Chapter 11: The Universal Plausibility Metric (UPM) & Principle (UPP)[*]

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Abstract: Mere possibility is not an adequate basis for asserting scientific plausibility. A precisely defined universal bound is needed beyond which the assertion of *plausibility,* particularly in life-origin models, can be considered operationally falsified. But can something so seemingly relative and subjective as plausibility ever be quantified? Amazingly, the answer is, "Yes." A method of objectively measuring the plausibility of any chance hypothesis (The Universal Plausibility Metric [UPM]) is presented. A numerical inequality is also provided whereby any chance hypothesis can be definitively falsified when its UPM metric of ξ is < 1 (The Universal Plausibility Principle [UPP]). Both UPM and UPP pre-exist and are independent of any experimental design and data set. No low-probability hypothetical plausibility assertion should survive peer-review without subjection to the UPP inequality standard of formal falsification ($\xi < 1$).

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Introduction: The seemingly subjective liquidity of "plausibility"

Are there any *objective* standards that could be applied to evaluate the seemingly subjective notion of *plausibility*? Can something so psychologically relative as plausibility ever be quantified?

Our skepticism about defining a precise, objective Universal Plausibility Metric (UPM) stems from a healthy realization of our finiteness [1], subjectivity [2], presuppositional biases [3, 4], and epistemological problem [5]. We are rightly wary of absolutism.   The very nature of probability theory emphasizes gray-scales more than the black and white extremes of p = 0 or 1.0. Our problem is that extremely low probabilities can only asymptotically approach impossibility. An extremely unlikely event's probability always remains at least slightly > 0.   No matter how many orders of magnitude is the negative exponent of an event's probability, that event or scenario technically cannot be considered impossible. Not even a Universal Probability Bound [6-8] seems to establish absolute theoretical impossibility. The fanatical pursuit of absoluteness by finite subjective knowers is considered counterproductive in post modern science. Open-mindedness to all possibilities is encouraged [9].

But at some point our reluctance to exclude *any* possibility becomes stultifying to operational science [10]. Falsification is critical to narrowing down the list of serious possibilities [11]. Almost all hypotheses are possible. Only a few of them wind up being helpful and scientifically productive. Just because a hypothesis is possible should not grant that hypothesis scientific respectability. More attention to the concept of "infeasibility" has been suggested [12]. Millions of dollars in astrobiology grant money have been wasted on scenarios that are possible, but plausibly bankrupt. The question for scientific methodology should *not* be, "Is this scenario possible?" The question should be, "Is this possibility a *plausible* scientific hypothesis?" One chance in 10^{200} is theoretically possible, but given maximum cosmic probabilistic resources, such a possibility is hardly plausible. With funding resources rapidly drying up, science needs a foundational principle by which to falsify a myriad of theoretical possibilities that are not worthy of serious scientific consideration and modeling.

Proving a theory is considered technically unachievable [11].   Few bench scientists realize that falsification has also been shown by philosophers of science to be at best technically suspect [13].   Nevertheless, operational science has no choice but to proceed primarily by a process of elimination through practical falsification of competing models and theories.

Which model or theory best corresponds to the data? [14 (pg. 32-98)] [8]. Which model or theory best predicts future interactions? Answering these

questions is made easier by eliminating implausible possibilities from the list of theoretical possibilities. Great care must be taken at this point, especially given the many non-intuitive aspects of scientifically addressable reality. But operational science must proceed on the basis of best-thus-far tentative knowledge. The human epistemological problem is quite real. But we cannot allow it to paralyze scientific inquiry.

If it is true that we cannot *know* anything for certain, then we have all the more reason to proceed on the basis of the greatest "*plausibility* of belief" [15-19]. If human mental constructions cannot be equated with objective reality, we are all the more justified in pursuing the greatest likelihood of correspondence of our knowledge to the object of that knowledge—presumed ontological being itself. Can we prove that objectivity exists outside of our minds? No. Does that establish that objectivity does not exist outside of our minds? No again. Science makes its best progress based on the axioms that 1) an objective reality independent of our minds does exist, and 2) scientists' collective knowledge can progressively correspond to that objective reality. The human epistemological problem is kept in its proper place through a) double-blind studies, b) groups of independent investigators all repeating the same experiment, c) prediction fulfillments, and d) the application of pristine logic (taking linguistic fuzziness into account), and e) the competition of various human ideas for best correspondence to repeated independent observations.

The physical law equations and the deductive system of mathematical rules that govern the manipulations of those equations are all formally absolute. But the axioms from which formal logic theory flows, and the decision of when to consider mathematical equations universal "laws" are not absolute. Acceptance of mathematical axioms is hypothetico-deductively relative. Acceptance of physical laws is inductively relative. The *pursuit* of correspondence between presumed objective reality and our knowledge of objective reality is laudable in science. But not even the axioms of mathematics or the laws of physics can be viewed as absolute. Science of necessity proceeds tentatively on the basis of best-thus-far subjective knowledge. At some admittedly relative point, the scientific community agrees by consensus to declare certain formal equations to be reliable descriptors and predictors of future physicodynamic interactions. Eventually the correspondence level between our knowledge and our repeated observations of presumed objective reality is considered *adequate* to make a tentative *commitment* to the veracity of an axiom or universal law until they are proven otherwise.

The same standard should apply in falsifying ridiculously implausible life-origin assertions. Combinatorial imaginings and hypothetical scenarios can be endlessly argued simply on the grounds that they are theoretically pos-

sible. But there is a point beyond which arguing the plausibility of an absurdly low probability becomes *operationally* counterproductive. That point can actually be quantified for universal application to all fields of science, not just astrobiology. Quantification of a Universal *Plausibility* Metric (UPM) and application of the Universal *Plausibility* Principle (UPP) inequality test to that specific UPM provides for definitive, unequivocal falsification of scientifically unhelpful and functionally useless hypotheses. When the UPP is violated, declaring falsification of that highly implausible notion is just as justified as the firm commitment we make to any mathematical axiom or physical "law" of motion.

1. Universal Probability Bounds

"Statistical prohibitiveness" in probability theory and the physical sciences has remained a nebulous concept for far too long. The importance of probabilistic resources as a context for consideration of extremely low probabilities has been previously emphasized [20 (pg. 13-17)] [6-8, 21]. Statistical prohibitiveness cannot be established by an exceedingly low probability alone [6]. Rejection regions and probability bounds need to be established independent of (preferably prior to) experimentation in any experimental design. But the setting of these zones and bounds is all too relative and variable from one experimental design to the next. In the end, however, probability is not the critical issue. The plausibility of hypotheses is the real issue. Even more important is the question of whether we can ever operationally falsify a preposterous but theoretically possible hypothesis.

The Universal Probability Bound (UPB) [6, 7] quantifies the maximum cosmic probabilistic resources (Ω, upper case omega) as the context of evaluation of any extremely low probability event. Ω corresponds to the maximum number of possible probabilistic trials (quantum transitions or physicochemical interactions) that could have occurred in cosmic history. The value of Ω is calculated by taking the product of three factors:

1) The number of seconds that have elapsed since the Big Bang (10^{17}) assumes a cosmic age of around 14 billion years. 60 sec/min X 60 min/hr X 24 hrs/day X 365 days per year X 14 billion years = 4.4 x 10^{17} seconds since the Big Bang.

2) The number of possible quantum events/transitions per second is derived from the amount of time it takes for light to traverse the minimum unit of distance. The minimum unit of distance (a quantum of space) is Planck length (10^{-33} centimeters). The minimum amount of

time required for light to traverse the Plank length is Plank time (10^{-43} seconds) [6, 7, 8, pg 215-217]. Thus a maximum of 10^{43} quantum transitions can take place per second. Since 10^{17} seconds have elapsed since the Big Bang, the number of possible quantum transitions since the Big Bang would be 10^{43} x 10^{17} = 10^{60}.

3) Sir Arthur Eddington's estimate of the number of protons, neutrons and electrons in the observable cosmos (10^{80}) [22] has been widely respected throughout the scientific literature for decades.

Some estimates of the total number of elementary particles have been slightly higher. The Universe is 95 billion light years (30 gigaparsecs) across. We can convert this to cubic centimeters using the equation for the volume of a sphere (5 x 10^{86} cc). If we multiply this times 500 particles (100 neutrinos and 400 photons) per cc, we would get 2.5 x 10^{89} elementary particles in the visible universe.

A Universal [6, 7]Probability Bound could therefore be calculated by the product of these three factors: 10^{17} x 10^{43} x 10^{80} = 10^{140}

If the highest estimate of the number of elementary particles in the Universe is used (e.g., 10^{89}), the UPB would be 10^{149}.

The UPB's discussed above are *the highest calculated universal probability bounds ever published by many orders of magnitude* [7, 8]. They are the most permissive of (favorable to) extremely low-probability plausibility assertions in print [6] [8 (pg. 216-217)]. All other proposed metrics of probabilistic resources are far less permissive of low-probability chance-hypothesis plausibility assertions. Emile Borel's limit of cosmic probabilistic resources was only 10^{50} [23 (pg. 28-30)]. Borel based this probability bound in part on the product of the number of observable stars (10^{9}) times the number of possible human observations that could be made on those stars (10^{20}). Physicist Bret Van de Sande at the University of Pittsburgh calculates a UPB of 2.6 X 10^{92} [8, 24]. Cryptographers tend to use the figure of 10^{94} computational steps as the resource limit to any cryptosystem's decryption [25]. MIT's Seth Lloyd has calculated that the universe could not have performed more than 10^{120} bit operations in its history [26].

Here we must point out that a discussion of the number of cybernetic or cryptographic "operations" is totally inappropriate in determining a prebiotic UPB. Probabilistic combinatorics has nothing to do with "operations." Opera-

tions involve choice contingency [27-29]. Bits are "Yes/No" question *opportunities* [30 (pg. 66)], each of which could potentially reduce the total number of combinatorial possibilities (2^{NH} possible biopolymers: see Appendix 1) by half. But of course asking the right question and getting an answer is not a spontaneous physicochemical phenomenon describable by mere probabilistic uncertainty measures [31-33]. Any binary "operation" involves a bona fide decision node [34-36]. An operation is a *formal choice-based function.* Shannon uncertainty measures do not apply to specific choices [37-39]. Bits measure only the number of non-distinct, generic, *potential* binary choices, not actual specific choices [37]. Inanimate nature cannot ask questions, get answers, and exercise choice contingency at decision nodes in response to those answers. Inanimate nature cannot optimize algorithms, compute, pursue formal function, or program configurable switches to achieve integration and shortcuts to formal utility [28]. Cybernetic operations therefore have no bearing whatever in determining universal probability bounds for chance hypotheses.

Agreement on a sensible UPB in advance of (or at least totally independent of) any specific hypothesis, suggested scenario, or theory of mechanism is critical to experimental design. No known empirical or rational considerations exist to preclude acceptance of the above UPB. The only exceptions in print seem to come from investigators who argue that the above UPB is *too permissive* of the chance hypothesis [8, 12]. Faddish acceptance prevails of hypothetical scenarios of extremely low probability simply because they are in vogue and are theoretically possible. Not only a UPB is needed, but a fixed universal mathematical standard of *plausibility* is needed. This is especially true for complex hypothetical scenarios involving joint and/or conditional probabilities. Many imaginative hypothetical scenarios propose constellations of highly cooperative events that are theorized to self-organize into holistic formal schemes. Whether joint, conditional or independent, multiple probabilities must be factored into an overall *plausibility* metric. In addition, a universal plausibility bound is needed to eliminate overly imaginative fantasies from consideration for the best inference to causation.

2. The Universal Plausibility Metric (UPM)

To be able to definitively falsify ridiculously implausible hypotheses, we need first a Universal *Plausibility* Metric (UPM) to assign a numerical plausibility value to each proposed hypothetical scenario. Second, a Universal *Plausibility* Principle (UPP) inequality is needed as plausibility bound of this measurement for falsification evaluation. We need a cut-off point beyond which no extremely low probability scenario can be considered a "*scientical-*

ly respectable" possibility. What is needed more than a probability bound is a *plausibility* bound. Any "possibility" that exceeds the ability of its probabilistic resources to generate should immediately be considered a "*functional non-possibility*," and therefore an implausible scenario. While it may not be a theoretically absolute impossibility, if it exceeds its probabilistic resources, it is a gross understatement to declare that such a proposed scenario is simply not worth the expenditure of serious scientific consideration, pursuit, and resources. Every field of scientific investigation, not just biophysics and life-origin science, needs the application of the same independent test of credibility to judge the plausibility of its hypothetical events and scenarios. The application of this standard should be an integral component of the scientific method itself for all fields of scientific inquiry.

To arrive at the UPM, we begin with the maximum available probabilistic resources discussed above (Ω, upper case Omega) [6, 7]. But Ω could be considered from a quantum or a classical molecular/chemical perspective. Thus this paper proposes that the Ω quantification be broken down first according to the Level (L) or perspective of physicodynamic analysis ($^L\Omega$), where the perspective at the quantum level is represented by the superscript "q" ($^q\Omega$) and the perspective at the classical level is represented by "c" ($^c\Omega$). Each represents the maximum probabilistic resources available at each level of physical activity being evaluated, with the total number of quantum transitions being much larger than the total number of "ordinary" chemical reactions since the Big Bang.

Second, the maximum probabilistic resources $^L\Omega$ ($^q\Omega$ for the quantum level and $^c\Omega$ for classical molecular/chemical level) can be broken down even further according to the astronomical subset being addressed using the general subscript "A" for Astronomical: $^L\Omega_A$ (representing both $^q\Omega_A$ and $^c\Omega_A$). The maximum probabilistic resources can then be measured for each of the four different specific environments of each $^L\Omega$, where the general subscript A is specifically enumerated with "u" for universe, "g" for our galaxy, "s" for our solar system, and "e" for earth:

Universe	$^L\Omega_u$
Galaxy	$^L\Omega_g$
Solar System	$^L\Omega_s$
Earth	$^L\Omega_e$ ($^L\Omega_e$ excludes meteorite and panspermia inoculations)

To include meteorite and panspermia inoculations in the earth metrics, we use the Solar System metrics $^L\Omega_s$ ($^q\Omega_s$ and $^c\Omega_s$).

As examples, for quantification of the maximum probabilistic resources at the quantum level for the astronomical subset of our galactic phase space, we would use the $^q\Omega_g$ metric.   For quantification of the maximum probabilistic resources at the ordinary classical molecular/chemical reaction level in our solar system, we would use the $^c\Omega_s$ metric.

The most permissive UPM possible would employ the probabilistic resources symbolized by $^q\Omega_u$ where both the quantum level perspective and the entire universe are considered.

The sub division between the $^L\Omega_A$ for the quantum perspective (quantified by $^q\Omega_A$) and that for the classical molecular/chemical perspective (quantified by $^c\Omega_A$), however, is often not as clear and precise as we might wish. Crossovers frequently occur. This is particularly true where quantum events have direct bearing on "ordinary" chemical reactions in the "everyday" classical world. If we are going to err in evaluating the plausibility of any hypothetical scenario, let us err in favor of maximizing the probabilistic resources of $^L\Omega_A$. In cases where quantum factors seem to directly affect chemical reactions, we would want to use the four quantum level metrics of $^q\Omega_A$ ($^q\Omega_u$ $^q\Omega_g$, $^q\Omega_s$ and $^q\Omega_e$) to preserve the plausibility of the lowest-probability explanations.

3. Quantification of the Universal *Plausibility* Metric (UPM)

We keep italicizing plausibility because of prior experience with readers confusing the UPM with a probability measure. The UPM is *not* a probability measure. It is a plausibility measure. The computed Universal Plausibility Metric (UPM) objectively quantifies the level of plausibility of any chance hypothesis or theory. The UPM employs the symbol ξ (Xi, pronounced *zai* in American English, s*ai* in UK English, *ksi* in modern Greek) to represent the computed UPM according to the following equation:

$$\xi = \frac{f\,^L\Omega_A}{\omega}$$

Equation 1

where *f* represents the number of *functional* objects/events/scenarios that are known to occur out of all possible combinations (lower case omega, ω) (e.g., the number [*f*] of functional protein family members of varying sequence known to occur out of sequence space [ω]), and $^L\Omega_A$ (upper case Omega, Ω) represents the total probabilistic resources for any particular probabilistic context. The "L" superscript context of Ω describes which perspective of analysis, whether quantum (q) or a classical (c), and the "A" subscript context of Ω enumerates which subset of astronomical phase space is being evaluated: "u"

for universe, "g" for our galaxy, "s" for our solar system, and "e" for earth. Note that the basic generic UPM (ξ) equation's form remains constant despite changes in the variables of levels of perspective (L: whether q or c) and astronomic subsets (A: whether u, g, s, or e).

The calculations of probabilistic resources in $^L\Omega_A$ can be found in Appendix 2. Note that the upper and lower case omega symbols used in this equation are *case sensitive* and each represents a completely different phase space.

The UPM from both the quantum ($^q\Omega_A$) and classical molecular/chemical ($^c\Omega_A$) perspectives/levels can be quantified by Equation 1. This equation incorporates *the number of possible transitions or physical interactions that could have occurred since the Big Bang*. Maximum quantum-perspective probabilistic resources $^q\Omega_u$ were enumerated above in the discussion of a UPB [6, 7] [8 (pg. 215-217)]. Here we use basically the same approach with slight modifications to the factored probabilistic resources that comprise Ω.

Let us address the quantum level perspective (q) first for the entire universe (u) followed by three astronomical subsets: our galaxy (g), our solar system (s) and earth (e).

Since approximately 10^{17} seconds have elapsed since the Big Bang, we factor that total time into the following calculations of quantum perspective probabilistic resource measures. Note that the difference between the age of the earth and the age of the cosmos is only a factor of 3. A factor of 3 is rather negligible at the high order of magnitude of 10^{17} seconds since the Big Bang (versus age of the earth). Thus, 10^{17} seconds is used for all three astronomical subsets:

$^q\Omega_u$ = Universe = 10^{43} trans/sec X 10^{17} secs X 10^{80} protons, neutrons & electrons = 10^{140}

$^q\Omega_g$ = Galaxy = 10^{43} X 10^{17} X 10^{67} = 10^{127}

$^q\Omega_s$ = Solar System = 10^{43} X 10^{17} X 10^{57} = 10^{117}

$^q\Omega_e$ = Earth = 10^{43} X 10^{17} X 10^{42} = 10^{102}

These above limits of probabilistic resources exist within the only known universe that we can repeatedly observe—the only universe that is scientifically addressable. Wild metaphysical claims of an infinite number of cosmoses may be fine for cosmological imagination, religious belief, or superstition. But such conjecturing has no place in hard science. Such claims cannot be empirically investigated, and they certainly cannot be falsified. They violate Ockham's (Occam's) Razor [40]. No prediction fulfillments are realizable.

They are therefore nothing more than blind beliefs that are totally inappropriate in peer-reviewed scientific literature.   Such cosmological conjectures are far closer to metaphysical or philosophic enterprises than they are to bench science.

From a more classical perspective at the level of ordinary molecular/chemical reactions, we will again provide metrics first for the entire universe (u) followed by three astronomical subsets, our galaxy (g), our solar system (s) and earth (e).

The classical molecular/chemical perspective makes two primary changes from the quantum perspective. With the classical perspective, *the number of atoms* rather than the number of protons, neutrons and electrons is used. In addition, *the total number of classical chemical reactions that could have taken place since the Big Bang* is used rather than transitions related to cubic light-Planck's. The shortest time any transition requires before a chemical reaction can take place is 10 femtoseconds [41-46]. A femtosecond is 10^{-15} seconds. Complete chemical reactions, however, rarely take place faster than the picosecond range (10^{-12} secs). Most biochemical reactions, even with highly sophisticated enzymatic catalysis, take place no faster than the nano (10^{-9}) and usually the micro (10^{-6}) range. To be exceedingly generous (perhaps overly permissive of the capabilities of the chance hypothesis), we shall use 100 femtoseconds as the shortest chemical reaction time. 100 femtoseconds is 10^{-13} seconds. Thus 10^{13} simple and fastest chemical reactions could conceivably take place per second in the best of theoretical pipe-dream scenarios. The four $^c\Omega_A$ measures are as follows:

$$^c\Omega_u = \text{Universe} = 10^{13} \text{ reactions/sec X } 10^{17} \text{ secs X } 10^{78} \text{ atoms} = 10^{108}$$

$$^c\Omega_g = \text{Galaxy} = 10^{13} \text{ X } 10^{17} \text{ X } 10^{66} = 10^{96}$$

$$^c\Omega_s = \text{Solar System} = 10^{13} \text{ X } 10^{17} \text{ X } 10^{55} = 10^{85}$$

$$^c\Omega_e = \text{Earth} = 10^{13} \text{ X } 10^{17} \text{ X } 10^{40} = 10^{70}$$

Remember that $^L\Omega_e$ excludes meteorite and panspermia inoculations. To include meteorite and panspermia inoculations, we use the metric for our solar system $^c\Omega_s$.

These maximum metrics of the limit of probabilistic resources are based on the best-thus-far estimates of a large body of collective scientific investigations. We can expect slight variations up or down of our best guesses of the number of elementary particles in the universe, for example. But the basic

formula presented as the Universal Plausibility Metric (PM) will never change. The Universal *Plausibility* Principle (UPP) inequality presented below is also immutable and worthy of law-like status. It affords the ability to objectively once and for all falsify not just highly improbable, but ridiculously implausible scenarios. Slight adjustments to the factors that contribute to the value of each $^L\Omega_A$ are straightforward and easy for the scientific community to update through time.

Most chemical reactions take longer by many orders of magnitude than what these exceedingly liberal maximum probabilistic resources allow. Biochemical reactions can take years to occur in the absence of highly sophisticated protein enzymes not present in a prebiotic environment. Even humanly engineered ribozymes rarely catalyze reactions by an enhancement rate of more than 10^5[47-51]. Thus the use of the fastest rate known for any complete chemical reaction (100 femtoseconds) seems to be the most liberal/forgiving probability bound that could possibly be incorporated into the classical chemical probabilistic resource perspective $^c\Omega_A$. For this reason, we should be all the more ruthless in applying the UPP test of falsification presented below to seemingly "far-out" metaphysical hypotheses that have no place in responsible science.

4. Falsification using The Universal Plausibility Principle (UPP)

The Universal Plausibility Principle (UPP) states that *definitive operational falsification* of any chance hypothesis is provided by the inequality of:

$$\xi < 1 \hspace{4cm} \text{Inequality 1}$$

This definitive operational falsification holds for hypotheses, theories, models, or scenarios at any level of perspective (q or c) and for any astronomical subset (u, g, s, and e). The UPP inequality's falsification is valid whether the hypothesized event is singular or compound, independent or conditional. Great care must be taken, however, to eliminate errors in the calculation of complex probabilities. Every aspect of the hypothesized scenario must have its probabilistic components factored into the one probability (p) that is used in the UPM (See equation 2 below). Many such combinatorial possibilities are joint or conditional. It is not sufficient to factor only the probabilities of each reactant's formation, for example, while omitting the probabilistic aspects of each reactant being presented at the same place and time, becoming available in the required reaction order, or being able to react at all (activated vs. not activated). Other factors must be included in the calculation of probabilities: optical isomers, non-peptide bond formation, many non-biological amino acids

that also react [8].   The exact calculation of such probabilities is often not straightforward.   But in many cases it becomes readily apparent that whatever the exact multi-factored calculation, the probability "p" of the entire scenario easily crosses the plausibility bound provided by the UPP inequality.   This provides a definitive objective standard of falsification. When $\xi < 1$, immediately the notion should be considered "not a *scientifically plausible* possibility."   A ξ value < 1 should serve as an unequivocal operational falsification of that hypothesis. The hypothetical scenario or theory generating that ξ metric should be excluded from the differential list of possible causes.   The hypothetical notion should be declared to be outside the bounds of scientific respectability.   It should be flatly rejected as the equivalent of superstition.

f / ω in Equation 1 is in effect the probability of a particular *functional* event or object occurring out of all possible combinations. Take for example an RNA-World model. 23 different functional ribozymes in the same family might arise out of 10^{15} stochastic ensembles of 50-mer RNAs. This would reduce to a probability p of roughly 10^{-14} of getting a stochastic ensemble that manifested some degree of that ribozyme family's function.

Thus f / ω in Equation 1 reduces to the equivalent of a probability p:

$$UPM \ = \ \xi \ = \ p \ ^{c}\Omega_e \qquad\qquad \text{Equation 2}$$

where "p" represents an extremely low probability of any chance hypothesis that is *asserted to be plausible* given $^{L}\Omega_A$ probabilistic resources, in this particular case $^{c}\Omega_e$ probabilistic resources.

As examples of attempts to falsify, suppose we have three different chance hypotheses, each with its own low probability (p), all being evaluated from the quantum perspective at the astronomical level of the entire universe ($^{q}\Omega_u$).   Given the three different probabilities (p) provided below, the applied UPP inequality for each $\xi = p \ ^{q}\Omega_u$ of each hypothetical scenario would establish definitive operational falsification for one of these three hypothetical scenarios, and fail to falsify two others:

$p \ = \ 10^{-140} \ \text{X} \ 10^{140} \ = \ 10^0 = 1$ giving a ξ which is NOT < 1, so NOT falsified

$p \ = \ 10^{-130} \ \text{X} \ 10^{140} \ = \ 10^{10}$ giving a $\xi > 1$, so NOT falsified

$p \ = \ 3.7 \ \text{x} \ 10^{-151} \quad \text{X} \ 10^{140} \ = \ 3.7 \ \text{x} \ 10^{-11}$ giving a $\xi < 1$,   so Falsified

Let us quantify an example of the use of the UPM and UPP to attempt falsification of a chance hypothetical scenario:

Suppose 10^3 *biofunctional* polymeric sequences of monomers (f) exist out of 10^{17} possible sequences in sequence space (ω) all of the same number (N) of monomers. That would correspond to one chance in 10^{14} of getting a functional sequence by chance ($p = 10^3/10^{17} = 1/10^{14} = 10^{-14}$ of getting a functional sequence). If we were measuring the UPM from the perspective of a classical chemical view on earth over the last 5 billion years ($^c\Omega_e = 10^{70}$), we would use the following UPM equation (#1 above) with substituted values:

$$\xi = \frac{f\,^c\Omega_e}{\omega} = \frac{10^3 x 10^{70}}{10^{17}}$$

$$\xi = \frac{10^{73}}{10^{17}} = 10^{56}$$

Since $\xi > 1$, this particular chance hypothesis is shown unequivocally to be plausible and worthy of further scientific investigation.

As one of the reviewers of this manuscript has pointed out, however, we might find the sequence space ω, and therefore the probability space f/ω, to be radically different for abiogenesis than for general physico-chemical reactions. The sequence space ω must include factors such as heterochirality, unwanted non-peptide-bond formation, and the large number of non-biological amino acids present in any prebiotic environment [8, 12]. This greatly increases ω, and would tend to substantially reduce the probability p of naturalistic abiogenesis. Spontaneously biofunctional stochastic ensemble formation was found to be only 1 in 10^{64} when TEM-1 β-lactamase's working domain of around 150 amino acids was used as a model [52]. Function was related to the hydropathic signature necessary for proper folding (tertiary structure). The ability to confer any relative degree of beta-lactam penicillin-like antibiotic resistance to bacteria was considered to define "biofunctional" in this study. Axe further measured the probability of a random 150-residue primary structure producing *any* short protein, despite many allowable monomeric substitutions, to be 10^{-74}. This probability is an example of a scientifically determined p that should be incorporated into any determination of the UPM in abiogenesis models.

5. Don't multiverse models undermine The UPP?

Multiverse models imagine that our universe is only one of perhaps countless parallel universes [53-55]. Appeals to the Multiverse worldview are becoming more popular in life-origin research as the statistical prohibitiveness

of spontaneous generation becomes more incontrovertible in a finite universe [56-58]. The term "notion," however, is more appropriate to refer to multiverse speculation than "theory." The idea of multiple parallel universes cannot legitimately qualify as a testable scientific hypothesis, let alone a mature theory. Entertaining multiverse "thought experiments" almost immediately takes us beyond the domain of responsible science into the realm of pure metaphysical belief and conjecture. The dogma is literally "beyond physics and astronomy," the very meaning of the word "metaphysical."

The notion of multiverse has no observational support, let alone repeated observations. Empirical justification is completely lacking. It has no testability: no falsification potential exists. If provides no prediction fulfillments. The non-parsimonious construct of multiverse grossly violates the principle of Ockham's (Occam's) Razor [40]. No logical inference seems apparent to support the strained belief other than a perceived need to rationalize what we know is statistically prohibitive in the only universe that we *do* experience. Multiverse fantasies tend to constitute a back-door fire escape for when our models hit insurmountable roadblocks in the observable cosmos. When none of the facts fit our favorite model, we conveniently create imaginary extra universes that are more accommodating. This is not science. Science is interested in falsification within the only universe that science can address. Science cannot operate within mysticism, blind belief, or superstition. A multiverse may be fine for theoretical metaphysical models. But no justification exists for inclusion of this "dream world" in the sciences of physics and astronomy.

It could be argued that multiverse notions arose only in response to the severe time and space constraints arising out of Hawking, Ellis and Penrose's singularity theorems [59-61]. Solutions in general relativity involve singularities wherein matter is compressed to a point in space and light rays originate from a curvature. These theorems place severe limits on time and space since the Big Bang. Many of the prior assumptions of limitless time and sample space in naturalistic models were eliminated by the demonstration that time and space in the cosmos are quite finite, not infinite. For instance, we only have 10^{17}-10^{18} seconds at most to work with in any responsible cosmological universe model since the Big Bang.   Glansdorff makes the point, "Conjectures about emergence of life in an infinite multiverse should not confuse probability with possibility." [62]

Even if multiple physical cosmoses existed, it is a logically sound deduction that linear digital genetic instructions using a representational material symbol system (MSS) [63] cannot be programmed by the chance and/or fixed laws of physicodynamics [27-29, 32, 33, 36-39, 64, 65]. This fact is not only true of the physical universe, but would be just as true in any imagined physi-

cal multiverse. Physicality cannot generate nonphysical Prescriptive Information (PI) [29]. Physicodynamics cannot practice formalisms (The Cybernetic Cut) [27, 34]. Constraints cannot exercise formal control unless those constraints are themselves chosen to achieve formal function [28, 66]. Environmental selection cannot select at the genetic level of arbitrary symbol sequencing (e.g., the polymerization of nucleotides and codons). (The GS Principle [Genetic Selection Principle]) [36, 64]. Polymeric syntax (sequencing; primary structure) prescribes future (potential; not-yet-existent) folding and formal function of small RNAs and even DNA. Symbol systems and configurable switch-settings can only be programmed with choice contingency, not chance contingency or fixed law, if nontrivial coordination and formal organization are expected [29, 38]. The all-important determinative sequencing of monomers is completed with rigid covalent bonds before any transcription, translation, or three-dimensional folding begins. Thus, imagining multiple physical universes or infinite time does not solve the problem of the origin of *formal* (nonphysical) biocybernetics and biosemiosis using a linear digital representational symbol system. The source of Prescriptive Information (PI) [29, 35] in a metaphysically presupposed material-only world is closely related to the problem of gene emergence from physicodynamics alone. The latter hurdles remain the number-one enigmas of life-origin research [67].

The main subconscious motivation behind multiverse conjecture seems to be, "Multiverse models can do anything we want them to do to make our models work for us." We can argue Multiverse models ad infinitum because their potential is limitless. The notion of Multiverse has great appeal because it can explain everything (and therefore nothing). Multiverse models are beyond scientific critique, falsification, and prediction fulfillment verification. They are purely metaphysical.

Multiverse imaginings, therefore, offer no scientific threat whatever to the universality of the UPM and UPP in the only cosmic reality that science knows and investigates.

6. Conclusions

Mere possibility is not an adequate basis for asserting scientific plausibility. Indeed, the practical need exists in science to narrow down lists of possibilities on the basis of objectively quantifiable plausibility.

A numerically defined Universal *Plausibility* Metric (UPM = ξ) has been provided in this paper. A numerical inequality of $\xi < 1$ establishes definitive operational falsification of any chance hypothesis (The Universal Plausibility Principle [UPP]). Both UPM and UPP pre-exist and are independent of any experimental design and data set. No low-probability plausibility asser-

tion should survive peer-review without subjection to the UPP inequality standard of formal falsification ($\xi < 1$).

The use of the UPM and application of the UPP inequality to each specific UPM will promote clarity, efficiency and decisiveness in all fields of scientific methodology by allowing operational falsification of ridiculously implausible plausibility assertions. The UPP is especially important in astrobiology and all areas of life-origin research where mere theoretical possibility is often equated erroneously with plausibility. The application of The Universal Plausibility Principle (UPP) precludes the inclusion in scientific literature of wild metaphysical conjectures that conveniently ignore or illegitimately inflate probabilistic resources to beyond the limits of observational science.   The UPM and UPP together prevent rapidly shrinking funding and labor resources from being wasted on preposterous notions that have no legitimate place in science. At best, notions with $\xi < 1$ should be considered not only operationally falsified hypotheses, but bad metaphysics on a plane equivalent to blind faith and superstition.

7. Appendix 1

2^{NH} is the "practical" number (high probability group), measured in bits, rather than the erroneous theoretical n^N as is usually published, of all possible biopolymeric sequences that could form, where

> N = the number of loci in the string (or monomers in polymer)
> n = the number of possible alphabetical symbols that could be used at each locus (4 nucleotides, 64 codons, or 20 amino acids)
> H = the Shannon uncertainty at each locus

For a 100 mer biopolymeric primary structure, the number of sequence combinations is actually only 2.69×10^{-6} of the theoretically possible and more intuitive measure of n^N sequences.   The reason derives from the Shannon-McMillan-Breiman Theorem [68-71] which is explained in detail by Yockey [72, pg 73-76].

8. Appendix 2

For best estimates of the number of atoms, protons, neutrons and electrons in the universe and its astronomical subsets, see [73].

Simple arithmetic is needed for many of these calculations. For example, the mass of our galaxy is estimated to be around 10^{12} solar masses. The mass of "normal matter" in our galaxy is around 10^{11} solar masses. The mass of the sun is about 2×10^{30} kg. The mass of our solar system is surprisingly not much more than the mass of the sun, still about 2×10^{30} kg. (The Sun con-

tains 99.85% of all the matter in the Solar System, and the planets contain only 0.136% of the mass of the solar system.) The mass of a proton or neutron is 1.7×10^{-27} kg. Thus the number of protons & neutrons in our solar system is around $2 \times 10^{30} / 1.7 \times 10^{-27} = 1.2 \times 10^{57}$. The number of electrons is about half of that, or 0.6×10^{57}. The number of protons, neutrons and electrons in our solar system is therefore around 1.8×10^{57}. The number of protons, neutrons and electrons in our galaxy is around 1.8×10^{68}. We have crudely estimated a total of 100 protons, neutrons and electrons on average per atom. All of these estimates will of course vary some through time as consensus evolves. But adjustments to $^{L}\Omega_{A}$ are easily updated with absolutely no change in the Universal Plausibility Metric (UPM) equation or the Universal Plausibility Principle (UPP) inequality. Definitive operational falsification still holds when $\xi < 1$.

Acknowledgements

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Chapter 12: The Formalism > Physicality (F > P) Principle [*]

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ABSTRACT: 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 epistemology, 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 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 cybernetic. 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) is physicodynamically indeterminate—decoupled from physicochemical determinism.

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Introduction: The reality of nonphysical formalism

Both the physicodynamic force relationships of classical physics and quantum statistical reality conform to mathematical description. The prescriptive mathematical formulae known as "natural laws" are formal, not physical. Why do these mathematical expressions work so well not only to describe, but to predict future physicodynamic interactions?   Eugene Wigner [10], Hamming [11], Steiner [12], and Einstein [13] all published on the "unreasonable" effectiveness of formal mathematics to describe and predict physical interactions. Einstein asked, "How is it possible that mathematics, a product of human thought that is independent of experience, fits so excellently the objects of physical reality?" [13] Mathematics is the ultimate expression of formal logic. Numerical representation and quantification are highly prized in science. Quantification permits by far the best modeling of physicality. But quantification is formal, not physical. The rational rules of mathematics, logic theory, and the scientific method are also all formal, not physical. Together they provide for reliable prediction of physical events.

Relationships in nature tend to stay constant despite varying local initial conditions. This constancy is defined by numerical constants. We value laws and the constants they employ because they are invariant in nature (excepting quantum decoherence, for the moment). Invariance is the key to prediction. Despite the variables, universal mathematical relationships exist that tell us how forces and physical objects will interact. The preciseness of quantification in force relationships minimizes subjective factors, objectifying our understanding of physical reality. Most advances in science have resulted from the formal manipulation of these numerical representations. In short, nonphysical formalism is the glue that holds all forms of scientific investigation together.

Other formalisms include logic theory, language, and cybernetics. None of these formalisms can be explained by physicality alone within a materialistic, physicalistic, naturalistic worldview. Naturalism looks for derivation of everything though mass/energy interactions and through chance- and-necessity causation. But chance contingency does not explain computational programming, or any other form of nontrivial utility. Logic gates cannot be set to open-or-closed functionality by redundant fixed law, either. If logic gates were set by law, they would all be set to the same position. Logic would be impossible. Binary programs would consist either of all "1's," or of all "0's." No uncertainty would exist, and therefore no Prescriptive Information potential. There would be no freedom of purposeful choice from among real op-

tions. Programming of any kind requires choice contingency, not forced law, and not mere chance contingency.

In the case of evolution, we refer to choice contingency as "selection pressure." But as has been covered many times in this anthology, selection pressure cannot steer events towards *eventual* utility. Evolution cannot pursue *potential* function at the decision-node programming level where organization originates. Evolution cannot work at the genetic/genomic/epigenetic/ epigenomic programming level where the phenomenon of regulation and control originates (The Genetic Selection [GS] Principle [5]).

At the level of consciousness, choice contingency in the intuitive sense is undeniably real. Certainly at the level of human cognition, no one doubts the reality of purposeful choice. In addition, one cannot even argue for the worldview of a strict physicalistic determinism without employing formal choice contingency in the logical argument itself. Any defense of physicalism is therefore self-contradictory. There will be no escape in logical or scientific debate from the reality of choice contingency. 95% of the practice of physics, (the study of physicodynamics), consists of formal nonphysical mathematics and logic theory. The other 5% consists of observation which cannot be reduced to mass/energy either. Why do mathematics and logic theory serve us so well in the pursuit of scientific knowledge? And why should a fundamentally chaotic, irrational and non-formal physicality be so wonderfully able to be modeled by rational and mathematical formalism? Could it be that physicality has its roots in, and arose out of, a formalism even more fundamental and causative than physicodynamics?

1. Is physicality chaotic, or organized?

This question may pose a false dichotomy, but naturalistic science tends to just metaphysically presuppose initial disorganization in its various cosmologies and cosmogonies. Mass/Energy is allowed, but not formal organization. Sometimes initial order is considered in the notion of a cosmic egg. But not bona fide organization as the primal force. How was it determined that reality was initially chaotic and only physical? Certainly not scientifically. The preassumption of ultimate chaos is not only purely metaphysical; it is antithetical to repeated observations of current reality, and to abundant formal prediction fulfillments of an underlying organization. It is contrary to the logic theory upon which math and science are based. Overwhelming empirical evidence exists that reality is *not* fundamentally chaotic. Not only repeated observation, but innumerable fulfilled predictions of physical interactions based solely on mathematical models is far more suggestive that physicality unfolds according to formalism's ultimate integration, organization and control of physicality.

The effectiveness of mathematics in science is only "*un*reasonable" if we are foolish enough to begin our thinking with purely physicalistic metaphysical pre-assumptions.   The Formalism > Physicality (F > P) Principle explains away this supposedly "unreasonable" effectiveness of mathematics in the natural sciences. What is unreasonable is a materialistic belief system that ignores or tries to deny the supremacy of formalism. Materialism has never been empirically or logically established to be absolute Truth. This physicalistic faith system is inherently self-contradictory. No "ism" is physical. Naturalism is illegitimately incorporated into the very definition of science. The term, "Naturalistic science" is an oxymoron. Science is a formal enterprise from beginning to end. "Naturalistic science" exists only in name. Science itself is an abstract, cognitive, epistemological quest of mind. There is nothing "natural" about it, at least as philosophic naturalism would define "natural." All of the formalisms inherent in scientific method cannot be reduced to cause-and-effect physicodynamic determinism. Mathematics and science cannot be practiced within a consistently held materialistic and naturalistic metaphysical worldview.   Neither can cybernetic pursuits—activities involving any form of control.

Science is an epistemological system. Science from the beginning was the pursuit of an ever-increasing collective knowledge of the way things actually are. The abandonment of realism led only to the decline of quality science.

The acquisition of information "about" reality is a purely formal enterprise. Whatever qualitative aspects of science that cannot be quantified are still dealt with logically. Linguistic logic theory, like mathematics, is also formal. Science also depends upon categorization. Categorization in turn depends upon drawing conceptual conclusions about distinctions between classes of objects and events. Categorization is formal, not physical.

The collection, categorization and organization of data, the reporting of results using representational symbols (e.g. in tables), and the drawing of conclusions are formal enterprises, not physicodynamic interactions.   Physicality doesn't govern science. Nonphysical formalism governs science.   In short, *formalism predominates,* not physicodynamics.

As Pattee has pointed out many times [14-18], even initial physical conditions must be formally represented with numbers within the laws of physics. Physical conditions themselves cannot be plugged into the nonphysical mathematical equalities and inequalities that we call "the laws of physics." We insert numerical *representations* of initial conditions. Initial conditions cannot measure or symbolically represent themselves. Without formal representations of initial conditions and formal manipulations using equations, no physicist could predict any physical outcome. The physics practiced by physi-

calists is not physical. It is nonphysical and formal. In order to practice physics, the materialist must violate his own metaphysical imperative; he must violate his or her own contention that physicality is all there is. Thus a dichotomy exists that categorizes physicodynamic reality from its formal representation and prediction. Physics and chemistry as sciences are dead without formalism. The scientific method cannot be practiced without abiding by the formal rules (not laws) of logic, mathematics and scientific ethics. In view of the historical existence of mathematical orderliness in nature (presumed by naturalism itself) prior to Homo sapiens, how should the scientific community respond to such a ridiculous, totally metaphysical pontification as, "The physical cosmos is all there is, ever was, or ever will be!"? [19] Professional philosophers of science typically respond to such dogma with, "SEZ WHO?" or at least, "How was this statement of absolute Truth established?"

2. Formalism is more than mathematics

We usually think of scientific formalism in terms of numerical axioms, quantifications, and manipulations of mathematical equations. But the essence of formalism is not just the use of number systems. Formal systems also involve choosing with intent characters from a finite alphabet of symbols, syntax, grammar, and assigned meanings to those symbols and symbol combinations. Additional formal linguistic rules also apply. In the broadest sense, formal enterprises include language itself, the rules of syllogistic deduction, abduction, induction, semantics, derived theorems and corollaries, and cybernetic steering of events and calculations towards pragmatic benefit. The pursuit of utility is a rational and formal pursuit that cannot be reduced to mass and energy.

3. The two subsets of contingency revisited

As covered in Chapter 2, *contingent* in a past tense context means that an event could have occurred other than how it happened. In a present and future context, contingency means that events can unfold in multiple ways despite both local and seemingly universal law-like constraints. Contingency is not forced by physicodynamic necessity. Contingency embodies an aspect of *freedom* from physicochemical determinism. Refusal to acknowledge the reality of contingency tends to make the practice of even weighted statistics rather difficult. No law of motion renders absolutely reliable predictions. Even the most dogmatic adherents to "hard determinism" can easily be cornered into admitting the reality of some degree of contingency.

But there are two kinds of contingency. The first is *chance contingency*. Chance contingency gives rise to random variation—"noise." The Brownian movement caused by the heat agitation of molecules is a seeming example of chance contingency. "Just how random is randomness?" remains an open question. Many have argued that seemingly random events are actually the result of unknown causes and complex interactions between multiple known physicodynamic causes [20-22]. But the bottom line of chance contingency is a non-willful, non-steered independence from straightforward cause-and-effect determinism. Possibilities and options are not purposefully chosen, but result from "the roll of dice."

The second type of contingency is *choice contingency*. Choice contingency is a purposeful selection from among real options. Choice contingency is exercised with directionality for a reason and purpose. The goal of choice contingency is almost always some form of utility that is valued by the chooser.

4. The essence of any formalism is purposeful choice contingency

Contingency—freedom from determinism—alone is not adequate to generate nontrivial function. No computationally successful program was ever written by a random number generator. Nontrivial programs can only be written by purposeful, wise choices at bona fide decision nodes. What is the garbage in the programmer's phrase, "Garbage in, garbage out!"? Usually it's bad data, but garbage can be bad programming choices too—something less than wise choice contingency—something moving either in the direction of chance contingency or physicodynamic self-ordering, neither of which can program formal function.

Randomness is contingent, but not formally determinative. To contingency must be added "choice with intent." Randomly occurring events have never been shown to generate optimized algorithms, nontrivial conceptual instructions, or sophisticated programming [8, 23, 24]. All formal systems, including mathematics, require *purposeful choice contingency*. Equation manipulations are a form of choice-contingent behavior.

Neither the rules of computation nor the computation itself are physical. What is computation? More than any other factor, the bottom line of *any* formalism is the exercise of *expedient choice with intent at bona fide decision nodes*. "Natural process" experiments that purport to have generated spontaneously occurring new programming, computational success, or non- trivial formal function can be shown invariably to be guilty of "investigator involvement" in experimental design and methodology [9]. Artificial rather than natural selection has been introduced.

Choice contingency has been thoroughly distinguished from chance contingency and law-like necessity in prior publications [2, 8, 9, 24]. Choice contingency cannot be derived from a combination of the chance contingency and necessity of physicodynamics. Any attempt to extirpate purposeful choice contingency from the explanation of sophisticated function invariably results in the rapid deterioration of that function. Noise replaces meaningful communication with gibberish. "Bugs" and "blue screens" replace programming. Failure to halt replaces successful computation. Nonsense replaces sound reason. No escape exists from choice contingency in any rational explanation of sophisticated function. Sophisticated utility is realized only at the behest of wise purposeful choices—the essence of formalism.

5. Formalism not only describes reality, it prescribes and controls reality.

The ability of mathematics to *predict* future physical interactions is a far more daunting problem for the physicalist than explaining how mathematics is able to *describe* so well those same interactions. Thus Wigner, Hamming, Steiner and Einstein, if anything, understated the problem. To the degree that mathematical formulae and their logical manipulations predict future physical interactions, it could be argued that they not only describe, but prescribe and control physical world unfoldings.

Statistical predictions are a special case in science. Assuming a theoretical total independence from any law-like orderliness, descriptions of future quantum outcomes are purely probabilistic. We would not consider statistical predictions to be determinative or controlling in any sense. Chance doesn't cause or even influence any physical event to happen. Chance is only a descriptive mental construct, not a physical cause of effects.

Most macroscopic "chance" events, however, do not conform to this theoretical total independence from law-like orderliness. Coin flips, for example, are not absolutely random because they are not absolutely "fair." The heads side may weigh ever so slightly more than the tails side. Thus a "fair coin flip" is theoretical rather than real unless a coin can be manufactured that has absolutely no variance of one side from the other. To whatever degree the coin is not "fair," law-like influence must be incorporated into "weighted means." In the quantum mechanical world, decoherence from expected events becomes an issue. But in the macroscopic world, mathematical formulae and rules govern physicodynamic unfoldings with amazing accuracy.

6. The derivation of formalism

How could purely formal mathematics and biological Prescriptive Information (PI) [6] utilizing linear digital programming choices be derived naturalistically from physicality alone? Much has been accomplished in science through reductionism. Let us therefore attempt to reduce the problem at hand to a maximally reduced and simplified query: Could inanimate physicodynamics have generated cybernetics, the mathematics of physics, the highly fine-tuned numerical force constants, and the linear digital programming upon which all life depends [25-27]?

Physical explosions (e.g., the Big Bang) do not create mathematical constructs and computational algorithms. The physical laws may have become *apparent* at 10^{-43} seconds. But that does not establish that they didn't exist prior to becoming physically instantiated and actualized. In addition, it does not establish that physicality produced those nonphysical formalisms. Indeed, as one of the reviewers of this paper pointed out, circular logic is involved in arguing that Physicality produced formalism which then produced physicality. It is much more likely that the nonphysical formal laws pre-existed the cosmic egg "explosion," and only became apparent at 10^{-43} seconds within the time-space physical medium. If true, the Big Bang was not a chaotic explosion, but a controlled unfolding of prescribed physical organization and reality.

7. The valuation and pursuit of utility in "applied science" is formal

The pursuit of functionality arises first out of a desire for and valuation of "usefulness." Inanimate nature (e.g., a prebiotic environment) possesses none of these formal attributes or motives. The environment does not value and does not pursue organization over disorganization. Physicodynamics *can* self-order spontaneously (e.g., Prigogine's dissipative structures: hurricanes, tornadoes, candle flames, falling drops of water forming spheres, etc.). But inanimate nature cannot self-organize itself into formal step-wise processes/procedures (e.g., algorithms) in pursuit of utility. A prebiotic environment had no sense of pragmatism. It exerted no pressure towards function over non-function. Only our minds imagine an environmental preference for function over nonfunction in order to make our molecular evolution models "work for us." Rationalization prevails rather than progressive communal discovery of what the objective world is actually like.

The postmodern concept of something "working for us" boils down to providing psychological, sociological and seemingly rational and empirical support for our already presupposed beliefs. Naturalism is already committed to the metaphysical presupposition that "physicality is sufficient to explain

everything." Most of us bring with us this axiomatic pre-assumption *to* science. We were told from an early age on that science requires it. So most of us have cooperated fully with the incorporation of philosophic materialism and naturalism into our very definition of science.

If anyone dares to raise an eyebrow of healthy scientific skepticism about the all-sufficiency of mass and energy at any stage of our education, we are immediately pounced upon, ridiculed, shouted down by peers, and flunked out by professors. If we wait to raise any questions about the all-sufficiency of materialism until after we hold a degree, we are silenced by the peer review of true believers in physicalism. If we are fortunate enough to get a few open-minded peer reviewers, we are still stifled by a concerted effort of physicalists not to cite any paper that dares to challenge the all-sufficiency of physicodynamics to explain the whole of observational reality.

The subject of this paper is nothing more than a statement of what should have been obvious to every scientist all along. Mass and energy cannot represent meaning or programming choices using arbitrary symbol assignments. Mass and energy cannot state or manipulate mathematical equations. Physicality cannot organize data or draw abstracted conclusions. It cannot predict outcomes or practice any aspect of the scientific method.

Applied science values and pursues useful applications of academic scientific principles, data, results and conclusions in each specific field of study. To ascribe value to something is a formal function. To pursue utility is a formal undertaking. Cause-and-effect determinism knows nothing of value or function. It cannot identify or pursue "usefulness." In a materialistic world, whatever effects are caused are just "the way it is." Benefit is irrelevant.

Grant money is a lot easier to come by when academic interests are applied to solving everyday practical problems. The value of science is often judged by its practical usefulness to humans. NASA received a lot more funding when the general public and their political representatives started seeing the practical every day devices and benefits that arose directly out of the space program. Seeking knowledge for knowledge sake is noble, but rarely generates much grant money or pays anyone's salary. Thus a forensic scientist who is able to generate reliable methods of identifying serial rapists and murderers tends to get more attention and grant money than the scientist who first figured out how to sequence DNA for purely academic reasons. The forensic science wouldn't have been possible without the academics. Both the scientific academics and the pragmatic application of those academics are abstract, conceptual and formal, not merely mass/energy cause-and-effect determined interactions.

8. Controls and rules, not constraints and laws, achieve pragmatism

Science must follow certain rules. Rules are not laws [7]. Rules are agreed-upon conventions that govern voluntary behavior. Rules exist to guide choices. Rules can be broken at will. Rules govern procedures, competing interests, and ethical behavior. Rules are formal. The rules of the scientific method require honesty in the reporting of results, for example. There is nothing physical about the expectation of and demand for honesty.   Science would collapse without adherence to certain ethical standards. We castigate scientists who falsify results or who plagiarize the work of others. Yet it is widely acknowledged that such moral "shoulds" and "oughts" are not derivable from a purely material world. Yet without these metaphysical and ethical demands, science could not be trusted as a source of reliable knowledge.   Thus, science depends upon formal values, rules and honest behavior. It cannot be reduced to the chance and necessity of physicality.

Obedience to rules is not constrained. It is voluntary. But for any formalism to proceed, choices must be voluntarily made according to arbitrary rules with the intent of achieving formal function. This includes any mathematical or logical pursuit in science. It includes language. And it includes cybernetic programming. Loss of formal utility usually accompanies the disobedience of those rules unless a pragmatically superior rule system is being explored.

Most of what is really interesting in life was produced by choice contingency, not chance contingency or law. Our most fundamental problem in naturalistic science lies in explaining how physicodynamic determinism could have produced the bona fide choice contingency that we all observe and practice on a daily basis. The most fundamental question of biology is, "How did law-constrained physicochemical interactions along with "random" heat agitation generate a formally prescriptive linear digital genetic system?"

Language and any other form of sign/symbol/token system require deliberately choosing alphanumeric symbols from an alphabet of multiple options. Linguistic *rules* of language convention also must be arbitrarily chosen and adhered to. By arbitrary, we mean choice contingent, not chance contingent. Arbitrary does not mean that the chooser flips a coin to decide, or that the chooser does not care what is chosen. In addition to being choice contingent, "arbitrary" also means "unconstrained by natural law." Arbitrariness excludes determinism by law-like self-ordering. Self-ordering phenomena are extremely low in information [9]. High uncertainty and freedom are needed as a pretext to programming. No linguistic or cybernetic system has ever been organized by chance contingency or physicochemical determinism.

All forms of cybernetic programming in computer science are formal. Computational success can only be prescribed through formal choices with intent. The same is true of algorithmic optimization, the engineering of sophisticated function, and organization of any kind. Such formal utility cannot be achieved through after-the-fact selection of the best algorithms. A pool of "potential solutions" first has to exist before optimization is pursued. These stepwise discrete procedures ("potential solutions" are algorithms) must be programmed *at the decision node level*. A mere stochastic ensemble of symbols is not a potential solution. When Scrabble tokens are dumped out of the box onto the board and lined up upside down in strings, they sometimes contain happenstantial "words" when turned over. But this is only because our minds pick out those random sequences of letters by prior association. They are in reality just as random as any other letters in the string. Similarly, a random pool of supposed "potential solutions" are not the problem solutions they are claimed to be. Only our minds select them in pursuit of the solution and optimization we are pursuing. Consciousness is always smuggled in subconsciously in successful Markov processes. Strings of symbols have to be processed to function as programmed computational solutions. This requires either the selection of logic gate settings according to arbitrary conventions prior to the existence of any function [5], or the reading and processing of these instructions according to previously agreed upon rules, or both. Optimization requires motivation, the declaration of value, and the pursuit of a desired ever-improving utility. All of these factors are formal, not physicodynamic.

What empirical evidence and prediction fulfillment support do we have for the metaphysical belief that physicality generated formalism (e.g., that physical brain generated mind)? Has anyone ever observed a single instance of chance and necessity generating nontrivial computational function? Has anyone ever observed constraints generating bona fide controls that specifically steer events toward formal nontrivial utility? Do the laws of physics and chemistry ever generate creative new Prescriptive Information (PI)?

Says Howard Pattee:

"The concept of control does not enter physical theory because it is the fundamental condition for physical laws that they describe only those relations between events which are invariant with respect to different observers, and consequently those relations between events over which the observer has no control. At the least, control requires, in addition to the laws, some form of local, structural constraint on the lawful dynamics. Pragmatic control also requires some measure of utility. To say that the river bed controls the flow of the river is a gratuitous use of

control since there is no utility, and the simpler term 'constraint' serves just as well." [21, pg. 69]

Without exception every sophisticated pragmatic tool, machine or mechanistic procedure known to humanity required decision-node programming or integrative configurable switch setting to achieve. No bona fide nontrivial organization has ever arisen without purposeful steering, controlling and regulating the process. Constraints and invariant laws cannot perceive or pursue utility. Constraints and laws could not have generated a single complex machine, let alone life.

9. The Law of Organizational and Cybernetic Decline (The OCD Law)

The OCD Law states that, absent the intervention of formal agency, any nontrivial organization or cybernetic/computational function instantiated into physicality (e.g., integrated circuits) will invariably deteriorate and fail through time. This deterioration may not be continual. But it will be continuous (off and on, but overall consistently downhill). Computers, robots, all forms of Artificial Intelligence and Artificial Life, messages instantiated into material symbol systems or electronic impulses, will invariably progress toward dysfunction and fail.

The OCD Law is not to be confused with the Second Law of Thermodynamics. The OCD Law is not concerned with the entropy of statistical mechanics or the "entropy" or "mutual entropy" of Shannon's probabilistic combinatorial uncertainty. Heat exchange, heat dissipation, phase changes, order and disorder are not at issue. The OCD Law addresses only the formal organization and utility already instantiated into physical media and environments. Only purposeful choice contingency at bona fide decision nodes can rescue from deterioration the organization and function previously programmed into physicodynamics.

Thermodynamicists differ widely in opinion as to whether entropy is physical. Most materialists find themselves seriously trying to argue that the negatives of log functions of probabilities are physical! Even if they were, entropy tells us nothing about organization or achieving nontrivial formal function.

The OCD Law, of course, raises the question of how organization arose in the first place. *The Organization (O) Principle* states that nontrivial formal organization can only be produced by Choice Contingency Causation and Control (CCCC). The O Principle, like the OCD Law, can still be treated as a mere null hypothesis if desired by skeptics and critics. The firm prediction is made that neither the OCD Law nor the O Principle will ever be falsified by

empirical evidence or prediction fulfillment data. It will never be overturned by sound Aristotelian logic, either.   A single legitimate exception to either generalization would serve as falsification.   It is incumbent upon those who religiously believe in spontaneous self-organization of mass/energy into non-trivial formal utility to provide empirical evidence or prediction fulfillment support for their blind belief.   Thus far, any logical defense of belief in self-organization has also been sorely lacking [9]. In the absence of scientific support, informationless self-organization hypotheses and models such as Ganti's [28] remain little more than superstition.

10. Is entropy physical?

Many thermodynamicists are uncertain as to whether "entropy" is physical. "Energy unavailable for work" is one of several common definitions of entropy. "Energy" would certainly have to be considered physical. But "unavailable for work" is a formal characterization, not a physical entity. "Work" as used in this context obviously does not refer to mere heat exchange between bodies. It refers to formal utilitarian potential. Can the energy be used to achieve function? When taken as a whole, "energy unavailable for work" is a formal construct that cannot be reduced to physicality. In addition, nonphysical formal mathematics is required to define entropy and measure it in scientific terms. Nevertheless, as mentioned above, most metaphysical naturalists find themselves seriously trying to argue that the negative of a log function is physical. This is especially true of those who insist that statistical mechanical entropy is one-in-the-same with Shannon entropy. Shannon uncertainty is a probabilistic measure. Reduced uncertainty (R) is still a mathematical subtraction based on "before" minus "after" uncertainty.   Reduced uncertainty is equated with gained knowledge. But even reduced uncertainty is formal.

Neurophysiology has never had much success trying to reduce epistemology to physicodynamics. But even if entropy were physical, entropy tells us nothing about organization or achieving nontrivial formal function.

Many try to define 'entropy" in terms of "increasing disorder."   But clearly many forms of crystallization simultaneously increase order while moving towards greater entropy within the system. This confusion was caused by the initial confusion of order with organization, and the confusion of constraints with controls. Self-ordering phenomena and constraints are physicodynamic properties.   Organization and controls are formal properties. Physicality cannot generate nonphysical formalisms. They lie in different categories. Self-ordering phenomena and constraints arise from the near side of The Cybernetic Cut (Chap 3). Organization and controls arise only from the far side of The Cybernetic Cut. The one-way Configurable Switch (CS) Bridge

allows controls to travel into the physicodynamic world from the formal non-physical world. Under no circumstances do physicodynamic phenomena ever traverse the CS Bridge from the near physicodynamic side to the far formal side.   What makes reality especially interesting is not order, but organization. What generates utilitarian work is choice contingency and controls, not constraints and laws.   We must learn to get order and disorder out of the discussion of organization.

11. Formalism's instantiation can alone temporarily and locally circumvent The 2nd Law

James Clerk Maxwell first stated his well known "demon paradox" in a letter to Peter Tait in 1867. A controllable trap door separating two compartments allows an imaginary demon to separate warmer and cooler ideal gas molecules on opposite sides of the door separating the two compartments. The temperature differential between compartments was to provide an energy potential needed to drive a potential heat engine.

There are good reasons why naturalism is forced to view Maxwell's demon as only a "thought experiment" [29]. Abstract concept and volition are required for the demon to *selectively* open and close the trap door. He must choose with intent to concentrate the fastest-moving particles on one side of the partition. No energy is required in this thought experiment for Maxwell's demon's *mind* to choose whether and when to open the trap door. No accounting is provided for the demon's brain or muscle energy requirements, either, to operate the trap door. The demon has no brain or physical reality. He and his purposeful choices are transcendent to physicality. The hotter faster-moving particles cannot be concentrated on one side of the partition without his purposeful choices. It is true that the actual opening of the trap door would require a physical force and energy. But the *vectors of door pull up or push down are not physically determined. They are formally chosen.* And the all-important choice of *when* to open or close the trap door is also purely formal.

The demon has always been prominent in physics and thermodynamics precisely because *he provides the energy-free formal agency that alone can explain temporary and local circumvention of the Second Law.* Take away the demon's formal purposeful choices—his agency—and equilibration of heat in both compartments is inevitable according to the 2nd Law of Thermodynamics. What is the natural-process equivalent of such a mystical demon?   None exists in the naturalist's materialistic metaphysical world. The demon's persistence in physics texts is nothing less than a classic demonstration of naturalistic rational inconsistency. The physical cosmos clearly cannot be "all there is, ever was, or ever will be" [19]. Seemingly local and temporary circumvention of

the Second Law is too evident and common; but only because the demon lives and purposefully chooses. All energy transduction mechanisms making non-trivial function possible can be traced back to the same formal controls. Mere constraints, laws and phase changes do not produce functional "work" and sophisticated utility.

But why couldn't some yet-to-be discovered natural-process law operate the trap door? The answer is that laws always preclude freedom of programming choice and control. The trap door would always be held open, or always locked closed, *by law*!

It could be argued that not even life violates the 2nd Law, at least the physical manifestation of life. But life's formal controls and regulation are nonphysical. Formalisms are not subject to the 2nd law because they are nonphysical. The instantiation of formalisms into physicality is alone what makes possible the seeming temporary and local circumvention of the 2nd law.

In the microscopic world, circumvention of the 2nd Law is considered a given by many. But the quantum world is highly laced with human epistemological factors. Some might argue that the microscopic world may be more of a subjective human mental construction than ontologic reality. Others might point to the role of mathematics, probabilism and imagination in quantum theory as further evidence of formalism being the most fundamental level and ultimate cause of overall reality, including physicality.

We might be quick to deny "vitalism;" but we will not succeed in denying the reality of life's formal programming, regulation and control. We will not be able to sweep under the rug the prokaryotes' representational symbol systems, cybernetic programming, tens of thousands of nanocomputers, firmware, operating systems, various application softwares, semiosis (messaging), coding and decoding, translation, and its orientation around the pragmatic goal of staying alive. All of these are formalisms, not mere physicochemical interactions. This leaves us with the uncomfortable question, "What exactly is the difference between the undeniable transcendence of all these formalisms that program and regulate life, and the vitalism we so vociferously decry?

In Rolf Landauer's review [30] of *Maxwell's Demon: Why Warmth Disperses and Time Passes* by Hans Christian von Baeyer [31], Landauer points out, "It is impossible to sort molecules without expending more energy than the work that can be extracted from the sorted molecules. The second law of thermodynamics does indeed hold true."

Szilard rightly argued that Maxwell's Demon must be "informed" in order to know when to open and close the trap door [32]. Uninformed and undirected constraints cannot operate the trap door so as to deliberately separate hot and cold particles. Only choice-based control can.

Gilbert Lewis wrote: "Gain in entropy always means loss of information, and nothing more." [4, 33, pg. 573).   Conversely, to reduce entropy requires increased information—not only increased Shannon information, but increased prescriptive information {Abel, 2007 #6367]. It takes prescriptive information for the demon to know how to achieve heat engine potential. But the problem is far greater than one of knowledge. It is one of deliberate steering, control, management and goal.   The Demon must *decide* when to open and close the door *for some useful reason.* The Demon must have desire and motive. With every approaching particle he must make a purposeful binary choice of whether to open or to close the door so as to create a future energy potential. By what naturalistic physical mechanism is this choice accomplished? The Cybernetic Cut {Abel, 2008 #6969;Abel, 2008 #8037} and The F > P Principle declares that no natural mechanism exists that can choose with intent to deliberately design, engineer and maintain a *Sustained Functional System (SFS)* [34] such as a thermal engine for pragmatic reasons. Prigogine's dissipative structures in chaos theory have little in common with SFSs. Falsification of the assertion that nontrivial SFSs do not spontaneously form in nature is simple: cite a single exception. Such falsification is invited to promote further discovery and to test axiomatic principles such as The F > P Principle "in the real world."

12. The source of Prescriptive Information (PI) is formal

Prescriptive information (PI) either instructs or directly produces nontrivial function [2, 8]. PI usually accomplishes this through programmed algorithmic processing. "Prescriptive Information either tells us what choices to make, or it is a recordation of wise choices already made" [6]. Prescription requires formal selective steering at successive decision nodes. The purpose of PI is to generate pragmatic results. Such utility is valued and pursued by agents. Inanimate nature cannot value or pursue a formal goal. Not even evolution has a goal. Expedient choice commitments must be made prior to the realization of function at each successive decision node in any program. Bifurcation points can be traversed randomly; but no significant computational halting success can be expected at the end of a random path.   Decision nodes require true decisions, not "coin flips" or "dice rolls," to generate PI and sophisticated function.

The definition of PI centers on selection *for potential (not yet existent) function*. What exactly do we mean by function? "A function is a goal-oriented property of an entity" [35]. Says Voie, "Functional parts are only meaningful under a whole, in other words it is the whole that gives meaning to its parts" [35].

The road to utility is paved with algorithmic intent [36]. A goal-based algorithm is a step-wise, usually discrete process or procedure leading to *future* utility. Natural selection cannot generate such procedures. Evolution is blind to potential function and the future. It can only eliminate inferior formal programs (highly integrated computational haltings manifested as already-computed phenotypic organisms [The GS Principle] [5]). Goal-based algorithms control events and behavior, steering them toward organized, predictable usefulness. But such steering requires free and purposeful choices at bona fide decision nodes. Neither chance nor necessity can generate or optimize algorithms. These programming decisions must be made wisely with the intent to achieve computational halting. The only known source of conceptually integrated function is formally-generated PI.

Given the right processing algorithms, PI not only instructs, but can actually produce sophisticated function. But, to accomplish this pragmatism, at the very least constraints must be purposefully chosen through the selection of particular initial conditions in order to influence physical interactions to move towards Aristotelian "final function." Constraints are blind to function. Constraints and laws have no pragmatic goal. Constraints cannot generate the symbol systems used by semiosis. It is only the purposeful choice of certain constraints (e.g., the choice of initial conditions in designing an experiment) that creates bona fide controls. The F > P Principle states that the fundamental ingredients of any semiotic system are *representationalism* and *choice contingency*, not chance contingency or necessity. Meaning is always formal, never physicodynamic.

13. Naturalistic "efficient causation" (Aristotle) is grossly inadequate

Physicodynamic cause-and-effect was classified by Aristotle as "efficient causation." Naturalistic science attempts to explain seemingly teleological (teleonomic) phenomena solely in terms of efficient causation. Naturalistic biologists universally just presuppose functionality in scientific literature without any explanation of its derivation: "The purpose of the kidneys is to excrete waste products from the blood stream." "Mitochondria function as the powerhouse of the cell." "Each amino acyl tRNA synthetase is present *in order to* bind the appropriate amino acid to its own tRNA." Naturalistic science has to be able to explain all of these purely formal "in order to's" with nothing but mass/energy interactions. It fails miserably.

How can we refine evolutionary explanations to incorporate "in order to" into efficient causation? We point to selection pressure as the cause. But environmental selection favors only the best already-living phenotypic "effects." It does not explain the cause—the programming, algorithmic processing, preser-

vation schemes and optimization that produced those effects (The GS Principle) [5].

In evolutionary theory, the chaperone proteins cannot come into existence "in order to" fill the need of helping other proteins fold correctly. They, too, have to be folded. For the consistent naturalist, "Folding correctly" must ultimately be purely accidental prior to secondary selection for after-the-fact fitness. Virtually every player in homeostatic metabolism participates actively in pursuing and eventually achieving cooperative holistic integration. Evolution theory provides no mechanism for anticipation or pursuit of goals. In addition, the probability of thousands of needed players all coming together at the same place and time, all to contribute their role in achieving the final function of homeostatic metabolism, is statistically prohibitive for any purely materialistic conglomerate. The notion that physicodynamics alone can accomplish even a protometabolism can be definitively falsified by the Universal Plausibility Metric and Principle [37].

14. The genomic symbol system's prescription, control and regulation are formal

Küppers [38, pg 166] makes the same point as Jacques Monod [39], Ernst Mayr [40, 41], and Hubert Yockey [42, 43], that physics and chemistry do not explain life. Niels Bohr argued that "Life is consistent with, but undecidable from physics and chemistry."[44] "Undecidable" means that life cannot be explained by mere physical interactions alone. What exactly is the missing ingredient that renders life unique from inanimate physics and chemistry? The answer lies in the fact that life, unlike inanimacy, traverses the Cybernetic Cut (See Chapter 3) [4] . The Cybernetic Cut dichotomizes reality into two fundamental categories. The dynamics of physicality ("chance and necessity") lie on one side of the great divide. On the other side lies the ability to choose with intent what aspects of ontological being will be preferred, pursued, selected, rearranged, integrated, organized, preserved, and used (formalism). Algorithmic programs and their optimization require traversing the Cybernetic Cut. Life is further differentiated from non-life by its linear digital Prescriptive Information that uses a material symbol system (MSS) [45, 46]. Says Hubert Yockey, "The existence of a genome and the genetic code divides living organisms from non-living matter. . . . There is nothing in the physico-chemical world that remotely resembles reactions being determined by a sequence and codes between sequences." [26, pg. 54]

Linear digital programming occurs prior to any folding. The source of this programming lies in the selection and sequencing of rigidly bound nucleotide (token) "choices."   Primary structure (sequencing) is the main determi-

nant of tertiary structure (the globular molecular machine). Chaperones and other factors contribute to folding. But rigidly-bound monomeric sequencing largely determines what folding thermodynamic tendencies will be. And chaperones are themselves prescribed by the same linear digital symbol system. The far weaker H bonding of average folding is primarily mediated by primary structure. Thus true selection must take place at the point of polymerization of each additional monomer onto the forming positive strand. Since polymerization of the primary single strand is nearly dynamically inert in coding regions, physicodynamics plays no role in sequencing. Nothing is left but randomness with which to program in a naturalistic context. Yet coin flips have never been observed to program computational halting in any cybernetic system. There is no escaping the reality that all known organisms are prescribed and largely controlled by this linear digital programming. A representational MSS is clearly employed in the triplet codon table of amino acid prescription. Even most epigenetic factors are produced only through linear digital instruction and control (e.g. regulatory peptides, proteins and small RNAs) [47-49]. Even DNA methylation and protein binding to histone tails are at least indirectly prescribed by nucleotide sequencing. Non-coding regulatory RNA prescribed by DNA controls much of the genome [48-51].

Even more confounding is that all of these processes require sophisticated nanocomputers, firmware, "high tech" operating systems and software. Formal algorithms are required. Sequencing has no meaning or function independent of an overarching formal system of arbitrary assignment of specific amino acid correspondences. No physical force or law explains these arbitrary correspondence assignments. Their formal functions are not physicodynamically mandated. They are formally prescribed.

DNA genetic sequencing *seems* 99% "random" when considered only from a Shannon probabilistic and combinatorial perspective. But of course this perspective is blind to the meaning or function of any message or program. A string of 1s and 0s, as the result of compiled computer source code, can look random even though every logic gate position represented in that string was purposefully chosen for maximized utility. From a Shannon point of view, any truly random mutation in a genetic sequence would seem to have minimal effect on the already *seemingly* random frequency of the four nucleotides. Since 99% of genes already appear to be random, random mutations would tend to randomize only the 1% of *apparent* order within that gene's bit content. Random mutations would have a much more dramatic effect on the Shannon uncertainty found in redundant sequences (e.g., in introns rather than exons).

But genes are in reality programming strings. They are not analogous to programming strings. They ARE programming strings. It could be seriously

argued that computer programs are analogous to genetic and genomic programming. Each nucleotide added to the string is an additional configurable switch setting added to the programming syntax. If genetic prescription is random, why are we spending billions of dollars on ascertaining reference sequences? Further, a mutation of a random sequence is more than bordering on a non-sequitur.

Mutations, whether random or ordered by varying degrees of physicodynamic determinism, corrupt existing programming "choices."   Random mutations of PI strings will consistently result in noise pollution and degradation of the meaning and function of that PI. Mutations resulting from extremely low-informational cause-and-effect determinism will also reduce any programming efficiency of an existing gene. The fixed orderliness of nature described by laws cannot program formal function because it freezes up logic gates. Switches must be freely configurable to program formal function.

The GS Principle (See Chapter 7) [5, 52] states that genetic determinism's strong contribution to life requires selection at its *formal* configurable-switch level, not just at the post-computational phenotypic level.   Nucleotides must be selected and covalently bound into primary structures (sequence strings) prior to the realization of selectable function. Environmental selection cannot occur until final function and the fittest already-living organisms exist.

Replicative function is often confused with information prescription in the literature. These two functions have nothing to do with each other. Templating and complementary base-pairing are purely physicodynamic. They are both highly ordered with high probability and very low uncertainty. There is no formal component to templating or base pairing. It is largely "forced" via physicochemical constraints ("laws" and local initial conditions). Templating and base-pairing, therefore, are unrelated to Prescriptive Information (PI) generation. The only exception to this is the prescriptive sequencing of the template itself. Naturalistic templates are all low informational (e.g., clay adsorption produces homopolymers, not informational strands). Yet templating and self-replication are often erroneously appealed to as an explanation for the source of biological information. Point mutations and wobbles are noise producers, not programmers. Pointing to a template does not explain the origin of PI in the initial linear digital sequence of the template itself. No explanation is ever provided by naturalism for the *source* of PI in any template or biopolymer. The *sequencing* of nucleotides in a single, positive, prescriptively informational strand is formal, not physical. Untemplated, merely physicochemical polymerizations of over 100 mers at higher temperatures produce homopolymers, not PI polymers [53].

Once the functional sequencing is established in a positive informational strand, base-pairing is purely physicochemical. In our naïveté, we would expect that replication would merely copy the existing PI in reverse direction. The discovery that the complementary negative strand of DNA is simultaneously prescriptive of entirely different regulatory function only bespeaks the added dimensions of formal causality instantiated into molecular biology that totally defy all physicodynamic explanation. Mere physicodynamic base-pairing will never answer how each complementary strand is able to prescribe a different formal function.

Technically, duplication yields no new information even in the Shannon sense of "information." Duplication plus variation does yield new Shannon uncertainty. But duplication plus variation has never been demonstrated to produce new nontrivial Prescriptive Information (PI) [6].

How can nonphysical formal mathematics and formal biological cybernetics be derived naturalistically from physicality alone? Admits Weinberger, " . . . a theory such as ours must explicitly acknowledge purposeful action, or 'agency', in such diverse fields as evolutionary theory . . ." [54, pg. 105] Yet the whole point of evolutionary theory was to obviate the need for purposeful action and "agency."

15. Formal biocybernetics predates *Homo sapiens* and our cognition

All known life is cybernetic. If one assumes that humans evolved from previous lesser life forms in only the last one thousandth of life's history on earth, it follows that cybernetics predates humans. The simplest known life forms all display undeniable evidence of linear digital prescription using a representational Material Symbol System (MSS) [45, 46] and cybernetic regulation [4]. The biosemiosis that produced life, humans and their minds included, is formal. Even at a primordial life level, each ribonucleotide selection in a polymer is a configurable switch-setting [2, 8]. It is a memory token in a material symbol system [55]. In a theoretical RNA World, each linear digital symbol sequence (syntax) prescribes a certain three-dimensional configuration space of potential ribozyme function [5, 9, 56].

Pre-metazoan life utilizes the same representational symbol systems, linear digital programming, coding/decoding/translation between language/operating systems, and redundancy block-coding for noise reduction. They cannot be attributed to human mentation or heuristics. Neither chance nor necessity can explain these phenomena. Linear, digital, genetic algorithmic programming requires ontologically real selection contingency. Life could have arisen only through selection operating at the covalently-bound level of primary structure formation. Environmental selection of the fittest al-

ready-computed phenotypes is irrelevant to the question of how initial genes were programmed. Formally functional configurable switch settings could not possibly have been programmed by physicodynamics.

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

Natural selection is always *post-computational.* Natural selection is *after-the-fact* of relatively bug-free program halting. Environmental selection does not explain how the program got "written." Genetic digital selections must be distinguished from analog dynamic folding and from environmental phenotypic selection. Molecular evolution models of the spontaneous generation of life must be able to demonstrate selection at the covalently-bound decision-node level. No such theory or model currently exists in naturalistic scientific literature. No empirical evidence or rational support exists for attributing genetic programming to stochastic ensembles. This would be like attributing a Ph.D. thesis to nothing but a secretary's typographical errors. Although a stochastic ensemble could happen to match a reference sequence, no operational context would exist for that particular sequence to mean anything metabolically. An entire formal operating system (or several), power plant, and manufacturing factory would have to simultaneously arise from sequence space at the same time and place. Cybernetics is required to generate homeostatic metabolic utility in the face of thermodynamic decline. Since cybernetics is a formalism, and since life at all levels is cybernetic, formalism predates not only *Homo sapiens*, but even invertebrates. Cybernetics cannot be reduced to human mentation. Cybernetics is not just a heuristic tool or metaphorical epistemology generated by our minds [55]. Molecular biological cybernetics produced our consciousness, not the other way around.

16. The F > P Principle

The Formalism > Physicality (F > P) Principle states that Formalism not only describes, but preceded, prescribed, organized, and continues to control, regulate, govern and predict physicodynamic reality and its interactions. The F > P Principle is an axiom that defines the ontological primacy of formalism. Formalism is the source of all aspects of reality, both nonphysical and physi-

cal. Formalism organized physicality before the fact of physicality's existence. Formalism gave rise to the equations, structure and orderliness of physicality rather than to chaos. This alone explains why the scientific method must be conducted in a rational manner, why the applicability of mathematics to physical interactions is reasonable rather than unreasonable, and why such formalism can predict physical interactions.

The quest for a mathematical unified field of knowledge presupposes the F > P Principle. The F > P Principle further states that reality is fundamentally arbitrary—rule and choice-contingency-based, not indiscriminately forced by an infinite regress of cause-and-effect determinism. Physicality cannot even spawn a study of itself—physics—because physics is a formal enterprise. Nothing within the "chance and necessity" of physicality itself is capable of generating formal logic, computation, mathematical relationships, or cybernetic control. Only formalisms can measure, steer, manage, and predict physicality. Physicodynamics constrains; formalism controls.

In this paper, we have defined critical terms, presented fundamental concepts related to emergence, and reviewed repeated and predictable observations that collectively demand acknowledgement of the F > P Principle as the most fundamental axiom of science. Reality is first and foremost formal; physicality is realized only secondarily. Formalism can be instantiated into physicality through the use of configurable switches, material symbol systems, and through the integration of components into a holistic functional system.

Physicality cannot merge with formalism. Physicality can *be used by* logical formalism, but physicality cannot merge with or control formalism. Only formalism can measure, steer, organize, manage, and predict physicality. The F > P Principle explains why and how design and engineering principles can be incorporated into physicality to render it uniquely functional and/or computational. Physicality cannot do this on its own.

A corollary of the F > P Principle is acknowledgement that humans did not create the formal physical laws; our minds just discovered them. Before our minds existed, physicality obeyed these mathematical rules of physical interaction. Their prescription and control are in no way dependent upon human consciousness. $F = ma$ governed physicality long before human mentation arrived on the scene to recognize such formal relationships.

While the initial formal rules were arbitrary (choice-contingent), once instantiated into physicality they became physical fixed "laws." Their formal prescription and control became translated into fixed invariant directives of physicodynamic determinism. Cause-and-effect chains became "ordered" or forced into regularities. The fundamentally formal rules became physical laws. From the physicality side of The Cybernetic Cut [4], the choice contingency of the

initial rule-writing and instantiation can seem imperceptible. We see only the forced regularities described by the laws of nature. But the prescription of these regularities prior to instantiation into physicality was free, choice-contingent, and purely formal.

This formal rationality extends even to the roles of heat agitation, undetermined degrees of freedom in nature, and stochastic quantum events. Even randomness, chaos and dissipative structures can be formally and mathematically described, defined and predicted. The only thing that Einstein got wrong in his statement "How is it possible that mathematics, a product of human thought that is independent of experience, fits so excellently the objects of physical reality?" [13] was that mathematics is "a product of human thought." Human thought did not create mathematics. Human thought is just progressively discovering it and its role in cosmic organization. As we have learned throughout this anthology, it is a logical impossibility for order to have produced PI or organization. The orderliness of nature could not have produced mathematics, cybernetics, language capacity, the scientific method, scientific ethics, and all the other non-material formalisms; rather, it's the other way around.

The F > P Principle states that the flow of control and organization is unidirectional from formalism to physicality. No reversibility exists between the law-based necessity of physicality and the rule-based choice contingency of formalism. Physicality cannot generate formalism. Phase changes at the edge of chaos, fitness landscapes, so-called evolutionary algorithms, neural networks, cellular automata, and the infodynamics perspective cannot circumvent the F > P Principle. In every case, nontrivial function requires formal, choice-based, behind-the-scenes, artificial selection in experimental design in order to produce nontrivial utility. The fundamental modus operandi of all uphill climbs to optimize the "fitness functions" of evolutionary algorithms is subtle choice contingency. Markov processes ("Drunken walks") are not devoid of experimenter steering. Optimization of fitness functions is formal, not physicodynamic. Genetic algorithms start with a pool of potential *formal solutions* to a problem. The preferred choices can be instantiated secondarily into material tokens and into Material Symbol Systems (MSS) [57]. Once instantiated into physicality, MSS's then can cause physicodynamic effects. But their utility was formally, not physico-dynamically, programmed.

The F > P Principle is a far more contemporary and less metaphysical axiom than Plato's original notion of Form [58, 59]. The F > P Principle adds to Plato's and Aristotle's early metaphysical explorations many benefits of the Enlightenment, modern and postmodern scientific thought and empirical experience. This axiom should be considered the most foundational principle of

science. Without it, no basis exists for demanding science's subjection to logic theory. It explains science's demand for quantification (formal representation with numbers followed by numerical manipulations). The axiom provides a basis for trust in repeated observations and demand for prediction fulfillment. It explains why falsifiability is a valid test of scientific objectivity. Apart from the F > P Principle, the requirement of mathematical quantification in science makes little sense. The sciences of physics, chemistry, and biology, along with applied mathematics, computer science, and engineering, all *demand* formalism's dominion and control over physicality.

Belief in "self-organization" and "emergence" in the absence of choice contingency is blind belief bordering on superstition. It completely lacks empirical confirmation, prediction fulfillment, and rational justification. The hypotheses of "self-organization" and "emergence" are not even falsifiable. What is potentially falsifiable is the null hypothesis that nontrivial *"self-organization does not happen absent choice contingency."* This null hypothesis was first published quite succinctly in peer-reviewed literature around the turn of the millennium [23, 60] and many times thereafter [1-9, 34, 52, 61-64]. The scientific community has been rigorously invited to provide such falsification. After a decade, no falsification has been provided. The firm scientific prediction is hereby made that no falsification of this null hypothesis will ever be provided without behind-the-scenes investigator involvement in experimental design (artificial selection rather than natural selection). After another decade or two with no worldwide success at falsification, the above formal scientific prediction should become a mature generalized theory or theorem, if not a tentative law of science. This proposed tentative law states that inanimate physicodynamics is completely inadequate to generate, or even explain, formal processes and procedures leading to sophisticated function (The Law of Physicodynamic Incompleteness). Chance and necessity alone cannot steer, program or optimize algorithmic/computational success to provide desired nontrivial utility.

The time has come to extend this null hypothesis into a formal scientific prediction"No nontrivial algorithmic/computational utility will *ever* arise from chance and/or necessity alone."

How can such a bold, dogmatic prediction possibly be made by any reputable scientist? The answer lies first in the fact that it is just a null hypothesis designed for open-minded testing. The author of the hypothesis himself actively pursues falsification. Its deliberately absolutist tone begs falsification all the more in the challenging spirit of quality science. Second, the hypothesis itself arises from logical inference in addition to seemingly universal empirical observation. The statement is not just a product of inductive reasoning. The latter

would be subject to overturning with minimal new data that could arise around the next blind empirical corner. The prediction is rather a logically valid inference enjoying deductive absoluteness within its own axiomatic system. Baring fallacious inference, the only possibility of falsehood would be that the logic flows from a faulty axiom. If a presupposition (pre-assumption about the nature of reality) is "out of touch with reality (ontologic, objective being)" then the prediction might not be "helpful." Unhelpfulness would be realized in the form of a prediction failure. Since no axiom is ever proven, science tends to proceed by assuming an axiomatic system to be tentatively valid, and testing it from many different directions through time. In this sense, all laws of science are considered best-thus-far generalizations subject to continuing experiment falsification.

After another decade or two with no worldwide success at falsification, the above formal scientific prediction should become a mature generalized theory, if not a tentative law of science, which Abel has named in advance ***"The Law of Physicodynamic Incompleteness."*** This proposed tentative law states that inanimate physicodynamics is completely inadequate to generate, or even explain, the mathematical nature of physical interactions (the laws of physics and chemistry). The Law further states that physicodynamic factors cannot institute formal processes and procedures leading to sophisticated function. Chance and necessity alone cannot steer, program or optimize algorithmic/computational success to provide desired nontrivial utility.

When we see sophisticated function of any kind, we have strong evidence suggesting that the Cybernetic Cut has been traversed across the one-way-only CS Bridge [4]. Nonphysical formalisms are the product of purposeful choice contingency [4, 7]. Choice contingency is instantiated into physicality via logic gates, configurable switch-settings, the purposeful selection of tokens from an alphabet of tokens, or cooperative integration of physical components into formal systems or conceptually complex machines [1-9, 23, 34, 55, 61, 62]. Mere physicodynamic constraints can accomplish none of the above examples of formal organization. Organization and sophisticated function in the physical world are all the products of formalisms instantiated into physicality. Physicality cannot generate nonphysical formalisms.

Physicality can self-order. But it cannot organize itself into or optimize formal algorithmic systems [9]. Physicodynamics cannot integrate parts into holistic, cooperative, functional metasystems. Inanimate physicality is incapable of producing organization because it cannot generate choice from among options or pursue the goal of function. The environment has no pragmatic preferences or values. It cannot generate nonphysical Prescriptive Information (PI) [6]. It cannot program logic gates or configurable switches [1]. Physico-

dynamics *does* include spontaneous non-linear phenomena; but it cannot practice the formal applied-science/math known as "non-linear dynamics." The latter is produced only by agents, not by inanimate nature.

But what is the utility of the F > P Principle? What does it *do* for us? The principle tells us to stop wasting time and hundreds of millions of research dollars trying to explain algorithmic optimization from physicodynamics alone. The Principle states that formal computational function cannot be generated by chance and necessity. Organization cannot be produced by physico-dynamic self-ordering phenomena. Organization can only be generated through educated, expedient "choice with intent" at successive decision nodes. Organization arises out of the formal pursuit of desired utility.

Philosophical and metaphysical considerations are minimized in accord with Einstein's tenet of exercising a "minimum metaphysic" in scientific thought. Science, however, simply cannot be practiced competently without presupposing The F > P Principle. We already do this without realizing it. We just need to name and acknowledge the axiom we already subconsciously presuppose, and scrap the one we consciously incorporate erroneously into the very definition of science.

17. The axiomatic nature of all laws and principles

The axiom of ontological primacy of Formalism and its governance of Physicality flows from a combination of repeated observation and rational plausibility. It is still axiomatic, of course, as are all laws and principles of science and mathematics. But human experience and reason are far more consistent with the axiom of formalism's primacy than the pre-assumption of chaos and/or physicality's primacy.

It is easy to demand proof of The F > P Principle, and in the absence of proof immediately discount it. This is true of all axiomatic principles. It is not so easy to falsify it, or to find the slightest bit of evidence inconsistent with the Principle. Metaphysical naturalism's rejection of the Principle is purely philosophic, not scientific. The dogmatic pontification that physicality is everything is easily falsified. The bottom line of reality repeatedly traces back to formalism's choice contingency and organization (e.g., the periodic table; the Anthropic Principle, the reliability of mathematical laws to predict future physical interactions).

Like all axioms and "universal" laws, absolute proof of such principles is unattainable. Whether hypothetico-deductive or empirico-inductive, universal principles and laws must be viewed tentatively. At best, they represent "best-thus-far" knowledge. We accept them primarily because they are internally

consistent and because they seem to work for us across a broad array of disciplines. Note that both of these criteria are formal requirements.

Principles should support a metanarrative (an over-arching story) of our experience of the whole of reality. We typically have a large sample space of observational data which conform to the principle. Fulfilled predictions made by the principle are especially convincing when they occur in unrelated and unexpected areas of science. But the principle nonetheless must be potentially falsifiable to be considered scientific [65, 66]. The F > P Principle is indeed potentially falsifiable. Only one example of physicodynamic causation of a single formalism is required.

Theorems are deduced from unproven axiomatic commitments. We choose to tentatively believe these axioms, and we choose to abide by the rules of logic theory within the deductive systems that flow from those axioms. We presuppose that self-contradiction cannot lead to progressive discovery of an objectivity outside our minds. We obey the rules of inference believing it will lead to pragmatic benefit or some computational utility. Obeying the rules seems to "work for us."

The reason Einstein advocated a "minimum metaphysic" in science rather than banning metaphysics from science was his realization of the inseparability of science from philosophy. He appreciated the axiomatic nature of mathematics and the presuppositional starting point of all scientific logic. The nature of the human condition is such that even scientific knowledge is inescapably finite, perspectival, and tentative. Some ideas must be pre-assumed to be true without absolute certainty. It is a non-sequitur to fallaciously conclude from our epistemological problem that objective reality is relative. Objective reality is exactly what it IS. We can only validly conclude that *our knowledge of* objectivity is subjective and relative, not reality itself.

Short-term usefulness can be provided even by ill-founded axiomatic systems. But long-term usefulness in many unrelated areas strongly suggests that an axiomatic system *corresponds to* objective reality—to the way things actually are. This is the realist's interpretation, at least. For the anti-realist, the centrality of choice with intent is all the more true. The solipsist's dreams of reality are not forced by external constraints and laws. The dream is a formal one, free and unconstrained by physicality or any inescapable objectivity outside of the solipsist's mind. Thus reality for the realist and anti-realist, for the modernist and the post-modernist, is ultimately formal, not physical. The F > P Principle holds either way.

The F > P Principle is nothing new. But it does need parsimonious expression using a formal term, and it needs to take its place as the most fundamental principle of science. It should not be surprising or controversial to pre-

suppose that formalism preceded and controlled the very birth of physicality and physicodynamic relationships (Figure 3). Only dogmatic metaphysical imperatives and a long-standing Kuhnian paradigm rut preclude our admission of the obvious. Physics flows from formalism, not from physicality (its object of study). Physicality cannot explain physicality.

The F > P Principle is fully falsifiable through documentation of a single observed incident of nontrivial spontaneous physicodynamic enlightenment of any formalism. The firm scientific prediction is made that no exceptions to the F > P Principle will ever be observed.

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Glossary

Abiogenesis—the belief that life emerged spontaneously from non-life through natural process.

"Adjacent other"—the wonderfully inviting, mystical, poetic notion of Stuart Kauffman describing his belief in a spontaneously arising formal capability of physicodynamics (the inanimate mass/energy interactions, forces and laws of motion that are the subject of physics). Unfortunately, such imagination is purely metaphysical, never once observed, unfalsifiable, and has never logged a single prediction fulfillment. It can best be described as superstition or fairy tale—certainly not science.

Agency—the ability to choose from among real options and to voluntarily pursue goals such as formal utility. Agents are able to program logic gates, steer courses of action through long strings of decision nodes, and assemble and organize objects and events to create potential function—function not yet existent at the time choices must be made. Agency is invariably associated with life. Life itself is utterly dependent upon cybernetic programming—a phenomenon never observed independent of agency.

Algorithm—a step-wise, discrete process or procedure—often computational—leading to future utility. Algorithms require wise choices at decision nodes, logic gates and configurable switches prior to the realization of any function. Algorithms cannot be generated by after-the-fact natural selection of the fittest computational result or already-programmed species.

Animate—living.

Arbitrary—unconstrained by initial conditions or cause-and-effect determinism. As used in the context of cybernetics, arbitrary means more specifically choice-contingent, not chance-contingent. Arbitrary does not mean that the chooser flips a coin to decide, or that the chooser does not care what is chosen. Symbol systems, for example, require purposeful, choice-contingent assignment of certain symbolic "strokes of pen" to represent specific meaning. By convention, arbitrary rules of interpretation are followed that allow sender and receiver to communicate the same meaning and function from those symbols and symbol syntax.

Artificial Selection—change brought about by the purposeful choice contingency of agents selecting from among real options at bona fide decision nodes.

Change induced by choice-contingent causation and control (CCCC). Selection FOR POTENTIAL fitness—something that natural selection cannot do.

Axiom—A deductively underivable, and empirically and logically unprovable, propositional statement that is tentatively assumed to be true, or self-evident, and which serves as the basis for a whole deductive system of thought and inference.

Bijection—a mapping, correspondence, or translation, usually one to one, of one symbol system to another. When Hamming redundancy block-coding is used to reduce noise pollution in the Shannon channel, mapping can be many to one (e.g. triplet codons prescribing each amino acid).

Blueprint—a two-dimensional picture, or composite of signs, representing the plans of a building or other physical structure. The term blueprint is often misapplied to genetic and genomic instruction.   Genomics does not employ signs or blueprints. Codons serve only as block codes of symbols in a formal linear digital material symbol system (MSS). No direct physicochemical interaction is involved in the polycodonic prescription of polyamino acid sequencing that determines which protein is produced in ribosomes.

Chance contingency—non-willful, non-steered independence from apparent "necessity" (cause-and-effect determinism). Possibilities and options are not purposefully chosen, but result from "the roll of the dice." Chance contingency gives rise to random variation—"noise." The Brownian motion caused by the heat agitation of molecules is an example of seeming chance contingency. "Just how random is randomness?" remains an open question. Many have argued that seemingly random events are actually the result of thus-far unknown causes, and highly complex interactions between multiple known physicodynamic causes.

Chaos—disorganization, not disorder! Abundant highly-ordered dissipative structures of Prigogine's chaos theory form momentarily out of chaos in nature. No spontaneous dissipative structure shows any evidence of formal organization. In fact, most self-ordered dissipative structures such as hurricanes and tornadoes only destroy organization.

Chemoton—Tibor Ganti's abstract model of the simplest all-or-none unit of life. It consists of three non-living, autocatalytic chemical components: a motor, boundary, and prescriptive information system. The stable motor is capable of self-reproduction and synthesis of everything needed for the other two subsystems. The chemical boundary is envisioned to be semipermeable and to

allow transport in of needed nutrients and the excretion of wastes. The pre-scriptive information must be capable of self-replication and must control, not just constrain, metabolism, growth, and reproduction. The chemoton model lacks enzymes and genetic code. The problems with Ganti's model are many, starting with the fact that no one has ever observed such a minimal unit of life short of the cell itself. The mechanisms provided in the model are entirely in-adequate to explain the derivation of most of this unit's attributes and capabili-ties.

Choice contingency—freedom from determinism involving a purposeful se-lection from among real options.   Choice contingency is exercised by agents with intent for a reason and purpose. The goal of choice contingency is almost always some form of utility that is valued by the chooser.

Choice-Contingent Causation and Control (CCCC)—the steering of physi-cal events and the organizing of physical entities into potential usefulness. CCCC can generate extraordinary degrees of unique functionality that have never been observed to arise from randomness or law-described necessity. Neither physicodynamics nor evolution can pursue potential utility (e.g., the programming of computational success prior to its realization). CCCC does. CCCC is the only known cause and governor of formalisms.

Code—a representational symbol system used to assign associations (e.g. via a codon table) or to convey meaningful messages (e.g., messenger molecules). In an everyday connotation, coding signs and symbols are usually substituted for letters or words.   Most codes (e.g., ASCII, Zip code) are "open," (non-encrypted) with arbitrary meaning to communicate between two independent worlds. The codon/amino acid code is the most widely known code in life, but more than 20 other biosemiotic codes have been discovered in the past decade, each with no known physicochemical "cause." In molecular biology, genetic code is specifically used for:

1. instantiation of formal, immaterial programming choices into physicality
2. efficiency in translation between two different material symbol systems where molecules serve as "physical symbol vehicles" (tokens) in two dif-ferent material symbol systems (MSS) rather than being mere physico-chemical interactants/reactants
3. ease-of-transmission
4. noise pollution prevention in the Shannon channel (e.g., redundancy block coding)

5. proof reading and error correction (e.g. the processing of parity bit coding to detect noise pollution)

Complexity—the opposite of regularity, order, redundancy, and pattern. Complexity does not lend itself to algorithmic compressibility. Maximum complexity corresponds to randomness which contains no order, pattern or compressibility. Complexity is at opposite extremes with order on a bidirectional vector. Combinatorial complexity itself has nothing to do with functionality or the choice-contingent causation and control (CCCC) that generates nontrivial utility.   The only relation of complexity to positive formalism is the mathematical probabilism used to measure complexity's negative uncertainty.

Composome—a hypothesized "metabolism-first" model referred to as an "ensemble replicator" or "compositional genome." The model imagines a self-reproducing assembly of different molecular species that manifests protometabolic "networks." The model was advanced because of serious problems with 1) template replication, 2) non-enzymatic biopolymer synthesis, and 3) a lack of Prescriptive Information (PI) source to program functional sequencing in RNA-World related models. No explanation has ever been provided for how protometabolic cybernetic networks could have spontaneously organized from physicodynamics alone, or how an ensemble of molecular species could have reliably reproduced themselves. Recent work by well-known and respected investigators has shown that the replication of compositional "information" is so inaccurate that fitter composomes could not possibly have evolved into metabolism-first life forms.

Configurable Switch—a purely physical device designed specifically to record (instantiate) nonphysical, formal choices into physical reality without any influence of physicodynamic forces, laws and constraints. Configurable switch settings are physicodynamically indeterminate (inert, decoupled, incoherent).

Configurable Switch (CS) Bridge—the one-way bridge that spans The Cybernetic Cut. Choice contingency causation and control (CCCC) traverses the vast ravine known as The Cybernetic Cut allowing traffic only from the formal far side to the physicodynamic near side.   All formal meaning, function and bona fide organization enters the physical realm via this one-way bridge. Through "configurable" switch settings, formal choice contingency can become a source of physical causation. The setting of these configurable switches and logic gates constitutes the building of the CS Bridge. Nonphysical formalism itself can never be physical. In addition, the chance and necessity of physicality cannot steer objects and events towards formal utility. Chance and

necessity cannot compute or make programming choices. Mere constraints cannot control or regulate. The inanimate environment does not desire or pursue function over nonfunction. So how does physicality ever get organized into usefulness of any kind? How does stone and mortar ever become a building? The answer lies in our ability to build a CS Bridge from the far side of The Cybernetic Cut—the formal side of reality—to the near side—the physicodynamic (physical) side of the ravine. The scaffolding needed to build this bridge consists of devices that allow instantiation of formal choices into physical recordations of those choices. This is accomplished through the construction of physical logic gates—the equivalent of Maxwell's demon's trap door. The gate can be opened or closed by agent choice at different times and in difference contextual circumstances. The open or shut gate corresponds to "yes" vs. "no," "1" vs. "0." Because the gate can be opened or closed by the operator at will, we call it a "configurable" switch. Another means of crossing the one-way CS Bridge across The Cybernetic Cut is to select physical symbol vehicles (tokens) from an alphabet of tokens available in a material symbol system. Assembling components into a holistic Sustained Functional System (SFS) or machine is another example of the one-way traffic flow across the CS Bridge from formalism to physicality.

Computational halting—a program finishes running rather than going on forever. Computational "success" is usually implied with the term halting, meaning that the program does what it is supposed to do within a finite period of time.

Constraints—a restriction or limitation of possibilities caused by initial (starting) conditions or by the regularities of nature described by physical law. Constraints themselves play no role in steering, controlling or regulating events to achieve formal function. Constraints are blind to formalisms. However, constraints can constitute barricades and bottlenecks for agent-pursued goals.

Contingency—in a past-tense context, contingency means that an event could have occurred other than how it happened. In a present and future context, contingency means that events can unfold in multiple ways despite both local and seemingly universal law-like constraints. Contingent behavior is not forced by physicodynamic necessity. Contingency embodies an aspect of freedom from physicochemical determinism.

Control—to purposefully steer toward the goal of formal function and pragmatic success. To regulate. To select for potential usefulness.

Cybernetic Cut—the most fundamental dichotomy of reality. The dynamics of physicality ("chance and necessity") lie on one side of a great divide. On the other side lies the ability to choose with intent what aspects of ontological being will be preferred, pursued, selected, rearranged, integrated, organized, preserved, and used (formalism). Life is unique from inanimate physics and chemistry in that life's control and regulation arise from the far side of The Cybernetic Cut.

Cybernetics—the study of control and of various means of programming, organizing, steering, and regulating physicality. Mere physicodynamic constraints are blind and indifferent to formal success. Only controls, not constraints, steer events toward pragmatic goals such as being alive and staying alive.

Decision nodes—bifurcation points which cannot be traversed by a mere "flip of the coin," at least not if one expects pragmatic results or reliable escape from danger. Decision nodes, as the name implies, require wise purposeful choices to achieve goals. A classic example is the purposeful setting of a "logic gate" in computing in order to integrate circuits or achieve computational success.

Decision theory—the study of various outcomes resulting from purposeful decisions at bona fide decision nodes. Decision nodes are more than mere "bifurcation points," which could be traversed using a fair coin flip to determine which way to go at each "fork in the road." When decision nodes are replaced with mere bifurcation points, universal experience shows a rapid deterioration of formal function potential.

Decode—to decipher the meaning of a message through mapping representational symbols to meaningful language or computation. The interpretation of symbols and symbol syntax in a symbol system.

Decrypt—to decode, but with the connotation that the original encoding was not "open," but written with the intent to make decoding very difficult by an enemy at war, for example.

Descriptive Information (DI)—positive background semantic information coming from an external source that serves to reduce uncertainty and to educate one's knowledge. DI provides valued common-sense knowledge to human beings about the way things already are. Thus, being can be described to provide one form of Functional Information (FI: intuitive and semantic information). However, the DI subset of FI is very limited and grossly inadequate

to address many forms of instruction (Prescriptive Information (PI) and "how to" information for design, creativity, engineering, control and regulation.

Dissipative Structures of Chaos Theory—spontaneously self-ordered, momentary phenomena usually occurring in rapid succession so as to give the impression of a sustained structure (e.g., a candle flame; a tornado). Dissipative structures occur naturally out of mass/energy interactions alone. They require no choice-contingent causation and control (CCCC). Dissipative structures are often mistakenly viewed as evidence of self-organization in nature when in fact they example nothing more than spontaneous self-ordering with no formal components and no attention to the goal of functionality of any kind.

Edge of Chaos— the wonderfully inviting and mystical notion of complexity pursued by Christopher Langton, Doyne Farmer, J.P. Crutchfield, Melanie Mitchell, Stuart Kauffman and others that loosely describes a state of spontaneously realizable formal capability and self-organization arising out of physicodynamics alone. Melanie Mitchell has since questioned the validity of this notion. Such imagination is purely metaphysical, unobserved in inanimate nature, unfalsifiable, and no record exists of a single prediction fulfillment. It can best be described only as superstition or fairy tale, except where formalism is smuggled in through the back door to illegitimately redefine such terms as "phase transitions" and "constraints" (e.g., using the word "constraints" to mean formal "controls," where the constraints of inanimate cause-and-effect determinism are illegitimately granted the ability to purposefully steer events toward formal functionality or pragmatic success).

Emergence—the spontaneous occurrence in nature of more complex patterns arising from multiple simpler interactions. The spontaneous formation of symmetrical patterns in snowflakes during atmospheric precipitation is an example of emergence arising from purely physicodynamic self-ordering. Candle flame shapes, vortices of swirling water at bathtub drains, tornadoes and hurricanes all self-order spontaneously into rapid successions of momentary dissipative structures (the subject of chaos theory). Poorly understood is that no known cases of emergent self-ordering have anything to do with organization, and especially not "self-organization." Organization is formal and always arises through choice contingent causation and control (CCCC) from the far side of The Cybernetic Cut. No instance of bona fide "self-organization" has ever been observed; only unimaginative, redundant, lo-informational, self-ordering occurs spontaneously in inanimate nature out of chaos (which means disorganization, not disorder!).

Encode—To use a symbol system to represent, record and communicate meaningful messages. Molecular biology stores and passes along into progeny Prescriptive Information (PI, of which linear digital cybernetic programming is a major component) needed for organization and metabolic function. Encoding involves conversionary algorithms that biject or translate one symbol system into another.

Encrypt—to encode using a symbol system not easily deciphered and purposefully inaccessible to unwanted decoders.

Entropy—energy not available for formally useful work; the progressing formal disorganization observed in nature that is so often erroneously confused with increasing "disorder." Evidence of the 2nd Law is regularly observed with simultaneous increases in order, as with crystallization. Clearly, increasing entropy is not synonymous with increasing disorder. Physicodynamic entropy is not the same as informational entropy, which is a measure of epistemological uncertainty associated with a random variable. Informational entropy is a purely formal concept which, being nonphysical, has nothing to do with mass or energy, and everything to do with mathematical probabilism.

Epigenetic—the study of variation in heritable gene expression that is not caused by variation in nucleotide sequence of the genes. Histone deacetylation and DNA methylation are classic examples of gene suppression that does not affect nucleotide sequencing. Such alterations continue to alter gene expression throughout multiple future generations. Differentiation of the zygote (fertilized egg) into different cell types during development involves still other aspects of epigenetic control.

Epigenomics—the study of factors such as epigenetic DNA methylation, histone protein modifications, and chromatin structure on overall genomics and upper-level DNA structural (three-dimensional) Prescriptive Information (PI).

Falsifiability—the possibility that a claim, particularly a universal assertion, can be evaluated and potentially refuted by empirical testing showing results incongruous with that claim. The capability of disproving a proposition, hypothesis or theory by showing logical contradiction, or by finding, through experimentation, repeatable contradictory exceptions.

Fits—functional bits. The measurement of Functional Sequence Complexity, denoted as ζ, is defined as the change in functional uncertainty from the ground state $H(X_g(t_i))$ to the functional state $H(X_f(t_i))$, or $\zeta = \Delta H (X_g(t_i), X_f(t_j))$. The resulting unit of measure is defined on the joint data and function-

ality variable. The unit Fit thus defined is related to the intuitive concept of functional information, including genetic instruction and, thus, provides an important distinction between functional information and Shannon information.

Formal—relating to Plato's forms and Aristotle's appreciation of general classes of form and function that transcend particular physical structure and shape. Formal behavior is abstract, mental, arbitrary, nonphysical, and choice-contingent. The cognitive behavior of agents is typically goal- and function-oriented.

Formalism—a system of rules of thought or action typically involving symbol systems and requiring choices to be made at decision nodes, logic gates or configurable switch settings. Formalisms employ conceptual representationalism, mathematics, language, and/or categorical groupings of related ideas. Formalisms arise out of uncoerced choices in the pursuit of function and utility. Formalisms are typically computationally successful, integrated-circuit producing, and/or algorithmically optimizing. Formalisms require bona fide decision nodes, not just "bifurcation points. Language, mathematics, programming, and logic theory are all formalisms. Formalisms are governed by arbitrary rules, not laws. 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:

1. Mathematics
2. Language
3. Inferential and deductive logic theory
4. The sign/symbol/token systems of semiosis
5. Decision theory
6. Cybernetics (including computer science)
7. Computation
8. Integrated circuits
9. Bona fide organization (as opposed to mere self-ordering in chaos theory)
10. Semantics (meaning)
11. Pursuits of goals
12. Pragmatic procedures and processes
13. Art, literature, theatre, ethics, aesthetics
14. The personhood of scientists themselves

All of the above formalisms depend upon choice contingency rather than chance contingency or necessity. Formalism also entails choices made in pur-

suit of potential function. Natural selection (NS) cannot select for potential function. NS can only favor the fittest already-programmed, already-existing, already living phenotypic organisms.

Formalism > Physicality (F > P) Principle—the most fundamental axiom of science states that Formalism not only describes, but preceded, prescribed, organized, and continues to control, regulate, govern and predict physicodynamic reality and its inter-actions. The F > P Principle is an axiom that defines the ontological primacy of formalism. Formalism is the source of all aspects of reality, both nonphysical and physical. Formalism organized physicality before the fact of physicality's existence. Formalism gave rise to the equations, structure and orderliness of physicality rather than to chaos (disorganization, not disorder!). This alone explains why the scientific method must be conducted in a rational manner, why the applicability of mathematics to physical interactions is reasonable rather than unreasonable, and why formalism can reliably predict physical interactions. The quest for a mathematical unified field of knowledge presupposes the F > P Principle. The F > P Principle further states that reality is fundamentally arbitrary—rule and choice-contingency based, not indiscriminately forced by an infinite regress of cause-and-effect determinism. Physicality cannot even spawn a study of itself—physics—because physics is a formal enterprise. Nothing within the "chance and necessity" of physicality itself is capable of generating formal logic, computation, mathematical relationships, or cybernetic control. Only formalisms can measure, steer, manage, and predict physicality. Physicodynamics constrains; formalism controls.

Function—usefulness; utility; contributing to productivity and efficiency. "A function is a goal-oriented property of an entity," Says Voie. "Functional parts are only meaningful under a whole, in other words it is the whole that gives meaning to its parts" [35].

Functional Sequence Complexity (FSC)—a sequence of subunits that produces utility in some larger context, as a string of amino acids performing a protein function of importance and value in a larger metabolic scheme. Also, a linear, digital, cybernetic string of symbols representing syntactic, semantic and pragmatic prescription; each successive symbol in the string is a representation of a decision-node configurable switch setting---a specific selection for potential function. FSC prescribes or produces usefulness, usually via algorithmic processing.

Functional Information (FI)—Intuitive semantic information that serves some purpose such as educating prior uncertainty, or instructing how to accomplish some goal. FI technically has two subsets: Descriptive (DI) and Prescriptive (PI), each discussed in this glossary.

Genetic Code—the arbitrary representational symbol system used by life to assign associations (e.g. via a codon table) or to convey meaningful messages (e.g., messenger molecules). In an everyday connotation, coding signs and symbols are usually substituted for letters or words. The codon/amino acid code is the most widely known code in life, but more than 20 other biological semiotic codes have been discovered in the past decade, each with no known physicochemical "cause." In molecular biology, genetic code is specifically used for:

1. instantiation of formal, immaterial programming choices into physicality
2. efficiency in translation between two different material symbol systems where molecules serve as "physical symbol vehicles" (tokens) in two different material symbol system (MSS) rather than being mere physicochemical interactants/reactants
3. ease-of-transmission
4. noise pollution prevention in the Shannon channel (e.g., redundancy block coding)
5. proof reading and error correction (e.g. the processing of parity bit coding to detect noise pollution)

Genetic Selection (GS) Principle—states that biological selection must occur at the point when the sequencing of monomers is established. Nucleotides must be selected at the molecular-genetic level of 3'5' phosphodiester bond formation. After-the-fact differential survival and reproduction of already-programmed, already-living phenotypic organisms (natural selection) does not explain polynucleotide sequence prescription and coding.

Genetics—the study of the prescription of form, function and metabolic contribution by the arbitrarily programmed material symbol system of polynucleotide sequencing in DNA. Triplet codon sequence in coding regions is translated into amino acid sequence in ribosomes which in turn determines minimum Gibbs-free-energy folding into three-dimensional protein globular structure. Genetics includes not only the study of coded genetic control through the inheritance of discrete units called genes, but variation through mutations, environmental factors, and the effects of many non-coding regulatory RNAs and

epigenetic elements that affect biomolecular structure, function, metabolism and phenotypic expression.

Genomics—a more holistic study than genetics that investigates the interactions of all of the various networks of the entire genome, mRNA transcriptome, and proteome. Genetics tends to focus more on the effects of individual gene knock-outs. Genomics includes a study of pleiotropy (where one gene affects multiple phenotypic traits), epistasis (where additional modifier genes affect a single main gene), and heterosis (where outbreeding leads to hybrid vigor).

Hamming Block Code—an error-correcting redundancy code using a fixed or constant number of multiple loci comprising each "block" of a linear string of symbols to represent each prescribed unit of instruction.   Triplet codons in coding regions of DNA, for example, always consist of a block of three nucleotides in a row to prescribe each amino acid. Discounting the stop codons, 61 ways exist to prescribe formally 20 amino acid options in the ribosomes. Catastrophic "frame shift" errors can result if decoding is not begun at the correct starting locus in the string, or if the number of loci in each block does not remain constant, or if additional amino acids are added to the code through time (each of which needing a new triplet codon block of representational symbols). The latter realities make the notion of gradual evolution of the genetic code from purely physicodynamic factors fraught with seemingly insurmountable problems.

Hypercycle—an autocatalytic cycle induced by circular constraints that lead to redundant self-replication. Hypercycles are envisioned to generate formal self-organization and progressively higher levels of formal organization. The model suffers from the confusion of formal programming and organizational controls with mere circular physicodynamic constraints. In the real world, these self-reinforcing loops lead only to the consumption of all resources in the production of the same few redundant products. The result is the depletion of the tremendous phase space that would be needed for any other theoretically contributing players to "evolve" into a legitimate protometabolism. Like all molecular evolution models of life origin, it suffers from a lack of organizational directionality and pursuit of formally useful interactive products. Empirical support for Eigen and Schuster's original notion of spontaneous hypercycles and their ever-increasing protometabolic competence has never accumulated.

Inanimate—non-living.

Instantiate—to insert or infuse aspects of one category into another normally separate and distinct category. In the context of cybernetics, the term is used to denote incorporating programming choices into physical computational devices. Nonphysical formalisms can only be instantiated into physical reality through the setting of configurable switches, the selection of "physical symbol vehicles" (tokens) from an alphabet of tokens, or though the design and engineering of physical devices (e.g., sophisticated machines, robots). In object-oriented analysis, design and programming, creating an object from a class is called instantiating the class. A class has certain aspects that are "infused", or become aspects of the object. Therefore, the word "instantiate" in this context involves not a "separate and distinct" category, but an "instance" of the category (class).

Law of Organizational and Cybernetic Deterioration/Decline (OCD Law)—The OCD Law states that, absent the intervention of formal agency, any nontrivial organization or cybernetic/computational function instantiated into physicality (e.g., integrated circuits; programmed computational success) will invariably deteriorate and fail through time.   This deterioration may not be continual. However, it will be continuous (off and on, but overall consistently downhill). Computers, robots, all forms of Artificial Intelligence and Artificial Life, messages instantiated into material symbol systems or electronic impulses, will invariably progress toward dysfunction and fail. The OCD Law is not to be confused with the Second Law of Thermodynamics. The OCD Law is not concerned with the entropy of statistical mechanics or the "entropy" or "mutual entropy" of Shannon's probabilistic combinatorial uncertainty. Heat exchange, heat dissipation, phase changes, order and disorder are not at issue. The OCD Law addresses only the formal organization and utility already instantiated into physical media and environments. Only purposeful choice contingency at bona fide decision nodes can rescue from deterioration the organization and function previously programmed into physicality.

Law of Physicodynamic Incompleteness—an axiomatic proposition stating that physicochemical interactions are inadequate to explain 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. nanimate physicodynamics is completely inadequate to generate, or even explain, the mathematical nature of physical interactions (the laws of physics and chemistry). The Law further states that physicodynamic factors cannot institute for-

mal processes and procedures leading to sophisticated function. Chance and necessity alone 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 cybernetic. Inanimate physics and chemistry are inadequate to explain the spontaneous self-organization of even a protometabolism, let alone the generation of life from non-life (abiogenesis.)**Laws**—generalized reduction algorithms, extracted and derived from observed regularities in reams of data, describing and predicting different aspects of regular physical interactions in nature despite varying initial conditions.

Linear digital symbol system—A system of recordation, transmission, and communication of messages between sender and receiver made possible by both following the same set of arbitrarily assigned rules of formal symbolization. Messages consist of a succession of discrete symbols and symbol syntax having arbitrarily assigned meaning and communicative function. Language, computer programs consisting of a succession of 0's and 1's, and polycodonic prescription of amino acid sequence in proteins by coding DNA are examples of linear digital symbol systems.**Liposomes**—artificially produced vesicles designed to deliver drugs and other agents to various locations within living cells, and used to mimic hypothesized protocells in life-origin studies.

Logic gates—a type of cybernetic configurable switch that can be set to either open or closed in a binary programming mode. Logic gates allow formal purposeful choices to be instantiated into physical computational systems and integrated circuits.

Machine— a physical device, often a relatively independent functioning contrivance, that utilizes mass and energy to accomplish a nonphysical formal function. The classical definition of machine involved the forces of motion and power to accomplish some desired task referred to as "work." Such "work" is far more than the mere transfer of energy. Even the "simple machines" are used by agents to transform the direction or magnitude of a force in order to accomplish a desired goal. Physicodynamics do not pursue goals. The advent of electronics and computers broadened our definition of "machine" no longer to require moving parts. Molecular biology has opened our eyes further to a vast array and coordinated interplay of the most sophisticated machines of all—molecular machines.

Macroevolution—the belief that evolution can spontaneously give rise to ever more sophisticated genetic and genomic PI programming, and to increasing

conceptual complexity in organisms, giving rise to "higher" families, orders, classes, and phyla. No observations or prediction fulfillments exist in support of macroevolution. Falsification is not possible, raising the question of whether the notion of macroevolution is a scientifically respectable theory.

Material Symbol System (MSS)—A symbol system that formally assigns representational meaning to physical objects (tokens, physical symbol vehicles). The Game of Scrabble employs physical symbol vehicles, wood block tokens with inscribed symbols, that can be resorted to spell meaningful words and messages.

Meaning—Aboutness; function; the sense, importance, significance, implication, value, consequence, import or purpose of a message; the reason for sending a communication. In molecular biology, "meaning" is usually defined in terms of contribution to biofunction and holistic metabolism.

Mechanism—a means, directed process, programmed procedure, technique, system, or component of a machine that achieves some pragmatic goal. "Mechanism" is a formal term, not a physicodynamic term. "Mechanism," like the term "useful work," has no place in a consistently held naturalistic physics and chemistry context. The etiology of "mechanism" from both Latin and Greek derives from the word "machine." Metaphysical naturalism has never demonstrated the ability of physicodynamics and so-called "natural process" to produce nontrivial machines or sophisticated pragmatic mechanisms.

Message—a signal that contains interpretable meaning, and that manifests or fosters functionality at its destination. A signal that conveys Descriptive (DI) and/or Prescriptive Information (PI), both of which are subsets of Functional Information (FI).

Metabolism-First World—A model of life-origin that proposes that a protometabolism spontaneously self-organized, probably in a vesicle, without the aid of any Prescriptive Information contained in a material symbol system (such as DNA nucleotide or codon sequence) or RNA memory or catalysis. Variations include the Garbage-First model, Clay Life and other Mineral First models, Chemoton World, Peptide World, Lipid World, and Protein world.

Micelle— A spherical aggregate of surfactant molecules containing often containing a liquid colloid. In water, the surfactant molecules spontaneously self-order (NOT formally organize) with the hydrophilic (water-loving) "heads" aimed outward towards the aqueous solvent, and the hydrophobic (water-

hating) tails aimed into the center of the sphere. A micelle is a crudely self-ordered structure similar to an oil-in-water droplet.

Microevolution—the universally acknowledged, spontaneously acquired, change in heritable phenotypic traits within a species, possibly within a family, but never extending to evolutionary transition to a more conceptually complex ("higher") order, class or phyla.

Molecular evolution—as used in this volume, molecular evolution pertains mostly to prebiotic evolution from inanimate molecules into a living state—abiogenesis. Of prime interest is how ordinary molecules could have self-organized, in a formal sense, under the influence only of physicochemical forces and attractions, to produce so many integrated biochemical pathways, cycles, highly tailored "parts" or components, and such goal-oriented holistic metabolism. All of these are needed to organize and sustain even the simplest conceivable life form.

Multiverse—the purely metaphysical rather than scientific notion that this Universe is only one of countless universes.

Mutations—alterations in genomic nucleotide sequencing, including the ribonucleotide sequencing of RNA viruses. A special case of mutation is when protein structure "mutates" (misfields) in prions in a way that affects the folding of other protein molecules in that family. Prion misfoldings are contagious and are subject to natural selection. Replication errors, mutagenic chemicals, radiation, transposons and deliberate hypermutation in immune cells are common causes of mutations. Mutations can be neutral (having no selective advantage, and no immediate apparent deleterious phenotypic effect), deleterious (most mutations), or in extremely rare instances, beneficial, at least in some very indirect way (e.g., sickle cell anemia rendering erythrocytes more resistant to the malaria parasite). The very recent discovery of vast new areas of functionality performed by non-coding DNA and non-mRNAs raises the question of whether most supposedly neutral mutations are really neutral. Far more likely is the progressive accumulation of noise pollution of what were highly refined regulatory instructions, the effects of which will only become apparent through time as our knowledge of molecular biology and microRNA regulation grows.

Natural selection—differential survivability and reproduction of the best already-programmed, already-living phenotypic organisms. Natural selection (NS) has no creative programming ability at the genetic or genomic level (See The GS Principle). NS is purely eliminative of less fit phenotypes. It cannot

program genomes or other material symbol systems at the molecular level. Natural selection results only in the differential preservation and reproduction of the fittest already-existing organisms.

Necessity—a term often used almost synonymously with Law, as in Monod's *Chance and Necessity*, referring to the physicodynamic cause-and-effect determinism of inanimate nature. Necessity refers to regular physical interactions in nature that are so dependable, despite varying initial conditions, that the outcomes seem unavoidable, completely predictable, or "necessary."

Neural net—originally, the central nervous system consisting of circuits of neurons and their interconnections. Artificial neural networks are mathematical and computational models of the central nervous system and are used to model information processing and artificial intelligence. Neural networks are formal cybernetic constructs, not just physicodynamic "buttons and strings."

Noise—chance-contingent, meaningless, non-functional, unwanted disturbances or perturbations that corrupt meaningful, functional, desired, choice-contingent messages and Prescriptive Information (PI) commands.

Order—regularity, recurring pattern, redundancy, algorithmic compressibility. Order is antithetical to complexity and at opposite extremes with complexity on a bidirectional vector. Maximum complexity corresponds to randomness, which contains no order or compressibility. Order contains very little information, whereas organization typically contains high Prescriptive Information (PI) content from instantiated choice contingent causation and control (CCCC).

Ordered Sequence Complexity (OSC)—a linear string of linked units, the sequencing of which is patterned either by the natural regularities described by physical laws (necessity) or by statistically weighted means (e.g., unequal availability of units), but which is not patterned by deliberate choice contingency (agency). OSC is marked by repetition or redundancy, or recurring pattern in its sequence. Reuse of programing modules or structures needed for construction can create the illusion of OSC when in fact the recurring pattern is generated by choice contingency (FSC).   . The more highly ordered (patterned) a sequence, the more highly compressible that sequence becomes, the less Shannon uncertainty, and the less potential prescriptive information that can be instantiated into that sequence.

Organization—the choice-contingent association, categorization, configuring, steering, controlling, arranging or integrating of ideas or physical parts into a

productive scheme, system or device that accomplishes formally useful work. Organization should never be confused with low-informational "order" or "pattern." Organization typically arises only out of high Prescriptive Information (PI) and sophisticated choice-contingent causation and control (CCCC).

Organization (O) Principle—Nontrivial formal Organization can be produced only by Choice-Contingent Causation and Control (CCCC). See Chap 12, Sec 9.

Panspermia— the belief that life originated elsewhere in the Universe and was spread to earth, probably by meteoroids or asteroids. This same definition applies to exogenesis. Panspermia suggests that life is more generalized throughout the Cosmos, whereas exogenesis does not necessarily make this claim. The notion of panspermia does nothing to help explain how life could have spontaneously self-organized out of nothing but physicodynamics. It does little to extend the time available for molecular evolution since the Big Bang, since the age of the cosmos is believed to be only three times that of the earth.

Pattern—predictable, regular or repetitive form. A recurring, compressible order that reduces Shannon uncertainty and the ability to instantiate functional choices (semantic information) into that medium. Patterns can arise, however, in meaningful messages and programs from deliberate reuse of linguistic elements and programming modules.

Peptide World hypothesis—the belief that life arose as a metabolism-first self-organization from interactions between short peptides and polypeptides. Adherents to this model point to the near impossibility of spontaneous ribonucleotide formation in a prebiotic environment, activation problems of ribonucleotides, difficulties of polymerization bond formation in water, short half-lives, etc.

Phenotype—the already-programmed, already-organized, already-living, holistic physical organism.

Physical symbol vehicle—a token; a physical object employed as a formal representational symbol. Meaning is consciously assigned arbitrarily to each physical object, thereby making possible the instantiation of choice contingency into the physical world. The physical token then functions as a formal meaningful and functional symbol in a material symbol system rather than as a

physical interactant. The blocks of wood with inscribed letters in a Scrabble game, or the nucleotides in genes serve as physical symbol vehicles.

Physicodynamic determinism—cause-and-effect physicochemical interactions that lead back in an infinite regress of determinism to some physical first cause. Physicodynamic determinism, often referred to as "necessity," does not explain the reality of choice contingency—the freedom to choose from among real options to achieve choice-contingent causation and control (CCCC). It also does not explain the rational, mathematical and formal nature of reality.

Physicodynamically indeterminate—Contingent; undetermined by cause-and-effect determinism; could have happened other than it did; having multiple possible options despite initial constraints and the laws of physics and chemistry.

Physicodynamically inert—physicodynamically indeterminate; contingent; undetermined by cause-and-effect determinism; could have happened other than it did; having multiple possibilities or options of occurrence despite initial constraints under the laws of physics and chemistry.

Physicodynamically incoherent— physicodynamically indeterminate; contingent; undetermined by cause-and-effect determinism; could have happened other than it did; having multiple possibilities or options of occurrence despite initial constraints under the laws of physics and chemistry.

Physicodynamic discontinuity— physicodynamically indeterminate; contingent; undetermined by cause-and-effect determinism; could have happened other than it did; having multiple possibilities or options of occurrence despite initial constraints under the laws of physics and chemistry.

Potential function—Formal function not yet existent, which, when nontrivial, only comes into existence through advanced planning, assembling of component parts or processes, programming and engineering choices. Physicodynamics alone is incapable of producing sophisticated formal function. Natural selection (NS) cannot select for potential function at the genetic programming level (The GS Principle). NS can only prefer existing fittest phenotypic organisms.

Pragmatic—functional, useful, helpful, utilitarian, productive, contributory to a larger or higher organization or goal.

Prebiotic—referring to the inanimate physical environment (nature) that existed prior to the origin of life.

Prescriptive Information (PI)—a subset of Functional Information (FI) that either instructs or indirectly produces nontrivial formal function. PI is semantic "how to" information. PI provides the instructions required to organize and program sophisticated utility. Potential formal function and computational success must be prescribed in advance by PI programming prior to halting, not just described after the fact. PI requires anticipation and "choice with intent" at bona fide decision nodes. PI either tells us what choices to make, or it is a recordation of wise choices already made. PI is positive, as opposed to negative uncertainty. Prescriptive information (PI) does far more than merely describe (Descriptive Information [DI]). We can thoroughly describe a new Mercedes automobile, providing a great deal of DI in the process. However, this functional DI might tell us almost nothing about how to design, engineer and build that Mercedes. PI provides the instructions required to organize and program sophisticated utility. PI designs, creates, engineers, controls and regulates. The inanimate physical environment is incapable of participating in such formal pursuits. So-called "natural" physicodynamics cannot generate nonphysical PI. PI can perform nonphysical "formal work." PI can then be instantiated into physicality to marshal physical work out of nonphysical formal work. Cybernetic programming is only one of many forms of PI. Ordinary language itself, various communicative symbol systems, logic theory, mathematics, rules of any kind, and all types of controlling and computational algorithms are forms of PI. Neither chance nor necessity has been shown to generate PI. 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.

ProtoBioCybernetics—the study of the derivation of control and regulation in the first life forms. 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.

Protobiont—a hypothesized initial precursor of living organisms, usually thought to have been a protocell with some semblance of a vesicular-like phospholipid or bilayer "membrane." Contained within this vesicle is believed

to have been the minimal unit of protolife or life. Tibor Ganti's minimal unit of life, the chemoton, includes the vesicular or membrane-like barrier.

ProtoBioSemiotics—the study of meaningful or functional messaging and how it arose within and between the first protobionts.

Protocell—a hypothesized initial "cell" with a vesicular-like phospholipid or bilipid "membrane" in which life is imagined to have spontaneously self-organized.

Protometabolism—the hypothesized first semblance of integration of bio-chemical pathways and cycles into a holistic, organized, functional metabolic system.

Random Sequence Complexity (RSC)—a linear string of stochastically linked units, the sequencing of which is dynamically inert, statistically un-weighted, and is unchosen by agents; a random sequence of independent and equiprobable unit occurrence. RSC is the most complex of the three kinds of sequence complexity, the reason being that a random sequence contains no al-gorithmically compressible order. Its sequence cannot be enumerated using any representational string shorter than itself. RSC manifests the absence of any order or pattern. RSC represents maximum uncertainty, and therefore con-tains the maximum number of Shannon bits.   Although maximally complex, RSC does nothing functional, emphasizing that complexity is not an explana-tion for utility or pragmatic worth.

Regulation—the choice-contingent steering, controlling, adjusting and fine-tuning of some formal process, procedure, or reaction sequence. To regulate presupposes freedom from law sufficient to manage events by formal choice-contingent causation and control (CCCC).

RNA analogues— Molecules similar in structure to RNA, but having the phosphate, ribose or nucleobase replaced with some alternative. Alternate nu-cleobase Molecules similar in structure to RNA, but having the phosphate, ri-bose or nucleobase replaced with some alternative. Altering nucleobases (e.g. fluorophores) typically result in altered base pairing and stacking properties. Peptide nucleic acid (PNA) is a phosphate-sugar backbone analogue. Other backbone analogues include threose nucleic acid (TNA), glycol nucleic acid (GNA), Morpholino or locked nucleic acid (LNA). Originally, it was hoped that RNA analogues might solve the many problems of prebiotic RNA chemis-try that threatened the RNA World hypothesis. However, the Pre-RNA World hypothesis has encountered many roadblocks of its own.

RNA World hypothesis—the belief that initial life consisted primarily of RNA rather than the DNA and protein necessary for current life. RNA can potentially retain nonphysical information in its physical matrix and self-replicate. RNA can act as a crude catalyst compared to proteins. Numerous biochemical hurdles in a prebiotic environment have rendered the RNA World hypothesis highly suspect. The PreRNA, RNA analog, and RNA World models probably remain the most favored models in life origin theory today. Ribonucleoprotein enzymes such as ribosomes are thought to have arisen from molecular evolution prior to DNA-protein life.

Rules—Choice-contingent guidelines intended to guide procedures, competing interests, and ethical behavior. Rules are nonphysical, formal, mental constructions. Rules are not laws. Laws describe and predict deterministic physicodynamic interactions. Loss of formal utility usually accompanies the disobedience of rules unless a pragmatically superior rule system is being explored. Rules can also be arbitrarily agreed-upon conventions that govern language and voluntary behavior. Rules exist to guide choices. Rules can be broken at will, often at the expense of efficiency or efficaciousness in accomplishing some pragmatic goal.

Semantic—meaningful or functional.

Semiotics—the study of symbolization using sign and symbol systems, meaningful message generation, language, programming, and the communication methods employed. The three main branches of semiotics are 1) semantics—the meaning generated by how symbols are arbitrarily assigned to represent objects and ideas, 2) Syntactics—the sequencing and relation of symbols to one another to create higher meaning, and 3) Pragmatics—the usefulness of symbol system applications and their communication.

Sign—a two-dimensional picture or drawing conveying representational meaning to one's senses. The picture or drawing is self-explanatory because we recognize by sight physical objects that are being depicted from our every-day empirical world. A visual image of real world objects is delivered by the sign. Our consciousness links the two-dimensional picture with our experience of and with that object. A picture of an automobile with two wavy lines emanating from behind its rear tires is a street sign conveying the message of slippery road conditions.

Signal—a transmission of mass/energy from one location to another, as a pulsating emission of light from a distant star. A signal need not have any meaning or function, and should be carefully distinguished from "message." Mes-

sages always contain formal meaning, and can only be instantiated into physicality through choice contingent causation and control (CCCC) from the far side of The Cybernetic Cut. Signals, on the other hand, can be entirely physicodynamic.

Stoichiometry—the branch of chemistry dealing with the relative quantities of reactants and products. Whole numbers usually represent the ratio of reactants to products.

Structure—a recognizable framework of categorization, pattern or order in an entity or relationship between entities. The manner in which the parts of a whole are assembled. Primary structure refers to the sequencing of monomers in a linear polymer. Secondary structure refers to the two-dimensional representation, at least, of alpha helices and beta strands (in proteins) and helices and stem-loops (in nucleic acids) due to base pairing and base stacking. Tertiary structure refers to the three-dimensional globular shape of folded proteins, ribozymes, and chromatin.

Sustained Functional Systems (SFS)—Any device, machine, network or system that both 1) continues on in time (is a non-dissipative structure in the sense of Prigogine's chaos theory) and that 2) generates sustained non trivial functionality. Prescriptive Information (PI) and Organization alone make Sustained Functional Systems (SFS) far from equilibrium possible. Maxwell's Demon's choice contingency of when to open and close the trap door so as to accomplish the goal of a sustained energy potential represents the very first true decision-node instantiation into physicality. The Demon's first choice is the birth of engineering and the artificial intelligence movement. Deciding when to open and close the trap door is the very first logic gate—the very first configurable switch-setting. The Demon's voluntary (arbitrary) trap-door operation represents the birth of integrated circuits, computational cybernetics, and life's regulatory mechanisms. No natural mechanism exists that can choose with intent to deliberately design, engineer and maintain a SFS. Yet without SFS's, life is impossible. SFS's predate and produced Homo sapiens. They therefore cannot be attributed solely to human mentation and creativity.

Symbol—an arbitrarily-shaped/generated character representing some assigned meaning by definition. The meaning of these "strokes of pen" is just arbitrary assigned by the sender and agreed to by the recipient. Otherwise, the message will not have meaning or function at its destination. A symbol, unlike a sign, conjures no meaning from one's sight memory of physical objects. The letters of most language alphabets are not signs, but symbols. Strings of such

symbol characters spell words leading to lexicons of words. Hierarchies of phrases, clauses, sentences, and paragraphs can be constructed from the lexicon of words according to syntactical rules. Sometimes only one letter symbol, such as "H" or "C" on a faucet handle, conveys meaning. Mathematical symbols such as π, Ω, ξ, Δ, $=$, and $\neq$ are symbols, not signs. We cannot ascertain the meaning of these symbols from the symbol itself, except that we sometimes become so familiar with a certain symbol's assigned meaning that it begins to take on a function similar to a picture or drawing, thereby having a sign-effect from our sight memory (e.g., the symbol " $=$ " begins to be recognized visually as the a physical sign of equality). Codons function as symbols in molecular biology, not as direct physicochemical reactants or pictorial signs. Genes are not blueprints (two-dimensional pictures).

Symbol Systems—a means of recordation or communication that employs symbols to represent and encode meaning. Symbol systems allow recordation of deliberate choices and the transmission of linear digital prescriptive information. Formal symbol selection can be instantiated into physicality using physical symbol vehicles (tokens). Material symbol systems (MSS) formally assign representational meaning to physical objects. Even the analog perturbations of verbal semiosis can be symbolized with numerical representations in voice recognition software.

Token—a physical symbol vehicle. A physical object on which a symbol has been inscribed or to which symbolic meaning has been ascribed.

Transcribe—in molecular biology, to synthesize meaningful/functional RNA sequences containing Prescriptive Information (PI) using RNA polymerase enzymes from a DNA template.

Translate—to map one symbol system onto another in an effort to decode the initial system.

Turing machine and tape—a thought experiment imagining a device that can algorithmically process a string of successive symbols on a linear tape according to a table of rules.   An infinite memory is afforded by an infinite tape. Each symbol represents not only meaning, but also arbitrary choice contingency rather than chance and/or necessity.   The rules are also choice- contingent. The thought experiment can simulate the function of modern computers and their computational limits.

Undecidable— a decision problem that is impossible to always answer with a "Yes" or "No" using a single algorithm.   The term is most applicable to com-

putational complexity theory. Alan Turing, for example, proved that the halting problem is undecidable for Turing machines. A verbal statement can also be considered "undecidable" with relation to Gödel's incompleteness theorems when that statement is neither provable nor refutable within a certain deductive axiomatic system.

Universal Probability Bound (UPB)—A quantifiable limit to an extremely low probability resulting from the limitation of probabilistic resources in that context. Statistical prohibitiveness cannot be established by an exceedingly low probability alone. Rejection regions and probability bounds need to be established independent of (preferably prior to) experimentation in any experimental design.

Universal Plausibility Metric—a numerical value measuring the plausibility (not probability) of extremely low probability events in view of the probabilistic resources in each context. The UPM employs the symbol ξ (Xi, pronounced zai in American English, sai in UK English, ksi in modern Greek) to represent the computed UPM according to the following equation:

$$\xi = \frac{f^L \Omega_A}{\omega}$$

where f represents the number of functional objects/events/scenarios that are known to occur out of all possible combinations (lower case omega, ω) (e.g., the number [f] of functional protein family members of varying sequence known to occur out of sequence space [ω]), and $^L\Omega_A$ (upper case Omega, Ω) represents the total probabilistic resources for any particular probabilistic context.   The "L" superscript context of Ω describes which perspective of analysis, whether quantum (q) or a classical (c), and the "A" subscript context of Ω enumerates which subset of astronomical phase space is being evaluated: "u" for universe, "g" for our galaxy, "s" for our solar system, and "e" for earth. Note that the basic generic UPM (ξ) equation's form remains constant despite changes in the variables of levels of perspective (L: whether q or c) and astronomic subsets (A: whether u, g, s, or e).

Universal Plausibility Principle—states that definitive operational falsification of any chance hypothesis is provided by the inequality of:

$$\xi < 1$$

where ξ is the measured UPM for that context. This definitive operational falsification holds for hypotheses, theories, models, or scenarios at any level of

perspective (quantum or classical) and for any astronomical subset (Universe, galaxy, solar system, and earth). The UPP inequality's falsification is valid whether the hypothesized event is singular or compound, independent or conditional. Both UPM and UPP pre-exist and are independent of any experimental design and data set. No low-probability hypothetical plausibility assertion should survive peer-review without subjection to the UPP inequality standard of formal falsification ($\xi < 1$).

Utility—formal usefulness or functionality, usually as decided or evaluated by agents with reference to their desires and goals. A more objective concept of "utility" might be found in the biofunctionality of molecular machines, for example, with reference to the holistic metabolic goals of cells and organisms.

Vesicles—a complex version of the micelle containing one or more phospholipid bilayers that can enclose, transport and digest other substances. Cellular vacuoles, lysosomes, transport and secretory vesicles in living organisms have attracted much attention as models of possible protobionts (protocells) with crude "membranes." Phospholipids can form bilipid layer walls of artificially prepared liposomes.

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