negative feedback mechanism, the syntax of executable commands and their cybernetic processing, computational halting, the management of a certain gene's prescriptive ability, the choice of when that gene is turned on or off, alternate splicing, tandem repeat number control, the formal cooperation of promotors and distant enhancers, the manufacture and delivery of transcription factors, the methylation of certain loci in DNA, the acetylation of certain loci in histone proteins, the integration of circuits, holistic cooperation between multiple gene networks, or even homeostatic metabolism in its entirety. All of these are tightly regulated by life. Do we not understand what this word means, and that it cannot possibly be explained by the fanatical, absolutist religion of physicalism? Regulation and control are formalisms. They are every bit as abstract, conceptual, non-physical and formal as language, logic theory, mathematics and scientific ethics in reporting results. There would be no point to steering, directing, regulating and controlling a process toward failure. When we use the word "regulate," we connote and intuit successful fulfilment of purpose and function. Mere physicodynamic interactions and physico-chemical reactions cannot steer and direct events toward "usefulness." Physicodynamics is blind to utility and pragmatism. Physicodynamics cannot perceive, let alone value or pursue, formal function. Physicality and the "work" of physics could care less whether anything is formally pragmatic. The work of physics is merely a mass being moved through space. It has nothing to do with purpose or usefulness.

Spontaneous irreversible nonequilibrium thermodynamics, Onsager's paired reciprocal fluxes [54, 55] and spontaneous mass/energy transductions have never been observed to achieve or govern any sophisticated formal function. They do not direct thermodynamics toward non-trivial functional success. Paired reciprocal fluxes have no sense of directionality toward any goal. They are not steered toward usefulness. Thermodynamics doesn't know or care what "function" means. Regulation and control require purposeful active selections from among real options. This spells "Choice Determinism." Life is replete with all manor of "Choice Determinisms." The uniqueness of life is found in the Universal Determinism Dichotomy (UDD) [56]. Biofunctions are purposefully pursued. Evolution may have no goals. But life certainly does. Maxwell's demon's choices of when to open and close the trap door between compartments is critical. The gas molecules in each compartment are inert. No physicodynamic functional attractions exist. The demon's choices are the only way a usable energy

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differential can be generated into the Sustained Functional System (SFS) [57] of a heat engine. A SFS is not just a string of momentary dissipative structures. Prigogine's chaos theory has nothing to do with control, regulation or function. SFSs are generated only by the demon's Choice Causation of exactly when to open or close the trap door. If this is true of the simplest heat engine, it is certainly true of any cell. Purpose and successful function both originate from the far side of The Cybernetic Cut via the Configurable Switch (CS) Bridge [7-9, 31-37, 58].

What exactly do we mean when we talk about "switching genes on and off"? Both "on" and "off" are real physical states of a physical configurable switch. A configurable switch is a material object. But, it is specifically designed and engineered *to record nonphysical formal choices into physicality.* In the case of genomics, the material object is a DNA sequence of semantic efficacious executable choice commands. The commands integrate into formal prescriptions of future potential computational functions. Those formal commands are just instantiated into the physical nucleotide sequencing of the DNA molecule. Nucleotides serve as physical symbol vehicles in a Material Symbol System (MSS) [59, 60]. The only way those commands can be realized and executed is if they exist in a formal transcription, translation, coding, and processing system run according to arbitrarily agreed-upon rules, not laws. Biofunction must be programmed and cybernetically computed. Every detail of life's all-or-none programming somehow overcomes Turing's halting problem. This is something our finest human cyberneticists cannot accomplish.

Then, we have a second tier of formal controls incorporated into physicality: the epigenetic *regulation* of whether that linear digital genetic prescription itself (the gene) should be currently turned on or off. Add to that the four-dimensional nature of modern genomic understanding of programming. All three of these layers, and many more, such as biosemiotic codes, superimposed multi-dimensional coding of the same physical symbol vehicle string, transcription factor controls, histone codes, etc., add up to what we mean by "regulation." This control cannot be reduced to mere physicodynamic complexity [50, 61-68]. Life is not just complex; it is *conceptually* complex. Both conceptual complexity and control are formal, not physical.

In a prebiotic environment, the active selection of one nucleoside out of four possibilities at each locus in the programming string was not physicodynamically determined. Each active selection of a nucleoside next to polymerize was "physicodynamically inert" [69, 70]. Physicodynamic inertness was the key to allowing programming choices with physical symbol vehicles. Each polymerization event was functionally a quaternary "decision node." How did an inanimate environment forming the first prescriptive informational polynucleotide know which nucleoside to select at each locus in the forming programming string? [71-74] Was the selection educated by some kind of foreknowledge of what the triplet codon table would require? Is the triplet codon table a physical entity or an abstract conceptual formalism? Even if inanimacy had fore-known the codon table, how would it have known what to do with it in protein prescription or lncRNA prescription? How did linear digital nucleotide syntax foreknow minimum Gibbs-free energy requirements needed for proper folding? One of four physical nucleoside options had to be purposefully chosen at each decision node in the programming string *prior to any function*. Yet one wrong choice out of three billion quaternary choices can result in sickle cell anemia or achondroplasia. Precise choices matter, not only in life in general, but in genetics, four-dimensional genomics and epigenomics. The choice of each nucleoside was rigidly bound by 3'5' phosphodiester bonds. No "mulligans" of polymerization were permitted in abiogenesis. No resorting could have taken place through time to make the holistic system work. The half-life of even RNA analogs is way too limited for tinkering over long periods of time. And "tinkering," crude as trial-and-error searches may be, is still a form of *goal-oriented search* which physicodynamics does not and cannot do.

Physical configurable switches are unique in their ability to record purposeful formal choices. Both configurable switches and the active selection of physical symbol vehicles in a Material Symbol System (MSS) Rocha, 1998 #5886;Abel, 2011 #15754} constitute the CS Bridge across which active formal selections can be instantiated into physicality from the far formal side of The Cybernetic Cut [7-9, 31-37, 58]. Configurable switches such as the light switches on our walls are specifically designed and engineered to register nonphysical, abstract, conceptual, formal, purposeful choices into a physical state of being. Gravity does not turn the wall light switch off. Only one thing turns that switch off: "End-User Freedom" designed and engineered into life's programming and its physical instantiation.

Life is literally programmed by syntaxes of semantic Efficacious Executable Choice Command Controls (EECCCs). These prescriptive commands are then cybernetically processed by nanocomputers and very sophisticated molecular machines. These machines themselves had to be programed, processed and engineered. Life is literally computed. The executable choice commands and their processing preceded computational halting. This means that the active selections of each configurable switch-setting, or the active selection of each physical symbol vehicle in a Material Symbol System (MSS), precede any prescribed phenotypic fitness advantage. After-the-fact, secondary, passive, natural selection could have played no role in the pre-made programming choices. Natural selection works only on the fittest already-living organisms. But the fittest organisms are produced only by the fittest programming (The Genetic Selection [GS] Principle [75, 76]). First, efficacious programming choices

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are made; second, fittest organisms result. In other words, life outsmarts Turing's halting problem. Life somehow knows what programming choices to make prior to computational success. Our finest human programmers cannot match this feat.

Prescriptive Information

Prescriptive Information (PI) as originally defined is ontological, not epistemological [77, 78]. It is not dependent upon or entangled in any way with human finite subjective knowledge. It is objective. It is independent of our understanding, or lack thereof. It predates human knowledge. Before *Homo sapiens* came along with their investigative interests, PI was doing its thing at the subcellular and cellular level in prokaryotes and eukaryotes. Prescriptive Information (PI) either instructs what choices to make, or it is a recordation of efficacious (halting) programming choices already made. Four-dimensional genomics, epigenomics and their cybernetic processing were causing the effect that we call "life" from its inception. PI not only instructs and makes life possible, it produces life. It computes life. It maintains and controls life. PI even produces the nanocomputers and highly sophisticated molecular machines needed to process itself. The subcellular and cellular EECCCC of life's PI produces life whether any higher consciousness "knows" it or not. We might want to know, after the fact:

1) What exactly is this purely objective, ontological Prescriptive Information (PI)?
2) What caused it? *How* did it arise?
3) Where can it be found within nature?

Ontological Prescriptive Information is generated only by Efficacious Executable Choice Command Causation and Control (EECCCC). This is the bottom line of four-dimensional genomics and life. PI alone is what produces life's orchestration, computational haltings and integrated circuits. Whether or not it conforms to our metaphysical presuppositions, it must be the object of molecular biological and bioinformatic exploration. It's origin in nature is a legitimate "How?" question. Science cannot sweep it under the rug. Only one thing can cause EECCCC and the semantic and syntactical PI that results: Choice Determinism at bona fide decision nodes, as opposed to Physicodynamic Determinism (The Universal Determinism Dichotomy [UDD] [56]. It is incumbent upon anyone disagreeing with this statement to explain how the following empirical formal realities were caused by Psychodynamic Determinism:

1) DNA programming with semantic and syntactical directives
2) The representationalism of nucleosides as physical symbol vehicles
3) The Material Symbol System (MSS) that utilizes those tokens
4) The triplet codon table rules
5) The Transitional Pausing coding rules
6) Transcription
7) Translation into a completely different language
8) Aminoacylation using independent tRNAs
9) The ability of linear digital prescription to foreknow Gibbs-free-minimal-energy folding of three-dimensional tertiary molecular structure
10) The spin and homochirality that ordinary chemistry cannot perceive
11) The engineered construction and sophisticated function of ribosome computers
12) The ingenious molecular machines that enable metabolism.
13) The highly tailored and specific protein catalysts needed for every task
14) The highly selective active transport of cell membranes
15) The independent production of chaperone proteins waiting to help folding at the exit channel of ribosomes
16) Extensive nonrandom, yet non-militated-by-law alternate splicing
17) The ingenious rules of lncRNA functionality
18) The sophisticated function of all the other RNAs
19) The choice of epigenetic methylation sites on DNA
20) The orchestration of 13-step processes such as the Krebs cycle that each has little or no worth until the final step
21) The choice of acetylation sites on histone proteins that determine DNA coiling
22) The placement and selection of promotors for appropriate metabolic tasks.
23) The selection of use of very disparate and distant enhancers.
24) Prescriptive polymorphisms that produce rapid adaptation
25) The functional choice of the number of tandem repeats to use
26) The feedback of transcription factor protein influence onto the DNA that produced those proteins.
27) The existence and role of micro- and mini-Satellites
28) The extraordinary polysaccharide phase space selections that are so essential to life
29) The highly specific phospholipid contributions

30) The absence of conserved genetic evolutionary histories for so many highly functional ORFans and OGs

31) The specific functionalities of intrinsically disordered proteins (IDPs) even though they lack physicodynamic order and structure.

Not a single item on this very incomplete list of examples can be explained with mere Psychodynamic Determinism. Only one factor causes our hesitancy to admit the obvious Choice component of life's PI: our purely metaphysical presuppositional commitments to a faulty axiom. We need to go back to the drawing board and reconsider our most fundamental life-long blind belief in the all-sufficiency of physicodynamics. We must do this, or we must excommunicate Biology from natural science. Executable choice commands are issued at each successive decision node. Decision nodes are not mere bifurcation points (forks in the road). Forks in the road can be measured by Shannon Uncertainty equations as possibilities. Both bifurcation points and decision nodes offer contingency—some degree of freedom from Physicodynamic Determinism. But there are two different kinds of contingency: Chance and Choice Contingency. Decision nodes provide opportunities to actively select something from among real physical options. To be efficacious, the selection cannot be random. No empirical evidence exists of any non-trivial halting program ever having been written randomly. The selection is not forced by the laws or forces of nature, either. The selection must be nonrandom, but it cannot be militated by law. Choices at some decision nodes can be partially constrained. But in the case of polynucleotide polymerization, the active selection of one nucleoside over the other three is "dynamically inert." Partial physicodynamic constraints do not exist that might cause prejudicial influences on which nucleoside is selected next to polymerize. If adenine, for example, were preferred by physico-chemistry, we would wind up with polyadenosine as our DNA. Little or no contingency would exist. No possibility of genetic programming could exist. DNA would be highly "self-ordered." It would not only have no bits of uncertainty, it would have no potential for recordation of PI choices at decision nodes.

The old argument that spontaneous mutations wrote the first programming has been thoroughly debunked [31-38, 58, 79]. These pre-programmed Efficacious Executable Choice Command Controls (EECCCs) are the essence of life's Prescriptive Information (PI) [31-35, 37, 77, 78, 80]. PI is not just any watered-down concept of pseudo "information." It cannot be measured with Shannon's Uncertainty/Possibility measures. It is not just after-the-fact Reduced Uncertainty (R), either. R cannot be calculated until after one has the certainty of halting computation to subtract from Shannon's Uncertainty measure. This halting certainty is the only thing that will reduce Shannon Uncertainty. But how is the certainty of successful computation arrived at? Only through confirmed efficacious processing of the executable command syntax; only through the performance of equipment that obeys voluntarily agreed-upon arbitrary rule conventions. These are all abstract, conceptual, non-material formalisms. These formalisms are Choice-Contingent. They cannot be produced by fixed laws, force constants, quantum entanglements, irreversible nonequilibrium thermodynamics, or probability bounds. In short, they cannot be reduced to physicodynamics. Such formalisms arise only from the far side of The Cybernetic Cut. They enter the near physicodynamic side of The Cybernetic Cut across the narrow one-way Configurable Switch (CS) Bridge [7-9, 81, 82].

What makes life possible is active unconstrained selection, prior to any final programmatic function (halting), of which nucleoside will contribute to establishing a semantic syntax of DNA. The choices of which nucleoside to pick at each polymerization decision node comprise *programming commands*. The nucleosides serve as physical symbol vehicles in a Material Symbol System. This system requires "voluntarily obedience" to arbitrary rule conventions by all players. It is not militated by physicodynamic laws or constraints. Each nucleoside was purposefully chosen to represent the execution of a command. The proof of this choice command being "executable" is found in the computational halting when those syntactical commands are cybernetically processed. These commands are not only instructive, they are effectual. They are efficacious in actually producing a desired result—coming to life, and staying alive. Inanimacy doesn't come to life and stay alive spontaneously. Pasteur's and Virchow's First Law of Biology has never been falsified. The spontaneous generation of life has never been observed. It hasn't even been observed with extensive human programming assistance. The point is that EECCCC actually *produces* not only ontological utility, but the ultimate in orchestrated function. EECCCC actually successfully computes life. PI was producing life long before "epistemology" was ever conceived. It is the duty of science to explore and progressively discover more aspects of ontological reality. The most prominent and significant aspect of nature is life. Whatever its definition, life is natural. Whatever its cause, life is the most legitimate subject of scientific investigation. We cannot exclude biology from natural science the way we did with the science of Engineering.

So what is the answer to the third question above? Where do we find the source of PI within nature? The answer is in only one place: within the cells of life, or as a product of life. EECCCC and PI are absolutely unique to life. They are the distinguishing feature and essence of life compared to non-life. But more epistemological aspects of information theory are also interesting. A 2025 paper on The Law of Information Conservation [38] demonstrates that conservation-of-information theorems are special

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cases of a simple probabilistic relation based on elementary probability theory. This provides the underlying rationale that makes all the previous conservation-of-information theorems work. Dembski provides a straightforward proof and general formulation of what may rightly be called the Law of Conservation of Information [38].

"Information cannot emerge spontaneously in sufficient quantity to resolve needle-in-a-haystack problems. These are problems whose successful resolution via search is vastly improbable. Instead, information that facilitates search must be derived from prior inputted information, which must be at least as substantial as outputted information. This fundamental relationship between information inputted and information outputted implies a conundrum for any attempt to explain the ultimate origins of information. Tracing information back to prior sources reveals an ever-intensifying challenge, as each higher-level round of search to explain information demands an account of still greater prior informational input. Without some final resting place of explanation, we confront a regress that cannot resolve itself. Search processes only redistribute existing information." [38].

Life is absolutely unique

Life, including at the subcellular level, is the only entity in the cosmos known to generate non-human-origin *programming, cybernetic processing, computational halting and engineering [31-37, 58, 83]*. All of these human enterprises were preceded and ultimately made possible by the same capabilities so apparent at the subcellular level of life itself. The programming that produces computational halting consists of a syntax of Efficacious Executable Choice Command Causation and Controls (EECCCC). But as impressive as these commands are, they are worthless without processing. At the subcellular level, they are processed by nanocomputers and incredibly engineered molecular machines. Processing is made possible by "voluntary" conformance to arbitrary rules of convention. These computations have nothing to do with laws, forces, constraints, kinetics, quantum entanglements, or irreversible nonequilibrium thermodynamics. Each command at each locus in the programming string is abstract, choice-contingent, purposeful, nonphysical, and formal rather than physicodynamic. Programming choices are directed with intent to achieve utility. They are purposefully motivated and controlled to meet some need. The commands are not only executable, but their computations halt when properly processed. To realize successful computations, the processing equipment must be able to reliably obey the commands. With programming, one wrong decision-node active selection can crash the entire computation. [31, 34, 35]. In a program, of course, the "voluntary" choices are just pre-recorded. At that point, each has a probability of 1.0. But this final causation certainty was deliberately chosen out of Shannon's measure of Uncertainty. The PI that results cannot be measured with fixed units of measure because each choice has a variable effect on the final computational product. An example of why PI cannot be measured with fixed units of measurable value is the vast array of relatively neutral mutations. Some choices are less important than others in the syntax of executable choice commands.

Evidence of clear Choice Causation in intracellular and cellular life.

Kalevi Kull [84] argues that "The theory of organic evolution is incomplete until it can explain life's meaning-making capacity and its role in the evolutionary processes, i.e. until semiosis is included." The representation of meaning is formal, not physical. Biosemiosis is impossible without the choice of signs and symbols to represent meaning. Efficacious executable commands have meaning as proven by the biofunction they ontologically produce. The nucleoside next chosen for polymerization serves as a physical symbol vehicle in a Material Symbol System (MSS). These symbols are used to represent and record executable commands. The syntax of those symbol choices is the essence of programming.

Robert Endres [6] in 2025 used estimates grounded in modern computational models to evaluate the difficulty of assembling structured biological information under plausible prebiotic conditions. His results highlight the formidable entropic and informational barriers to forming a viable protocell within the available window of Earth's early history. Endres argues that uncovering physical principles for life's spontaneous emergence remains a grand challenge for biological physics. He estimates that a minimal protocell would need 10^9 bits to emerge in Earth's available timespan of 500 Myrs. But only if a tiny fraction of prebiotic interactions ($\eta \sim 10{-}8$) would have been persistently retained over vast stretches of time. His list of requirements include some degree of physical or chemical bias (e.g., compartments, cycles, autocatalytic networks); sufficient persistence in time if information accumulates via a biased random walk through chemical space; and protection and reuse of functional molecules. He concludes that some form of prebiotic informational structure had to have preceded Darwinian evolution. He asks, "Where did the directionality come from? What structures or environmental constraints enabled long-term memory or error suppression without evolved proofreading?"

Wang [5] in 2025 showed that life cannot be reduced to chemistry. Life requires a prescriptive information role. Wang showed that objects are linked to representational symbols in coding and decoding functions. He defines biological information in terms of the decoding process. Molecular machines such as membrane receptors and ribosomes connect signs to physical objects. He argues that the unidirectional flow of prescriptive information through molecular machines and nanocomputers violates the microscopic time-reversal symmetry of physical laws. The principle of microscopic reversibility in chemistry forces acknowledgement of a prescriptive informational contribution to life's processes.

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Extracellular signals unidirectionally flow to intracellular second-tier messengers. The role of nucleotide triplets in translation depends on their position in mRNA. No basis exists for amino acids to flow to specific triplet codons. No reversibility exists. Wang contends that biological information is non-physicochemical and differs ontologically from physical chemistry. An arrow of time is manifest in life that is not apparent in inanimate nature [5]. Wang contends that the unidirectionality or irreversibility of biological information violates the (microscopic) time-reversal symmetry in physical laws and the principle of microscopic reversibility in chemistry.

Sequence *vectors* prevail in life. Any attempt to change or reverse the prescribed directionality usually results in no product at all, not just a contaminated unusable product like tar. Time reversal precludes life's synthetic chemistry. It thwarts progress toward the goal of production of each needed final product. This in turn kills holistic biofunction from cooperative biochemical pathways.

What exactly introduces the time vector into life's essential processes? Even before discussing life, any synthetic chemist knows the importance of *how critically reactions must be isolated and sequenced.* Many other factors are also critical, like the purity and precise quantities of reagents, light, pressure, etc. But of particular interest here is the critical sequencing of reactions. Each reagent must be produced and presented to the reaction arena in a certain order. Each independent catalyst must also be presented in the right order at the right time and place. Once each reaction takes place, only then can the new product contribute to the next essential step in manufacturing the final needed product. Some reaction sequences are 13 steps long, with no usable product until the thirteenth step (e.g., the Krebs cycle). This process must be purposely directed and formally governed. Any attempt to skip steps, or to rearrange their order, results in failure to produce the needed final product. The process is of a one-way nature with irreversibility. The reaction order cannot be shifted around. When the wrong reagent is accidentally produced, the system cannot back up and take a mulligan (do it the right way). The reason is the irreversibility of the instruction and processing flow. The executable commands are themselves sequenced in a linear digital Prescriptive Information (PI) flow. These sequential commands are steering controls, not mere constraints. They not only steer events in a certain direction. They do it on time in the right places and under the right conditions. These requirements relate especially to any protometabolism model. Progress towards protolife requires undeniable directionality. Reversible physicochemical microscopic reactions thwart any progress towards achieving a homeostatic metabolism far from equilibrium.

The reality of four-dimensional genomics only compounds the already existing problem of explaining linear digital prescription naturalistically. Evidence of life's Efficacious Executable Choice Command Causation and Controls (EECCCC) continues to mount in many other areas of biological controls.

Alternate splicing is purposefully directed.

Alternate splicing generates tremendous expansion of the functional number of genes and their capabilities. Alternate splicing purposefully selects which exon combination variant of a gene will be expressed [85, 86]. This greatly expands the prescriptive potential and function of almost every gene. 20,000 genes can generate over 90,000 proteins as a direct result of 95% of human multi-exonic genes undergoing alternate splicing. Alternate splicing is quite deliberate and purposeful. Alternative splicings are chosen and executed according to need. There is nothing "naturalistic" about alternate splicing. Life's controls falsify naturalism and physicalism at every turn. More than 11,000 isoforms exist of human multi-exon genes [87]. Song et al in their 2025 paper employed multiple metrics to identify splicing-induced structural alterations, including template matching score, secondary structure composition, surface charge distribution, radius of gyration, accessibility of post-translational modification sites, and structure-based function prediction. They found that alternate splicing induced clear changes in nearly all of these properties. Altered sequencing correlated largely with isoform structure. Note that "altered sequencing" defines "mutation." Yet the alternate splicings are anything but "spontaneous mutations" They are neither random nor physico-dynamically induced nonrandom mutations. They are prescribed polymorphisms [32]. Prescribed polymorphisms are purposefully chosen syntaxes of executable commands.

Despite high *sequence* similarity, Song et al often found low *structural* similarity in the different isoforms of the same alternatively spliced gene. This highlights the mystery of how linear digital sequencing could have so successfully commanded ahead of time ideal Gibbs-free-energy effectual folding. Surface charge and radius of gyration especially were altered. Splicing also buried or exposed numerous post-translational modification sites. Alternatively-spliced isoforms manifested marked changes in functionalities. These expanded functions were not happenstantial. They were critical to human embryo cell differentiation, and a clear manifestation of genomic Efficacious Executable Choice Command Causation and Control (EECCCC) in determining system biofunction. Cooperation of cis-acting RNA and trans-acting protein determine how exons and introns are pieced together in alternate RNA splicing. A cis-acting genetic element acts only within the homologues of the chromatid in which it is located. A trans-acting protein can act on any copy, not just the copy that it came from. Linked genes are located on the same chromosome. Large RNA-protein complexes forming spliceosome machinery such as snRNPs: U1, U2, U4, U5 and U6 catalyze intron removal and exon joining. Sequence signals in pre-mRNA

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guide these controls of alternate splicing. These controls are not constraints [50]. They steer and direct function. They are formal, not physicodynamic, although their control function can be instantiated into physicality via the Configurable Switch Bridge of The Cybernetic Cut. Controls will never be explained by psychodynamics. Mass/energy interactions are blind to formal function and controls. Controls can only arise from purposeful choice causation. RNA sequence signals, SR proteins, ribonucleoproteins such as hnRNPs, spliceosomes, and many other factors such as tertiary chromatin structural states control alternative splicing which in turn steers and controls various tissue differentiations and development. When alternate splicing is misdirected by typographical-like syntax errors, genetic diseases and cancer often result.

Prescribed Highly functional lncRNAs are major control factors

lncRNAs are not mRNAs that instruct protein manufacture. Instead, lncRNAs bind to DNA to regulate gene transcription into mRNA, other lncRNA transcripts, and even post-transcriptional factors such as altering the stability vs degradation of transcripts [88]. lncRNAs control chromatin transcription. Network regulating mechanisms are largely mediated by lncRNA's dialing up or down gene activity. A single lncRNA can actually regulate a gene at both the transcriptional and post-transcriptional levels. "These lncRNAs may act as molecular chaperones that control the stability and translation of mRNAs they helped transcribe, leading to tightly coupled expression profiles." [88]

Tens of thousands of these lncRNAs exist in humans [88, 89]. We have only just begun to scratch the surface of understanding the *conceptual* complexity, not just complexity, of lncRNA controls. Conceptual complexity is formal, not just physicodynamic.

Regulation by epigenetic configurable switch-*settings*

Epigenetic configurable switches are *purposefully set* to regulate gene function [90-100]. Specific sites on DNA are chosen for methylation [101-109]. These particular methylation sites are no accidents. Specific sites on histone proteins are chosen for acetylation. The purpose of these active selections is usually to produce the desired DNA coiling [110-117]. These specific acetylation's are not passive, after-the-fact natural selections. They are completed prior to any functional benefit. Histone alterations through acetylation modify chromatin structure. This affects transcription speed and affects the site of splices. RNA polymerase II elongation rate is also involved in exon selection in co-transcriptional splicing. Fukai et al [118] demonstrated that increasing histone H4 acetylation density enhances structural fluctuations and relaxation times. In vitro Hi-C revealed power-law decay of the nucleosome contacts consistent with Gaussian chains. This was globally reduced by acetylation. They also showed that heterogeneous modification patterns alone are sufficient to create distinct structural domains reminiscent of higher-order chromatin organization. Organization, unlike the self-ordering phenomena of Prigogine's studies, is altogether formal, not physicodynamic. Their findings establish how histone modifications modulate chromatin architecture via changes in local stiffness and nucleosome interactions. Their findings actually provide some quantitative framework for genome organization and orchestrated function. Watt et al [119] developed a genetic approach to manipulate whole-genome histone acetylation in memory-bearing neuronal ensembles. By showing that an increase in histone acetylation promotes fear memory recall, they revealed the existence of a functional relationship between histone acetylation and memory expression within memory-bearing engram cells. Downregulation has the opposite effect. All of these studied Efficacious Executable Choice Command Controls (EECCCs) reveal precise governance, not just fixed physicodynamic necessity.

The controls accomplished by promotors and enhancers.

Both promotors and enhancers are DNA sequences. A promotor is a DNA sequence which binds proteins that initiate transcription of a single RNA transcript. Promoters are located near the gene start site in the 5' end of the sense strand. The DNA transcribed is downstream from the promoter. This RNA transcript can encode a protein as a mRNA, or it can function directly as a tRNA or ribosomal RNA (rRNA). Promoters are usually 100 to 1000 base pairs long. Sequencing depends on the gene, and the class of RNA polymerase used at the specific site, and the product of its transcription.

An enhancer is a DNA sequence that increases gene transcription when bound by activators. Enhancers, silencers, and proteins all interact with pre-mRNAs to function as formal controls. Every subcellular activity provides empirical evidence of sophisticated purpose. Both exonic and intronic splicing enhancers and silencers exist. These are Cis-acting controllers. Exonic splicing enhancers and silencers are short sequences found within exons that can recruit proteins that in turn promote or repress splicing. Similar enhancers and silencers are located within introns. GU at the 5' end and AG at the 3' end serve as consensus splice sites. Branch point A and polypyrimidine tracts also contribute. Serine/Arginine-rich proteins are Trans-acting "SR proteins." They activate splicing by binding to enhancers. Repression is accomplished by heterogeneous nuclear ribonucleoproteins called "hnRNPs." They bind silencers. These players act in opposition to each other to tightly regulate and achieve the cooperation of contributor molecules. These processes are utterly formal, not just material. Distinct sets of splicing regulators are expressed in different tissues. Thus, the same gene can produce different isoforms in muscle cells compared to neurons. Splicing is also modulated by the stage of development and external signals. All of these unique

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controls allow incredible proteome diversity. Isoforms can have varying binding partners, enzymatic activity and locations. When controls become pathogenic, they frequently cause cancer and neurological disease, especially.

Purposeful Tandem Repeat controls

The number of tandem repeats (TR) was once thought to be neutral junk. The number of tandem repeats has been proven instead to be EECCCs and programmed polymorphisms important in achieving needed growth, development and adaptation. Micro-satellite TR units consist of one to nine nucleotides. Mini-satellites are longer units. Even homologous chromosomes from each parent can contain a different number of TRs. Adaptation often results in a different number of unit repeats within that variety or species, even within the same local population. A significant percentage of eukaryotic gene promoters show variation in TRs, as do other parts of genes, including untranslated regions (UTRs). These variations in TRs function as formal configurable switch-*settings* [120]. They *regulate* gene activity. They *control* whether genes are turned on or off. Although introns are spliced out of the transcript, they contain many EECCCs in the form of TR numbers. UTRs give signals to the ribosome when to begin and stop protein production. UTRs can be found in many different parts of genes. They have been shown to switch on and off production of crucial cell membrane proteins in bacteria [121] as a form of adaptation and phase variation. Thus, tandem repeat variation is not happenstantial, but highly functional [122-126].

22% of coding regions in yeast contain functional TRs'. These optimize air-liquid interfaces controlled by proteins on the cells' surfaces [121]. The number of TR repeats also affects transcription factor proteins and epigenetic controls.

In multicellular eukaryotes such as fruit flies, changing the number of TRs controls circadian rhythm clocks of temperature and light. In pelagic seabirds, polymorphisms of TR variation controls breeding time and latitude adjustments in migration [127]. Plant hormone function and stress responses are controlled by variation in TRs [128].

Wang et al [129] found that 264 TR variations controlled phenotypic traits relating to climate, altitude and soil conditions in Caragana plants. An additional 2424 functional TR repeat variations were linked to other environmental challenges. All of this research reveals that TR variation falls into the category of prescribed polymorphisms rather than spontaneous mutations or physicodynamically caused nonrandom mutations [32, 120]. They are true choice controls. They cannot be explained by Chance and Necessity. They are purposefully prescribed by programmed Efficacious Executable Choice Control Commands (EECCCs) that can arise only from Choice Causation in response to formal biofunctional intent and needs. Not only are protein-coding genes affected, but the manufacturing of critical lncRNAs, especially, allow formal control of other lncRNAs that regulate still other genes.

Multiple other kinds of RNA provide formal controls.

Davenport and Swanson [130] point out the incredible number of cellular regulatory functions that are performed by RNAs. These include functioning as adaptors, catalysts, guides, messengers, scaffolds, and structural components. RNAs often perform these functions by recruiting RNA-binding proteins (RBPs) to form ribonucleoprotein complexes (RNPs). These RNA-RBP interaction networks allow precise RNP assembly. They also allow subsequent structural dynamics required for normal functions. Normal polymorphic STR functions in RNA processing and localization provide important Efficacious Executable Choice Command Controls (EECCCs). But Davenport and Swanson remind us of the seriousness of when these normal control functions are corrupted. RNA motif mutations can trigger the formation of aberrant RNP structures that lead to cell dysfunction and disease. Davenport and Swanson study one type of RNA motif mutation: RNA gain-of-function mutations associated with the abnormal expansion of short tandem repeats (STRs) [130]. These malfunctions can cause multiple developmental and degenerative diseases such as the neuromuscular disease myotonic dystrophy. STR expansion disorders can be caused by both coding and noncoding genes.

Transcription factors function as choice-induced controllers

Transcription factors are trans-acting elements that promote or inhibit gene expression. Transcription factors can act in concert with others to regulate a single gene or group of related genes expression. More than one transcription factor can bind a gene's cis-regulatory elements at different times, or even at the same time. Both cis- and trans-acting elements play a major role in the regulation of gene expression. Both the environment and intra-cellular factors can signal and play a role in that gene's control.

Adaptation requires clear algorithmic optimization and epigenomic choices

Genetic algorithms are regularly rapidly optimized to achieve adaptation. Polymorphisms are prescribed by programming modules called-up into upper memory in response to abrupt environmental challenges. This process is controlled, not constrained. It has nothing to do with the four known forces, the laws of motion, kinetics, thermodynamics, quantum entanglements, probability bounds, etc. [10, 31, 32, 34-37, 58]. With each algorithmic optimization, "efficacious" continues to mean, "The command works—it accomplishes the intended function." Optimization simply means it does it better. Executable means the command is still doable within its intended cybernetic context. It is helpful to return to the Turing machine to understand all these basic concepts. The

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executable command tells the machine exactly what to do, and the machine is designed and engineered to be able to execute the command with no hitches. This is all pure choice-contingent formalism, not physicodynamic necessity.

How does EECCCC arise in nature?

In an inanimate environment, where would these efficacious executable commands come from? How would such commands possibly arise in a prebiotic environment? They could not arise from law. Law would issue the same fixed command (by law) every time. It wouldn't be a command. It would be "necessity." It would just happen, the same way every time. Extremely high redundant order would be produced, not formal organization or orchestration. But sophisticated function never "just happens" in a purely physical world. If laws alone ruled, there would be no contingency for efficacious programming choices. No formal computational halting would ever occur. Programming requires freedom of choice. Pre-programming can only arise from choices at bona fide decision nodes involving active selections from among real options. These cannot be mere bifurcation points (forks in the road of possibility and opportunity measured by Shannon's equations). Decision nodes require action in the form of active selection of one of the options. This is called Choice Causation, as opposed to mere Physicodynamic Causation. The Universal Determinism Dichotomy (UDD) [56] states that all effects arise from one of two categories of causation: either Physicodynamic Determinism, or Choice Determinism. "Chance and necessity" (mass/energy interactions) comprise the Physicodynamic Determinism category of causation. Chance, however, is generally not regarded as a true cause of any effect. It is merely a probabilistic description of what might happen as a result of complex, poorly understood, interactive Necessity (physical law-like determinism).

There is no getting around the Universal Determinism Dichotomy [56] in nature. Life is just too ubiquitous. We cannot consider life as unnatural, and exclude it from natural science investigation. Life is as natural as dust, rocks, gas, electromagnetic waves and water. The classic cause-and-effect chains that involve initial conditions, the effects of force fields, the laws of motion, kinetics, thermodynamics, quantum reality, etc. are all aspects of Physicodynamic Determinism (PD). Although the physical world seems ruled by physical cause-and-effect determinism, a seemingly independent phenomenon, contingency, is also frequently observed. Contingency [131-137] means that events can occur in multiple ways despite the monotonous/redundant constraints of physical law, initial condition constraints, and set probability bounds. But, there are two kinds of Contingency: 1) Chance Contingency and 2) Choice Contingency [138]. Of special interest is the reality of physical effects caused by formal Choice Causation originating from the far side of The Cybernetic Cut across the one-way narrow Configurable Switch Bridge to the near physicodynamic side of reality. If any substantial utility is expected to result from these commands, they must be efficacious: they must produce an effective hoped-for result. The product of the commands, if ever executed, must be successful and useful. Function must result.

Processing devices must appear simultaneously with programming

The programming of life is worthless without processing by highly engineered devices. Arbitrary rules of convention shared by source and destination across Shannon channels are "willfully obeyed" according to pre-agreed-upon rules of convention. This obedience is independent of any law. It must be programmed and engineered into the equipment according to the rule conventions. The executed sequence of Efficacious Executable Choice Command Controls (EECCCs) produces halting formal computations leading to useful, highly integrated circuits and very sophisticated holistic biofunction. But this is accomplished only by life's subcellular nano-equipment. The processing of these biosystems is thoroughly automated. No nanocomputers and highly sophisticated molecular machines—No processing, and no homeostatic metabolism far from equilibrium. The orchestration is so sophisticated that the genome seems to program its own operating system, hardware and wetware, not just its many specific aps and recorded data [80, 139, 140]. Manufactured molecular products actually participate in controlling the expression of genes that prescribed those products (e.g., transcription factors and lncRNAs).

Life's maintenance and continuing controls depend upon Choice Determinism

Actionable modules producing prescribed polymorphisms are called up into upper memory from caches in response to environmental challenges. The data stored in caches can be the result of earlier computations or data stored elsewhere in the DNA. Life is not fashioned or orchestrated by the four known forces of nature or by laws and constraints. Life is fashioned by engineering choices and cybernetic formalisms. Error corrections [141-143] are formally prescribed by supplemental Prescriptive Information (PI) [77, 78, 80, 138, 144]. Chance and Necessity are not capable of optimizing functionality of nucleotide sequence mutations. Physicodynamics has no ability to recognize or correct bad cybernetic commands. Chance and Necessity could care less whether anything "works" in a formal sense. This concept of something "working as intended" is quite different from the physics definition of "work." Life is all about formally orchestrating exquisite circuit integration and programmed, coded biosemiotic instructions and controls. We are hard put to find anything at the sub cellular level that is not deliberately caused with intent. Spontaneous mutations may increase genetic phase space possibilities, but

nearly all of these spontaneous genetic variations degrade current wild type Prescriptive Information (PI). What few spontaneous mutations that are purported to improve programming are almost always contrived benefits. They are usually accompanied by corruptions of some other current programming function that is far worse than the supposed benefit. Even supposedly neutral spontaneous mutations are often later proved to be subtlely deleterious.

Discussion

Alexi Sharov and Morten Tønnessen in their recent book [145] *Semiotic Agency: Science Beyond Mechanism* define "agents" supposedly naturalistically as "autonomous systems that incorporate knowledge on how to make sense of their environment and use it to achieve their goals." Do inanimate *things* incorporate knowledge and make sense of their environment to achieve their goals? If they are alive, these things might. But if not already alive, physicodynamics provides us with no explanation for how they evolved into the real agents these authors describe. Sharov and Morton go on to point out that, "The explanatory power of mechanistic analysis is not sufficient for complex agents. Non-mechanistic methods rely on the goal-directedness of agents whose dynamics follow self-stabilized dynamic attractors." But teleonomic self-stabilized dynamic attractors are purely physicodynamic. They have no pragmatic sense. Such attractors have no link to formal concepts of "usefulness" or "function." They cannot possibly value or pursue any formal goal. Yet goal is being attributed to an inanimate source. Teleonomically redefined "agents" are stripped bare of real agency, and of any goal-directedness.

Life cannot possibly self-organize and emerge from Chance and Necessity [146]. Such a notion is a logical impossibility. Something would have to already exist for it to organize anything. It could not possibly organize itself into existence. Blind belief in mystical "self-organization" and "emergence" is scientifically unacceptable. They are both pipe dreams articulated out of desperation stemming from the sterility of metaphysical physicalism. Zero empirical evidence exists of spontaneous generation of even nontrivial functionality, let alone life. Virchow and Pasteur's First Law of Biology has never been falsified. Constraints cannot dial up or down in a productive analogue sense, nor can constraints digitally prescribe formal function. Without Choice Determinism at bona fide decision nodes, homeostatic metabolism would be impossible. Even spin and homochirality must be consistently formally selected. Chemistry cannot discern the difference. Directionality and microscopic irreversibility in time of biochemical pathways and cycles cannot be attributed to physicalistic forces. That would violate microscopic time-reversal symmetry in physical laws and the principle of microscopic reversibility in chemistry [5]. Spontaneously ordered dissipative structures, mere physicodynamic complexity, laws, kinetics, quantum entanglements, or irreversible nonequilibrium thermodynamics have never been observed to produce a single non-trivial function. Both metaphysical and methodological naturalism tend to incorporate physicalism into the most fundamental starting axiom of natural science:

"The causes of all phenomena can be found within the cosmos itself. Only natural laws and forces operate in the universe. The study of mass/energy interactions is sufficient to explain reality."

This dogma is a purely metaphysical presuppositional imperative that is crippling science. It excludes major aspects of reality. The natural science of Biology, especially the sciences of genomics, epigenomics, molecular biology, computational biology, and biological informatics, encounter irreconcilable roadblocks to progress as a direct result of purely philosophic naturalistic dogma. Philosophical naturalism is a bogus religion that has no place in science.

The undeniable role of Choice Determinism in life's subcellular processes has been previously established in hundreds of papers, some of which were mentioned in this paper. Science *must* pursue *how* genetic programming of executable commands arose in an inanimate environment. In addition, we must address the origin of formal *representation* of these commands using physical *symbol* vehicles in Material Symbol Systems (MSS). How did so many configurable switches all get set so cooperatively so as to integrate sophisticated circuits? We may well be limited by Gödel's incompleteness theorem [147] and Turing's undecidability [148]. We may not understand how Choice Determinism could have come into existence in a prebiotic world. But we don't understand how mathematics and the logic theory of scientific method arose out of a cosmic explosion, either. That doesn't stop us from practicing science. Legitimate science is much bigger than methodological naturalism allows. We have no excuse for denying the fact of The Universal Determinism Dichotomy (UDD) [56]. The natural science of Biology demands acknowledgement of Choice Determinism within ontological reality and the so-called natural world that includes so many different extremophiles and ubiquitous life.

Life is literally programmed and computed. Formal organization requires active selections [144]. Genomic algorithms are regularly optimized to achieve adaptation. Executable programming commands, configurable switch-settings, circuit integration, the design and engineering of nanocomputers and very sophisticated molecular machines, halting computations prescribed in advance of any selectable functional success, even theorized proto-cells orchestrated prior to the existence of natural selection—all of these required formal Choice Causation emanating from the far side of The Cybernetic Cut [7-9]. Their only entry point into physicality was across the one-way narrow Configurable Switch Bridge

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to the near physicodynamic side of The Cybernetic Cut [7-9]. Whatever our purely metaphysical presuppositions, every living cell makes hundreds of purposeful choices per day, including prokaryotes. The reason we have had such difficulty in defining life is that we refuse to accept the clear essential characteristic and criterion of life: EECCCC. Why do we refuse the obvious? Because our purely metaphysical presuppositional commitment forbids it. Our *philosophic* worldview—our blind-belief imperative that "physicality is sufficient to explain the whole of reality"—precludes acknowledgement of the obvious. The starting axiom we incorporated into our very definition of science continues to thwart scientific progress—the life sciences, especially. Refusal to acknowledge the Choice Determinism of life into the sciences of genomics, epigenomics and molecular biology renders purely physicalistic/naturalistic science incapable of studying and ever really understanding life. This is the very reason abiogenic naturalistic science has remained stymied for over a century.

Conclusions

This paper provides the basis for an irrefutable absolute dichotomy of life from non-life: "The Animacy/Inanimacy Dichotomy." How long are we going to continue to make fools of ourselves by arguing that nothing but laws, constraints, and irreversible nonequilibrium thermodynamics orchestrated life's programming choices and controls? Any child knows better. The conceptual, carefully orchestrated complexity of gene regulation is nothing less than mind-boggling. There is no way mere physicodynamics could ever explain this orchestration. Life is not constrained. Life is controlled. Life is *directed* by what can only be called "purposeful choices" at bona fide "decision nodes." These decision nodes cannot be reduced to mere bifurcation points measured only by Shannon theory. Specific active selections are made at each *decision* node that only later prove to be efficacious. The first genome, and innumerable algorithmic optimizations since, have been proven to overcome Turing's "halting problem." This is better than our finest human programmers can accomplish. Life's choice determinism is proven hundreds of times per day by operon and enhancer controls, alternate splicing, algorithmic optimization with methylation regulation of genetic configurable switch-settings, acetylation's of certain histone protein sites that control DNA coiling function, tandem repeat number choices that achieve adaptation to sudden extreme environmental challenges, and scores of other molecular biological controls. A formally stated definition of life still seems to remain somewhat elusive. But the dichotomy between life and non-life has become quite specific, reliable and concrete. Life is divided from non-life first by the Universal Determinism Dichotomy (UDD). Life clearly arises only out of Choice Determinism rather than mere Physicodynamic Determinism. Specifically, what dichotomizes life from non-life is Efficacious Executable Choice Command Causation and Control (EECCCC).

EECCCC is the means by which all known life is

1) Programmed,
2) Cybernetically Processed by nano-equipment
3) Computationally Halts.

The computation of life employs:

a) Physical symbol vehicles in material symbol systems,
b) Biosemiotic codes with arbitrary rule conventions
c) Engineered configurable switches able to record active selections.
d) Formally chosen configurable switch-settings.

Abstract, conceptual, non-physical, formal mathematics governs physicality and physical law. But the uniqueness of life even more firmly establishes the validity of The Formalism > Physicality (F > P) Principle:

"The F > P Principle states that "Formalism not only describes, but preceded, prescribed, organized, and continues to govern and predict Physicality." The F > P Principle is an axiom that defines the ontological primacy of formalism in a presumed objective reality that transcends both human epistemologies, our sensation of physicality, and physicality itself. The F > P Principle works hand in hand with the Law of Physicodynamic Incompleteness, which states that physicochemical interactions are inadequate to explain life and the mathematical and formal nature of physical law relationships. Physicodynamics cannot generate formal processes and procedures leading to nontrivial function. Chance, necessity and mere constraints cannot steer, program or optimize algorithmic/computational success to provide desired nontrivial utility. As a major corollary, physicodynamics cannot explain or generate life. Life is invariably programmed and cybernetically processed. The F > P Principle denies the notion of unity of Prescriptive Information (PI) with mass/energy. The F > P Principle distinguishes instantiation of formal choices into physicality from physicality itself. The arbitrary setting of configurable switches and the selection of symbols in any Material Symbol System (MSS) are physicodynamically indeterminate—decoupled from physicochemical determinism." [149]

Formalism from the far side of The Cybernetic Cut reigns supreme over physicality. Both the foundational role of mathematics in governing physicality and the EECCCC that controls and dichotomizes life from non-life affirm this fact of reality.

Nature includes life. Life is natural. Whatever our philosophic worldview, "Natural science" must redefine "natural" to include life and the essential determinant and criterion of life: EECCCC.

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