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Are Life and Meaning Coextensive?*

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Abstract

There are a small number of key evolutionary developments which our attention is drawn to. One of those is the nature and origin of living systems, another that of semiotic systems. The former category has a common sense meaning (whether or not it is a good one), while the latter can be characterized as an entity, typically an organism, which manifests or embodies semantic relations. Semantic relations are particular regularities which result from some form of "rule following" or "meaningfulness", where there is necessity at one explanatory level, but contingency at another. The core question for systems theory is a question of biosemiotics: to what extent are the classes of biological and semiotic systems identical or distinct? A working null hypothesis is that they are equivalent, so the burden is to find counter-examples or counter-arguments. Morowitz has moved in this direction by suggesting a simple, metabolic, non-genetic evolutionary history of primordial living systems which are non-semantic.

Keywords: Life, origin of life, semantics, semiotics, meaning, codes, Harold Morowitz, semiotic systems, biosemiotics, systems science, evolution, control.

1 Introduction

The purpose of this paper is to lay out the structure of an argument about what our understanding of the proper relation between the categories of living and semiotic (semantic) systems is or should be. I will attempt to identify important conceptual distinctions which could be made, decision points in the argument, and what's at stake at each step.

My fundamental perspective is that of a systems scientist, attempting to develop theories and components of theories (concepts, explanatory principles, modeling methods) which span system types and disciplinary boundaries. Thus my attitude is necessarily interdisciplinary and conceptual, and concerned with *general* evolutionary theory.

From within that research context, in order to test our ideas about the nature of complex, evolved systems, we pursue a number of different direction simultaneously: we generalize to the broadest possible interpretations; simplify as much as possible in terms of the real systems being examined; and consider the discrete evolutionary steps from which these qualitatively new forms of organization arose. For example, when looking at the nature of human cognition, we are drawn to consider non-human cognition, then non-human cognition in very simple animals like worms, and finally the origin of neural systems in general.

Continuing in this manner leads quickly to a knot of the questions which are central to systems science: what is the nature and origin of information? of meaning? of control? ultimately, of life? Furthermore, what are the relations among these ideas?

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2 Methodological Preliminaries

I would like to begin with a bit of "meta-argument", examining the methodology which is brought to bear in this kind of discussion.

2.1 Necessity, Sufficiency, and Contingency

In this paper we will consider whether there is any necessary relation between the classes of living and semiotic systems. In so doing, I will distinguish between two different senses of necessity.

What I will call "extensional necessity" is contrasted with "sufficiency". Saying that a class or property A is extensionally necessary for a class or property B is simply saying that the class B is included in the class A. So asking about the extensional necessity between the classes A and B leads to questions as to whether they overlap, whether one is included within the other, or whether they are identical classes.

This is an expression of material entailment as a matter of *fact*, that all existing B's *are* A's, for whatever reason. Perhaps it is because of an accident of history; perhaps it is because of some other causal factor or force. For example, there are no New World elephants, so living in the Old World is extensionally necessary for being an elephant. It remains to be seen whether there is something in the Americas which is deadly to elephants, or whether they could be introduced and thrive.

Extensional necessity contrasts with what I will call "ontological necessity", which is itself contrasted with "contingency". Saying that a class or property A is ontologically necessary for a class or property B is saying that B requires A because of the *nature* of A and B, because of some causal relation or property of natural law. Otherwise the relation would be ontologically contingent. This is clearly a stronger expression of material entailment as a matter of *truth*, that all B's *must* also be A's, or otherwise they simply *could not* be B's.

For example, breathing air is ontologically necessary for me, but living in the United States is (ontologically) contingent. Asking about ontological necessity between the classes A and B leads to questions as to whether it *could have been otherwise* that there is a given relation between A and B.

2.2 On Definitions

In this discourse there is a great deal of discussion about a wide range of very complicated and difficult ideas, and it is not uncommon to have raging arguments about the meanings of terms. So perhaps in this community more than any other, it is absolutely vital to pay close attention to definitions, and to try to forge some kind of consensual meaning. When I expound a theory of "life", or "information", what am I actually talking about? Whatever it is, is it the same as what you mean? If not, then we will simply be arguing past each other.

It should also be clear just what is at stake in such semantic argument, that is, in argument about the meanings of terms. Definition-making is an action of people taken for the specific purpose of parsimoniously capturing appropriate and meaningful distinctions, and identifying them with particular linguistic markers (terms). Further, the purpose of propounding certain definitions within a linguistic community is to bring others to make those same distinctions, and for those terms to be shared among them.

It should be clear that the purpose of working with definitions is not to *discover* the "true" meaning of a term. Nor should the purpose be (only) to win an argument. Thus there is a clear distinction between "mere" semantic "quibbling" over the usage of terms and a reasoned, deliberate, valuable, and fundamental argument about which semantic distinctions are significant, and what their appropriate linguistic labels should be.

Little is at stake in the choice of specific words for specific concepts, except, of course, for the *rhetorical* value gained in the battle of the *politics* of ideas. Perhaps the most cogent example from within this community is Shannon's mathematical measure of the spread of a probability distribution. Whether we call this quantity a "dispersion", an "information", or an "entropy", the formalism remains unaffected. But the result is decades of confusion among generations of scientists.

Nor should semantic argument necessarily go on prior to or be cleanly separated from the rest of an argument. That is, any hope that we would all sit down together, decide on the usage of terms, and only then go on to engage in argument using those terms, is vain. Rather, argument should proceed at both levels complementarily and simultaneously, with a vigorous interplay between argument *within* and *about* the linguistic frame.

The point is that there are vastly more *concepts* that we wish to discuss than there are specific *terms* to use. Therefore the key is to clearly distinguish *senses* of terms from each other, and then appropriately and consistently identify them with specific qualified terms or phrases. So, for example, if two scientists A and B are arguing about the proper use of the term "complexity", they should simply identify two senses complexity_A and complexity_B. It may turn out through their discussion that one sense is a case of another, or that a different term (say "organization", or "information") would be more appropriate for one sense or the other. The goal is to reduce the overall set of required terms, where possible, and where not, to achieve the "null consensus" of simply agreeing to disagree. In this way, a linguistic community can move towards a consensual basis for usage and meaning.

3 Semantics and Life

In surveying the broad spectrum of scientific problems and issues, it is clear that there are a small number of key developments in general evolutionary history which our attention is drawn to. One of those is the nature and origin of living systems. Another is the nature and origin of what I will call "semiotic systems". We can *a priori* consider these classes of systems to be independent of each other, and then go on to consider what their proper relation is. In particular, we are interested in deciding what the relations of necessity, sufficiency, and contingency are among them, if any.

The category of living systems has a common sense meaning (whether or not it is a good one), and in the spirit of the discussion about definitions from the previous section, this is what will be adopted uncritically here. But the latter category of semiotic systems requires some elaboration.

3.1 Living Systems

When it comes to the class of living systems, we have a general idea of what we mean. There is, of course, significant debate over an appropriate definition of life, and to what extent pursuing such a definition is feasible or worthwhile. For example, is it useful to consider applying either the crisp label "living" or "nonliving" to an organism, or is it more valuable to introduce degrees of living-ness (for example, for a virus)?

It is useful here to identify at least the following schools of thought about definitions of life:

- From the perspective of the **relational biology** school of Rashevsky and Rosen, Rosen defines life as "closure to efficient causation" (Rosen 1991).

- In the **biosemiotics** school, including Sebeok (1992) and Hoffmeyer (1991), the presence of life in a system can be understood as equivalent to the presence of meaning in that system. Whether the simultaneous origins of life and meaning are contingent or necessary is partly the question of this paper.

- Similarly, in the **control theory** school of William Powers, the presence of life in a system can be understood as equivalent to the presence of control in that system (Powers 1973, 1989, 1995). There is some further question as to what extent the presence of control is equivalent to the presence of meaning.

- Finally, Morowitz (1992) favors a gradual view of a *movement towards* life, rather than a distinct *origin of* life. His perspective emphasizes energetic and metabolic processes over information, meaning, and reproduction. This will be discussed more below.

3.2 Rules, Codes, and Semiotic Systems

I think of a semiotic system as a real entity (typically, although perhaps not necessarily, an organism) which manifests, embodies, or in other ways "makes actual", semantic relations (Joslyn 1995). In turn, a semantic relation is a particular regularity or stability in a system which cannot be explained by natural law alone, but rather results from some form of "rule following" (to use Pattee's (1991) terminology), or "meaningfulness".

Consider a system S wherein two sets of phenomena $A = \{a\}$ and $B = \{b\}$ are related according to such a regularity or stability. This situation can be represented by denoting $S = \langle A, B, f \rangle$, where f is a functional relation or entailment $f \colon A \mapsto B$, where for each $a \in A$, there is a corresponding $b = f(a) \in B$. While in general there are many such possible functions f, at any particular time only one particular f is present.

When f is a law then it is ontologically necessary in all ways (in this universe, at least): nature supplies us, or rather we discover in nature, the particular regularity f which holds within S, and from that for a given a can predict the associated $b = f(a)$. But when f is a rule, then it is extensionally necessary at one explanatory level, but contingent at another. As with the law, once f as a rule is established *within* S, then f must necessarily be followed *by* S: $f(a) = b$. But *which* rule f among a class of rules is or has been selected or manifested by S is *contingent* at least on that system's evolution and history, and perhaps on its design by a human agent.

This combination of fixedness and arbitrariness is familiar to us from semiotics as being a hallmark property of symbols, and codes (Deely 1990, Sassure 1959). It is clear that a acts to "stand for" b in virtue of the coding f; a is the signifier or sign-vehicle, b the signified or object, and f the sign function; a is what is interpreted, b the interpretation, and f the interpreter; a is the token, b the referent, and f the code.

But further, in a symbol (for Peirce) the relation between the signified and the signifier, that is the nature of the code or sign-function, is necessarily an *arbitrary* one, without "motivation". At the individual level, I am free to construct any coding I choose, to have anything stand for anything else I wish. At the group level, each linguistic community evolves in a unique historical direction, with a unique lexicon. Codes act as rules, not laws.

Thus all semiotic systems, as so characterized, are dependent on the semiotic frame of reference established by the coding f. The manifestation of the code is the *action* of interpretation, of the system taking a's for b's in virtue of the coding $f(a) = b$. The semantic boundary imposed by f also marks the limit of the semiotic system's subjectivity: it is that entity which establishes the code which is the system's interpreter. Pattee (1982) refers to this property as "semantic closure", which can be briefly stated as the requirement that the interpreter of a semiotic system is also a referent (an a) of that system. It is through the manifestation of a code, that is through the action of interpretation by an interpreter, that meaningfulness is introduced into the world: within S, b means a to the subject, that is, to the interpreter.

3.3 Coding in Living Systems

The perspective of "biosemiotics" (Deely 1992) examines the role of semiotics in biology, for example in intra-organismal communications systems (hormones, neuroreceptors, genetic bases, and biomolecular recognition and memory in general); and similarly the role of biology in semiotics (to what extent are sign-functions determined by an organism's biology and evolution).

Thus the core question for systems theory is a question of biosemiotics: to what extent are the classes of biological and semiotic systems identical or distinct? But living systems are complex, with many aspects and components. So in answering this question, it is first necessary to consider *where* in an organism coding is present.

Obviously, genetics is the first thing which comes to mind. The genetic code is itself a prime example of a semantic relation, mapping codons to amino acids in an ontologically contingent manner. Since its discovery, this analogy has fueled generations of scientific speculation about the informational basis of life, the role of meaning and interpretation, and biological semiotics in general.

At a completely separate level of analysis is the active, ongoing control relations manifested between an organism and its environment. Unlike genetics, it is not at first clear why this is a semantic relation. As an example, consider a simple organism O which lives near an oceanic thermocline with warm water above and cold water below. O has an internal variable of temperature which can be either too hot, too cold, or just right, and it can take the actions of going up, going down, or doing nothing.

There are many possible relations between the internal temperature and the action performed, many different ways that O can react to a change in temperature. But only some are consistent with life. In particular, if O goes up when hot, and down when cold, then positive feedback will lead either to a floating, baked O or a sunken, frozen O; other relations result in negative feedback, and a comfortable, swimming O.

O will perform behaviors consistent with life because it possesses certain biological structures, typically neural, which provide it with certain instincts. But what is crucial to realize is that the nature of these biological structures, the functions of these instincts, are not ontologically necessary. There is no *a priori* physical reason for O not to rise when hot, no ontological necessity or fundamental natural law for it to sustain itself near the thermocline: O *could have been* wired differently.

But if so, such organisms would die rather quickly, and certainly not survive to reproduce. Thus the effect of the reproductive process is that O's behavior be established within the O as a contingent rule in virtue of the evolution of the Os. Thus the relation between the perception and the action of the organism is a semantic relation, and in fact a control relation (Joslyn, 1995).

It should be clear that this semantic relation is completely distinct from that of the genetic level. Although no doubt O's instinctive behavior is genetically coded, presumably other genes could result in the pathological behavioral pattern.

Furthermore, it should be recognized that a consequence of this position is to say that for O "too hot" actually *means* "go down", and "too cold" actually means "go up". While this can be argued, it is a very interesting view.

4 The Relation of Life to Meaning

So finally we are ready to consider the proper relation between living-ness and meaningful-ness in systems. The question in general is whether, and how to determine whether, coding is either extensionally or ontologically necessary for life, and vice versa. More specifically, we would wish to ask this question of the various components of life: metabolism, replication, evolution as variation with selective retention, and the control relations between organisms and their environment. Such a detailed task is perhaps beyond the scope of this paper, but we can take a shot at the general question.

A working null hypothesis is that there is an **ontologically necessary extensional equivalence** between the class of living systems and the class of semiotic systems; in other words, that it is not contingent that living systems are both extensionally necessary *and sufficient* for semiotic systems. Or, stated yet another way, that (extensionally) all living systems are semiotic, and vice versa; but further that this is not an accident of history, but rather an ontological necessity. We will now go on to consider this hypothesis in detail, and see what is at stake at each stage.

4.1 Extensional Necessity

First, we consider the question "is life necessary for meaning?" in the sense of extensional necessity. For this to be true, then all semiotic systems must be biotic. As we review the cases of semiotic systems, at first this appears to be the case: semantic relations appear only in the living world.

But then we consider tools and machines, and more generally our semiotic productions like languages and texts. These are unquestionably semiotic systems, in that there is a rule-like, semantic relation between a tool and its use. But also clearly a hammer is not alive.

However, it can be observed that extant rule-following systems are either organisms or *require the presence and action of* organisms. That is, nonliving semiotic systems exist only as *used by* living systems. So while a linguistic utterance is a semiotic production of a person, so is the written form or the tool produced by that person. They are thus logically considered as *extensions* of the semantic space of the organism. For Pattee (1982), all of these entities are part of the *semantic closure* of the organism.

Now given the extensional necessity of life for meaning, what about the ontological necessity? To say that it is ontologically necessary that life is extensionally necessary for meaning is to say that only living systems are *capable* of manifesting codes. And this is indeed a strong statement. What is it about the *ontological* nature of living systems, as opposed to their historical development, which results in this? This is indeed a mystery to me at this point.

But on the other hand, if life's necessity for meaning is contingent, then it must be possible for there to be semiotic systems which are not alive, and do not include living systems in their semantic closures. If so, then why have they not been realized on the Earth? Is it possible for them to be so realized in the future, either on the Earth or elsewhere? Is it possible for them to be constructed or grown by us, but *outside* or our semantic closures? Indeed, what would that even mean, if we attempted this move: what is there that we affect which is *not* within our semantic closure?

4.2 Extensional Sufficiency

The converse of the previous case is the question "is life sufficient for meaning", or equivalently "is *meaning* necessary for *life*", again in the sense of extensional necessity. For this to be true, then all living systems are semantic. Again, on the surface this appears to be true. As argued above, any organism using the genetic code manifests semantic relations in virtue of that coding.

The universality of basic biochemistry and the metabolic chart would then seem to clench the argument.

So here, the real question is about the ontological necessity or contingency of this result. Consider that it would be ontologically necessary for living systems to be semantic, that there would be some law of nature which required life in the presence of semantics. The results are quite striking: given that the universe is so constructed that life requires semantics, and furthermore (from above) that conversely all semantic systems are biological (whether this is ontologically necessary or not), then it is natural to advance semantic relations as the *key explanatory principle of life*.

Indeed, there is little to separate this view from the desire to advance semantics as the much sought-after *definition* of life, the "holy grail" of theoretical biology. Of course, there is a vitalistic danger in this view, merely reducing one phenomenon (life) whose origins and nature are difficult to explain to another (semantic relations). But on the other hand, if semantics does in fact emerge as the necessary *and sufficient* condition for life, and furthermore that this is an ontological necessity, then there would be little to stand in our way from making this move.

But of course there is no *a priori* reason to accept the ontological necessity of the extensional sufficiency of life for meaning. Rather, we could entertain the view that coding is "merely" a catalyst for the processes of living systems, simply a vast expedient. And indeed, there are good arguments for this view, and possibly good counterexamples to the converse.

This view is, in fact, that of Morowitz (1992) mentioned above. He has long challenged the traditional "RNA world" view of the origins of life by theorizing about the relatively late appearance of nitrogen, and therefore nucleic acids and genetic coding, in prebiotic evolutionary history. Morowitz's program is a bold effort to approach the origins of life problem the "orthodox" way: through chemistry. Thus his view of Artificial Life (AL) would be as an attempt to produce *real* AL by forming objects resembling organisms (protocells) in the laboratory setting: "Biogenesis must be pursued as an experimental science" (Morowitz 1992, p. 97). A brief appendix suggests that he and his colleagues have made some progress towards this goal, in particular, by producing non-enzymatic catalysis in a non-biotic flask-type experiment. Indeed, Morowitz has recently said that they have been hesitant to publish their recent experimental results in order to avoid a "cold fusion effect".[1]

What would a counterexample of a non-semantic, but nevertheless biotic, system look like? Morowitz has offered some tantalizing suggestions. Morowitz's basic premise is to turn the traditional Miller-Urrey (1959) approach to biogenesis on its head. Rather than a "primordial soup" of prebiotic organic monomers and macromolecules, within which is established a complex set of reactions eventually leading to vesicle formation, he proposes the formation of closed ampiphilic (lipid) bilayer membrane vesicles very early. Echoing the autopoeitic theory of Maturana and Varela (1974), these protocellular vesicles provide the key property of systems formation: a thermodynamic boundary dividing system from environment, and establishing a three-way phase separation across which energy and molecules are asymmetrically transported. Just by itself, this could result in protocellular growth, division, and replication.

A number of conditions are required, including:

- Catalysis in the absence of nitrogen, and thus of enzymes;
- Early proto-photosynthesis, as an early source of energy input to the protocells, in the form of photonic energy transport mediated by a variety of non-clorophyl pigments (chromophores and retinals); and

[1]personal communication, November 1994.

- Electron and proton transport, mediated by a variety of non-protein molecules adsorbed within the protocellular walls, to facilitate redox and acid-base reactions respectively.

Thus Morowitz is able to articulate the startling image of proto-biotic cells within which the emergence of non-genetic molecules provides increased fitness through the reflexive action of auto-catalysis, increased energy transduction, or increased transport of its own chemical constituents. But through the differential production and faithful reproduction of various forms of protocells with different species and concentrations of molecules, and therefore different chemical networks and cycles, all of these cases would result in a form of non-genetic, but nevertheless Darwinian, variation, selection, inheritance and evolution.

Note that Morowitz claims that the early stages of cellular evolution went on for millions of years without any genetic coding. This is accomplished strictly through carbon-based reactions, independent of amino acids and peptides, not to mention the far more complex machinery of enzymatic catalysis, RNA transcription, and protein synthesis. For him, these necessarily semiotic components of extant living systems are simply *not relevant* for biogenesis.

5 Conclusions

We have considered what the proper relation is between the classes of semiotic and living systems, both extensionally and ontologically, in the context of a circumspection about the making of definitions. Morowitz provides a major challenge to the null hypothesis that the constellation of properties including meaning, control, information, semantics, and semiotics is roughly equivalent to that of life, and furthermore that this is ontologically required.

The essence of that challenge is the idea that proto-life evolved for millions of years in a non-genetic context, and that this implies a non-coded, non-semantic, non-semiotic context. The question then becomes, if coding and semantics are not *necessary* for life, what *is* the role of coding in biological evolution?

Of course genetic (coded) variation and selection has been the central mechanism for the vast preponderance of evolutionary history. Further, von Neumann (1966) has made the strong argument that open-ended evolution *requires* symbolic representations and coding. But it is well known that complex self-organization exists in purely physical systems, and Morowitz also strongly argues that heritable variation and selection are possible without coding. So presumably there is some kind of qualitative difference between Morowitzian evolution and genetic evolution, and this remains to be explicated. But the hypothesis that there is a large *quantiative* advantage to genetic evolution—a quantity which, as they say, has a quality all its own—can also not be rejected.

Given Morowitz' claimed empirical results, this question may shortly be decidable. If it turns out that this is a valid criticism, then the danger of identifying meaning and information as the vitalistic principle of life may be able to be avoided.

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