Prescriptive Information (PI)

David L Abel
Director, The Gene Emergence Project
Department of ProtoBioCybernetics/ProtoBioSemiotics
The Origin of Life Science Foundation, Inc.

Scirus Sci-Topics Page

Semantic (meaningful) information has two subsets: Descriptive and Prescriptive. *Prescriptive Information (PI)* instructs and programs. When processed, PI is used to produce nontrivial formal function. [1] Merely describing a computer chip does not prescribe or produce that chip. Thus mere description needs to be dichotomized from prescription.

Computationally halting cybernetic programs and linguistic instructions are examples of Prescriptive Information. "Prescriptive Information (PI) either tells us what choices to make, or it is a recordation of wise choices already made."[1]

Not even semantic Descriptive Information (DI) is achievable by inanimate physicodynamics.[2-6] Measuring initial conditions in any experiment and plugging those measurements appropriately into equations (e.g., physical "laws") is formal, not physical. Cybernetic programming choices and mathematical manipulations are also formal.

The specific term PI originated out of a need to qualify the kind of information being addressed in peer-reviewed scientific literature. Shannon measured only probabilistic combinatorial uncertainty. Uncertainty is not information. It is widely recognized that even reduced uncertainty ("R," poorly termed "mutual entropy") fails to adequately describe and measure intuitive information. Intuitive information entails syntax, semantics and pragmatics. Syntax deals with symbol sequence, various symbol associations, and related arbitrary rules of grouping. Semantics deals with the meanings represented within any symbol system. Pragmatics addresses the formal function of messages conveyed using that symbol system.

Most research into the nature of intuitive and semantic information has unfortunately centered primarily on description. But the formal function instructed or actually produced by PI is far more important than mere description. PI prescribes and controls physical interactions so as to create and engineer sophisticated formal function. The latter is the subject of both cybernetics and systems theory.

We must remember, however, that not even PI *does* anything on its own. It must be acted upon. PI *must be processed*. In addition, the processing of PI is itself just as formal as the PI it processes. Physicodynamics cannot generate PI or its processing. Both require Choice Determinism (CD) in addition to Physicodynamic Determinism (PD).

Semiosis is the sending and receiving of meaningful messages. PI is often contained within meaningful messages. The sender must choose with intent from among real options at bona fide decision nodes. Letters, for example, must be purposefully selected from an alphabet at each locus in a string of symbols in order to spell words and sentences. In a sense, even description is a subset of prescription. All descriptions must themselves be prescribed.

Both sender and receiver must be privy to and abide by the same set of arbitrary rules for the message to be understood at its destination. By "arbitrary" we do not mean "random." Arbitrary means, "Could have been other" despite occurring in a physicodynamically determined world.

No random number generator has ever been observed to generate a meaningful message or a non-trivial computational program. No physical law can determine each selection, either. If selections were dictated by law, all selections would be the same. This would make recording PI impossible. Uncertainty (measurable in bits) is necessary at bone fide decision nodes. But bits of uncertainty cannot measure purposeful choices, the essence of PI. The regularities described by physical laws oppose uncertainty and information *potential*. Law-like behaviors manifest a probability approaching 1.0, while maximum binary uncertainty approaches a probability of 0.5 in the opposite direction. Maximum quaternary uncertainty (with four independent and equiprobable possibilities) approaches a probability of 0.25. Neither physicodynamic law (necessity) nor random coursing through mere "bifurcation points" can explain the formal semiosis and pragmatic controls of PI.

Formal choices of mind can be recorded into physicality through the purposeful selection of unique physical objects called "tokens." A different formal meaning and function is arbitrarily assigned to each token. Formal rules, not laws, govern the combinations and collective meaning of multiple tokens in a Material Symbol System (MSS).[7,8] The recordation of successive purposeful choices into an MSS allows formal PI to be instantiated into a physical matrix.

Letters written with ink molecules on molecules of paper is an MSS. The written letters are technically a form of physical tokens, the same as arranging Scrabble tokens to spell words on a game board. Even speech (verbal semiosis) of PI (instructions) is an MSS. We use different frequencies, volumes, inflections and rhythms of physical sound waves to instantiate formal PI into physicality.

Another means of instantiating non-physical formal PI into physicality is through the programming of configurable switches. Although configurable switches are themselves physical, their settings are uniquely designed to be physicodynamically indeterminate. The setting of each switch is decoupled from or incoherent with physical cause-and-effect determinism.[8,9]

Configurable switches can only be set by non-physical formal choice contingency. This is why we call them "configurable." Physics and chemistry cannot cause or explain their specific utilitarian settings. Circuits are integrated and systems are organized through particular programming choices at each configurable switch. A computer program is a sequence of binary configurable switches set to either the "On" or "Off" positions by purposeful choices.

DNA strings are formed through the selection of one of four nucleotides at each locus in a string. These programming choices at quaternary decision nodes in DNA sequences must be made prior to the existence of any selectable phenotypic fitness (The GS Principle).[10,11] Natural selection cannot explain the programming of genetic PI that precedes and prescribes organismic existence.

The informal adjective "prescriptive" has been used for decades, if not centuries, to describe functional information. But, the formal term "Prescriptive Information (PI)" first appeared in scientific literature in 2004,[12] although its unnamed uniqueness and importance was delineated

earlier.[13,14] The formal term of PI was further developed in "More than metaphor: Genomes are objective sign systems."[15,16] The "meaning" (significance) of Prescriptive Information (PI) is the function that information instructs or produces at its destination, upon being processed. The definitive paper on prescriptive information, especially as it relates to genetic and epigenetic controls of living metabolism, was literally "in press" for nearly two and a half years. It finally appeared in peer-reviewed literature in April of 2009.[1]

A closely related and integral concept of prescriptive information is *Functional Sequence Complexity (FSC).*[17] FSC addresses the unique ability of linear digital symbol systems to represent and provide integrative controls of physical systems. A method exists to quantify FSC, including the FSC of nucleic acids and proteins.[18,19]

Szostak et al have shared in emphasizing the need to further qualify the nature of functional information.[20,21] Their attempts to quantify functional information, however, fail to actually measure functional/semantic information.[22]

Important terms relating to PI include *Choice Contingency*, as opposed to mere Chance Contingency and law-like necessity. [22,23] *The Cybernetic Cut* defines a seemingly infinitely deep ravine that divides mere physicodynamic constraints from formal controls.[24-26] *The CS Bridge* is the one-way bridge across The Cybernetic Cut made possible through instantiation of formal choices into physical configurable switch-settings.[24,26] No one has ever observed PI flow in reverse direction from inanimate physicodynamics to the formal side of the ravine—the land of bona fide formal pragmatic "control." *The GS Principle* states that selection for potential function must occur at the molecular-genetic level of nucleotide selection and sequencing, prior to organismic existence.[10,11] Differential survival/reproduction of already-programmed living organisms (natural selection) is not sufficient to explain molecular evolution or life-origin.[25,27-29] Life must be organized, prescribed and processed into existence. It must also be managed by Prescriptive Information (PI) found in both genetic and epigenetic regulatory mechanisms. The environment possesses no ability to program linear digital folding instructions into the primary structure of biosequences and biomessages. The environment also provides no ability to generate block codes (e.g. triplet codons that preclude noise pollution through a 3-to-1 symbol representation of each amino acid).[15,16] The

environment cannot decode or translate from one arbitrary language into another. The codon table is arbitrary and physicodynamically indeterminate.[8,9] No physicochemical connection exists between resortable nucleotides, groups of nucleotides, and the amino acid that each triplet codon represents. Although instantiated into a material symbol system, the prescriptive information of genetic and epigenetic control is fundamentally formal, not physical.

References:

1. Abel DL. The biosemiosis of prescriptive information. *Semiotica.* 2009;2009(174):1-19 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
2. Pattee HH. Laws and constraints, symbols and languages. In: Waddington CH, ed. *Towards a Theoretical Biology.* Vol 4. Edinburgh: University of Edinburgh Press; 1972:248-258.
3. Pattee HH. Evolving Self-Reference: Matter, Symbols, and Semantic Closure. *Communication and Cognition-Artificial Intelligence.* 1995;12:9-28.
4. Pattee HH. Artificial Life Needs a Real Epistemology. In: Moran F, ed. *Advances in Artificial Life*. Berlin: Springer; 1995:23-38.
5. Pattee HH. The physics of symbols: bridging the epistemic cut. *Biosystems.* Apr-May 2001;60(1-3):5-21.
6. Pattee HH. Irreducible and complementary semiotic forms. *Semiotica.* 2001;134:341-358.
7. Rocha LM. Syntactic autonomy: or why there is no autonomy without symbols and how self-organizing systems might evolve them. *Annals of the New York Academy of Sciences.* 2000:207-223.
8. Rocha LM. Evolution with material symbol systems. *Biosystems.* 2001;60:95-121.
9. Rocha LM, Hordijk W. Material representations: from the genetic code to the evolution of cellular automata. *Artif Life.* Winter-Spring 2005;11(1-2):189-214.
10. Abel DL. The GS (Genetic Selection) Principle. *Frontiers in Bioscience.* 2009;14(January 1):2959-2969 Open access at http://www.bioscience.org/2009/v2914/af/3426/fulltext.htm [Last Accessed March, 2015] Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
11. Abel DL. The Genetic Selection (GS) Principle. In: Abel DL, ed. *The First Gene: The Birth of Programming, Messaging and Formal Control*. New York, N.Y.: LongView Press--Academic; 2011:161-188 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
12. Trevors JT, Abel DL. Chance and necessity do not explain the origin of life. *Cell Biol Int.* 2004;28(11):abel729-739.
13. Abel DL. Is Life Reducible to Complexity? Workshop on Life: a satellite meeting before the Millennial World Meeting of University Professors; 2000; Modena, Italy.
14. Abel DL. Is Life Reducible to Complexity? In: Palyi G, Zucchi C, Caglioti L, eds. *Fundamentals of Life*. Paris: Elsevier; 2002:57-72.

15. Abel DL, Trevors JT. More than metaphor: Genomes are objective sign systems. *Journal of BioSemiotics.* 2006;1(2):253-267 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
16. Abel DL, Trevors JT. More than Metaphor: Genomes are Objective Sign Systems. In: Barbieri M, ed. *BioSemiotic Research Trends*. New York: Nova Science Publishers; 2007:1-15 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
17. Abel DL, Trevors JT. Three subsets of sequence complexity and their relevance to biopolymeric information. *Theoretical Biology and Medical Modeling.* 2005;2:29-45.
18. Durston KK, Chiu DK, Abel DL, Trevors JT. Measuring the functional sequence complexity of proteins. *Theoretical biology & medical modelling.* 2007;4:Free on-line access at http://www.tbiomed.com/content/4/1/47.
19. Durston KK, Chiu DKY. Functional Sequence Complexity in Biopolymers. In: Abel DL, ed. *The First Gene: The Birth of Programming, Messaging and Formal Control*. New York, N.Y.: LongView Press--Academic, Biol. Res. Div.; 2011:117-133.
20. Szostak JW. Functional information: Molecular messages. *Nature.* Jun 12 2003;423(6941):689.
21. Hazen RM, Griffin PL, Carothers JM, Szostak JW. Functional information and the emergence of biocomplexity. *Proc Natl Acad Sci U S A.* May 15 2007;104 Suppl 1:8574-8581.
22. Abel DL. *Primordial Prescription: The Most Plaguing Problem of Life Origin Science.* New York, N.Y.: LongView Press Academic; 2015.
23. Abel DL, ed *The First Gene: The Birth of Programming, Messaging and Formal Control.* New York, NY: LongView Press-Academic; 2011.
24. Abel DL. The 'Cybernetic Cut': Progressing from Description to Prescription in Systems Theory. *The Open Cybernetics and Systemics Journal.* 2008;2:252-262 Open Access Also available from http://lifeorigin.academia.edu/DrDavidLAbel
25. Abel DL. Constraints vs. Controls: Progressing from description to prescription in systems theory. *Open Cybernetics and Systemics Journal.* 2010;4:14-27 Open Access at http://benthamopen.com/contents/pdf/TOCSJ/TOCSJ-14-14.pdf Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
26. Abel DL. The Cybernetic Cut and Configurable Switch (CS) Bridge. In: Abel DL, ed. *The First Gene: The Birth of Programming, Messaging and Formal Control*. New York, N.Y.: LongView Press--Academic, Biol. Res. Div.; 2011:55-74 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
27. Abel DL. The capabilities of chaos and complexity. *Int. J. Mol. Sci.* 2009;10(Special Issue on Life Origin):247-291 Open access at http://mdpi.com/1422-0067/1410/1421/1247 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.
28. Abel DL. The Universal Plausibility Metric (UPM) & Principle (UPP). *Theor Biol Med Model.* 2009;6(1):27 Open access at

http://www.tbiomed.com/content/26/21/27 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.

29. Abel DL. The three fundamental categories of reality. In: Abel DL, ed. *The First Gene: The Birth of Programming, Messaging and Formal Control*. New York, N.Y.: LongView Press-Academic: Biolog. Res. Div.; 2011:19-54 Also available from http://lifeorigin.academia.edu/DrDavidLAbel.