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Biosemiotics' greatest potential contribution to biology

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Abstract: Encouraging biologists to factor semiotics into their research is likely to fall on deaf ears because they already factor it in through an accepted life science methodological standard here called *Abstract Parallel Engineering* (APE). Biosemiotics' most significant contribution to biology – a contribution that biologists would come to depend upon – would be a more rigorous alternative methodology to APE through a proof-of-concept explanation for how semiotics – here defined as beings making functional interpretive effort – can emerge within nothing but physical phenomena. It would explain organisms' most basic agency – their struggle for existence – *ergodynamically* (i.e., an emergent change in likely physical work) that results in work (effort) that works (functions) to keep a chemical system working (a being) in semiotic response to their workspace (interpretation).

Keywords: agency; emergence; function; interpretation; semiotics

1 Introduction

If biosemiotics' core thesis is that biology is semiotic, this is not news to biologists. Biology already assumes that information is fundamental to living systems. Biology's central dogma recognizes the flow of genetic information (i.e., signs) from DNA to RNA to the production of functional proteins. What, then, is biosemiotics' most significant potential contribution to biology, a contribution that biology and the life sciences would come to depend upon?

Perhaps biosemiotics is not really a separate research topic. Perhaps it's just biology research by a different name. Or perhaps its greatest contribution would be a theory of everything semiotic in biology, a central dogma of signs, a systematic way to describe information processes in biological systems based on the simple assumption that signs are somehow different in the context of living systems without explaining how or why.

Here I will argue that there's a greater potential contribution to be made – a scientific explanation for how semiotics, signs, and information emerged at the

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origins of life. I won't offer or promote that contribution by offering a hypothesis for how semiotics emerged at the origins of life. Still, I should disclose that my argument is derived from an exemplar of the methodology I suggest. I have worked closely with Terrence Deacon for 26 years. This paper attempts to extract what distinguishes his research methodology from normal life and social science today. At the end of this paper, I touch on some of his contributions, but they are not the focus here.

Instead, I'll focus on the methodological paradigm shift that would be necessary in order to provide such an explanation. I will argue that the normal-science methodological paradigm in biology and biosemiotics diverts attention from explaining the emergence and nature of semiotics in biology. I will call this normal-science methodology *Abstract Parallel Engineering* (APE).

APE is an entrenched human tendency to imagine engineering unexplained phenomena and to assume that our imagined models are not merely descriptive but explanatory.

APE is the intuitive, folk means by which humans speculate about anything from cars to bodies to societies. People who don't know how computers work can still model them intuitively using APE, positing categories of physical/functional black boxes, for example, keyboard, audio, and video processors, all assembled and connected somehow to an information processor. A refrigerator is likewise a box attached to a cooling gizmo. A car is a box on wheels with a motion-generating device that somehow converts gas into motion.

People who know little about how human bodies work can generate APE models: Bodies have a physical-functional pump (heart) connected to a physical-functional ventilator (lungs) connected to other physical-functional units. It's no wonder that APE is the human forte. We live and breathe symbols and technology. We naturally assume everything is a describable machine.

APE serves well for everyday purposes. People don't need to know how a car, fridge, or body functions to use them. APE works for scientific description, too, just not for biological explanation. However, it's relied upon with increasing conviction, in large part because, between natural selection and computation, researchers have confidence that existing organisms simply evolved by natural selection and can be schematized like software and hardware.

The history of biology tracks ambivalence about explaining vs. explaining away semiotics and teleology in general. Natural selection was regarded as a death blow to vitalism that eliminated the need for teleological explanations. Neo-Darwinist Ernst Mayr redoubled this effort through his promotion of the post-hoc concept of teleonomy: "the Wood Thrush migrates in the fall in order to escape the inclemency of the weather," but put teleonomically, "the Wood Thrush migrates in the fall and thereby escapes the inclemency of the weather" (Mayr 1974: 14).

Biologists have neither eliminated nor embraced semiotics and teleology. Historian of science professor Jessica Riskin describes the vocational tightrope-walking in biology as expressed by a biologist friend:

> It is absolutely against the rules in her field to attribute agency to a natural entity such as, say, a cell or a molecule, but she also agreed that biologists do it constantly, just as a manner of speaking: they speak and write as if natural entities expressed all sorts of purposes and intentions, but they don't mean it literally. Sure, we do it all the time, when we're teaching, in lectures, even in published articles. But it's just a sort of placeholder for things we don't know yet. The more we get to know, the less the phenomena will seem purposeful. (Riskin 2015: 13)

In practice today, biologists employ APE on the tacit assumption that life is simply different from physics because it involves DNA and natural selection even though neither a molecule nor a process of elimination can explain the struggle for existence. APE assumes parallel, dual-aspect, physical-semiotic, or physical-functional components. It reverse engineers living systems the way a machine's architecture might be sketched on the back of an envelope.

APE simply posits and employs black-box components that need not be unboxed or constructed. The black boxes are ambiguously assumed to be either algorythmic processors or homunculi. It assembles these components as if connected by "black arrows" occult in that researchers tolerate ambiguity about whether the arrows are correlational, causal, or teleological.

APE models are abstract in two senses. Of course, all models are abstractions. The question then is what a model ignores. APE models are abstracted away from the physical work necessary to generate and maintain the functional phenomena in question. For example, in evolutionary theory, the physical work required for gene replication is commonly ignored. Likewise, in biosemiotics, the physical work whereby an interpretant is generated from a sign is commonly ignored.

Second, APE models are abstract in that unlike an engineer's models, APE models need never be constructed. To produce an artifact, an engineer must eventually unpack their black boxes. Not so with APE.

APE models are engineered or reverse-engineered. To generate them, one imagines assembling previously independent parts connected by "black arrows," as one would when engineering a machine. In contrast, most physiology is not assembled but differentiated, as in embryo development.

APE models are often detailed, intricate, and complex, incorporating math, computer simulations, diagrams, and technical language so complex that it conceals APE's lack of rigor. Such models often yield high predictive utility and practical insights. Indeed, over the centuries, they have yielded us life science's cornucopia of ingenious and life-saving insights.

Despite this great bounty, they only yield practical descriptions, predictions, and prescriptions, not explanations for life and semiotics. Through physical/functional dualism, they assume but don't explain how beings making functional interpretive effort are related to non-functional physical work. Hence, the gap between the physical and life sciences remains unbridged and often unnoticed.

In English, "to ape" is to copy closely but often clumsily and ineptly. In the life sciences, however, APE is a legitimized or at least tolerated source of equivocation. APE accepts naturalization without grounding – naturalization like rationalization – a contrivance that relies on crypto-Cartesian dualism while disavowing it.

Today's crypto-Cartesianism assumes dualism, software instantiated on hardware, like Descartes' mind/body dualism. Like res cogitans, software is treated as an immaterial abstract idealization. Software is immaterial and by itself does no physical work. Still, when instantiated on hardware, it yields functional work, as does Descartes' res cogitans on res extensa. Hardware is treated as res extensia, a non-degenerative material mechanism – non-degenerative in the sense that computer hardware is built for durability.

The instantiation of software on hardware is imagined to occur through some variation on Descartes' analytic geometry in which abstract symbols or codes manifest in res extensa.

My aim here is to suggest steps toward a rigorous scientific methodological alternative to APE. I will first argue that sign dynamics are distinct from physical dynamics not due to the existence of signs or information but due to the existence of interpreters, beings making functional interpretive effort on their own behalf. I will then demonstrate how, through APE, this distinction is often overlooked in both biology and biosemiotics, leading to confusion about how the life sciences distinguish the category life from non-life.

I will then explore abduction or categorization and highlight insights into making realistic categorical distinctions more efficiently. From these insights, I will suggest a more scientific approach to categorization than is employed in APE. I will then apply these insights to distinguishing semiotic responsiveness from strictly physical phenomena, thus proposing an often-overlooked potential contribution that biosemiotics could yield that biology would come to depend upon.

2 Biosemiotics is the study of interpretation, not signs

Occasionally, the name of a research topic hamstrings research with a false-start assumption. Teleology may be an example, suggesting that human- or godlike grand purpose rather than semiotic effort is what must be explained. Semiotics, literally the study of signs, may be another such term, since it identifies signs as the research topic rather than sign interpreters. Peirce's treatment of interpretants avoids the risks of psychologism but in so doing, falls by the end of his work into an eliminativist treatment that fails to distinguish between teleological and non-teleological dynamics.

Information theory may be similarly misnamed. The convergence of Neo-Darwinism, Shannon communication theory, and computationalism have given life scientists confidence in a metaphoric, reifying treatment of information as an object or a property that some or all material things possess (e.g., "information-bearing" molecules). In his article titled "Why do we need a semiotic understanding of life?" Jesper Hoffmeyer critiqued this "notion of information as something 'flowing,' 'running,' 'being passed on,' or 'transferred' from one place to another" (Hoffmeyer 2013: 136). This accepted reification is enabled by the term "sign."

The treatment of information flow in biology today is akin to how, before the discovery of thermodynamic explanations, caloric, a reified heat-bearing substance, was assumed to explain heat. Such reification is a typical stage in the development of human understanding given our symbolic and technical habits, which incline us to engineer with abstract impressionistic reified objects and processes. We conceive of phenomena most readily in terms of material cause-and-effect interaction. When we cannot explain a kind of interaction, we posit pseudo-material elements and forces to describe them.

Information is also a term of art in the physical sciences because all phenomena are measurable in Shannonian bits, which is a bit like saying that since roads can be measured in miles, roads are made of miles. Thus, some physicists claim that the whole universe is information.

This isn't the standard, practical meaning of information. Intuitively, signs are interpreted by living beings as *about* something useful for their effort. Though any physical phenomenon can become a sign, it does so only when it is interpreted by a living interpreter as functionally significant for some real, assumed, or imaginary interpreter, given that interpreter's aims.

Consider the respected science writer James Gleick's bestseller, *The information: A history, a theory, a flood* (2011). In this book, which won the Royal Society's Winton Prize, the word "information" appears over 500 times but "information about" appears only eight times, and "information for" an interpreter never appears.

By the end of the book's middle third on information theory, Gleick has endorsed the physical-science assumption that all phenomena in the universe are and have always been information. In the final third, Gleick explores the current information flood without answering, let alone asking, how there could be a flood of something that was always already everywhere.

We live in “the information age” but continue to define information only figuratively, metaphorically, and impressionistically. While rejecting such figurative theological concepts as the migration of souls, biologists often tolerate similarly loose metaphors in their pseudo-materialistic assumptions about signs and the agents that interpret them, as I’ll show below.

The necessary and active element of any sign relation is the interpreter. We can describe the features of the interpreter much the way the proverbial blind men describe the characteristics of an elephant. However, these descriptions remain ungrounded unless we explain how interpreters emerge within nothing but physical chemistry.

An explanation for the physical emergence and nature of semiotic interpreters could do to the currently-reified concepts of “sign” and “information” what thermodynamics did for the then-reified concept of caloric and, as I’ll suggest below, by the same means – attending to the pragmatic thermodynamic challenge to the existence of interpreting beings.

3 APE semiotics in biology

In biology, APE is justified on the assumption that life differs from chemistry. Chemistry doesn’t have beings engaged in functional interpretive effort, but life does. Beings struggle for their existence. Chemistry doesn’t.

Biologists tend to assume that natural selection or the presence of “information-bearing molecules” like DNA or RNA justify the distinction between life and non-life and therefore justify assumed beings making functional interpretive effort.

Natural selection no more explains motivation than the existence of a mountain explains the motivation to climb it or “selects” who reaches the top. Richard Dawkins suggests that natural selection is a blind watchmaker. A blind watchmaker still aims to make watches. Aims continue to play a part in biology that biologists will tend to deny.

Natural selection is not the survival of the fittest but the non-survival of beings making an insufficiently functional interpretive effort, a failure of beings struggling for their own existence. Beings making functional interpretive effort are the business end of life. Natural selection was not some new force that entered the universe and created life. Life precedes natural selection, not the other way around.

Darwin (1859) said, “In looking at Nature, it is most necessary [...] never to forget that every single organic being may be said to be striving to the utmost to increase in numbers”. In practice, “may be said” is the operative term here. Assuming functional interpretive effort is an option available to biologists as needed. Alternatively, they can describe biological phenomena in strictly physiochemical terms (e.g., the Krebs Cycle).

Hoffmeyer highlights this often-overlooked gap in Darwin's theory, stating that:

> Darwin's masterpiece was concerned with the origin of species, not with the origin of life, and he remained agnostic when it came to the question of the origin of life. That all the creatures of this world were incessantly 'striving' to find food, escape predators, find mating partners, etc., was so obvious to Darwin that he simply took this fact as a point of departure for his whole analysis. (Hoffmeyer 2011: 68)

Under the theory of Universal Darwinism, natural selection has become, even in the hands of some biologists, a justification for assuming merely that which lasts last lasts best. That's a failure to distinguish between elements that persist by durability and agents struggling for their own persistence.

Likewise, RNA and DNA, mere molecules, no more explain life than hormone molecules explain the appetites they trigger, but researchers often assume that polynucleotides are inherently different from other chemicals. DNA and RNA are somehow "information-bearing," with information ambiguously treated as res extensa molecules or patterns and as res cogitans, "instructions."

Biological explanation is often closer to the explanation one could expect in reverse engineering a functional machine than in explaining strictly physiochemical phenomena. An engineer could, for example, explain the functions of each bicycle part on the assumption that a bicycle is a machine and, therefore, functional.

In biology, as in engineering, researchers assume dual-aspect parallelism: elements that are physical/functional and described as either. For example, talking about hormone molecules as triggering appetites is tolerated without explaining how a molecule with no appetites of its own does this triggering. Hormone originally meant "set in motion." In general, when biologists identify the function of a physical element, they name it for its function, much as an engineer names their purpose-built assembled parts.

Function is inescapable in the life sciences and impermissible in the strictly physical sciences. However, for all we have discovered in the physical and biological sciences, we still have no rigorous explanation or justification for the distinction between them. A physicist or chemist won't claim that a molecule, star, or stone is *trying* to achieve anything or struggling for its own existence. Still, just down the academic hall, their fellow life/social scientists are perfectly free to refer to beings making functional interpretive effort, yet with no scientific explanation for this double standard other than that life is different. Nor, to a surprising degree, is there much acknowledgment of this unbridged gap since it is managed using APE. This ambiguity suggests three optional explanatory toolkits available to biologists, which here I'll distinguish as mechanics, mechanisms, and motivations:

> *Mechanics* (e.g., quantum, classical, chemical mechanics): Strictly aimless cause-and-effect physiochemical phenomena.
>
> *Mechanisms*: Functional mechanics assembled from physical/functional parts by engineers to meet their goals.
>
> *Motivations*: An unidentified, occult teleo-causal factor posited as the explanation for functional behavior without explaining what this posited factor is or how it emerges from strictly physical mechanics.

Today, life/social scientists identify motivations only by their consequences. If they observe effort, they assume it was the consequence of a motivation, presumably instantiated in physical mechanics though not engineered except metaphorically by natural selection. A motivation is like an entelechy, an assumed factor that is no more explained than such reified theological concepts as "soul," "spirit," or "vital force."

Biologists often justify APE with what could be termed *pedagogical license*, anthropomorphizing in presenting life/social science for lay audiences, using figures of intuitive APE speech because a detailed understanding would be over the audience's heads. As the acclaimed biologist Ursula Goodenough states in her trade book, *The sacred depths of nature*:

> I often use anthropomorphic language in these descriptions – amino acids prefer to do something and enzymes recognize something – because that's how humans think: we follow narratives with protagonists that have agency. Indeed, biologists use such analogies/metaphors all the time; we speak of orphaned receptors and proteins that serve as chaperones and genes that hitchhike. While we hold robust science-based understandings of the molecules and mechanisms of which we speak, it's usually easier to communicate those understandings in carefully chosen anthropomorphic frames that convey the essence of a process. (Goodenough 2022: 8)

Still, no matter how nuts-and-bolts the researcher's depth of scientific analysis, APE remains operative. Even the most microscopic biological bolt remains a physical object that functions as a bolt. No matter how detailed one's understanding of messenger RNA is, it remains a dual-aspect physical polynucleotide and functional messenger.

APE models can be very formal and technical but may nonetheless have no bearing on how processes work in nature. AI illustrates this disconnect: That a computer can simulate human tasks with high predictive utility tells us nothing about whether humans perform these tasks by computational means. Computationalism, functionalism, and instrumentalism suggest that APE is sufficient for science, and it is, but only if science is regarded as engineering – description, prediction, and prescription, but not explanation.

With the status "living" assumed as an initial condition for their research subjects, biologists have amassed a vast array of descriptions of living behavior and explanations for that behavior, optionally employing mechanistic, mechanical, and motivation toolkits. As a result, our detailed understanding of living phenomena grows but an explanation for life itself continues to elude us.

APE is operative in research on the origins of life. The RNA world, today considered its most promising direction, operates on the assumption that RNA replication explains or explains away beings making functional interpretive effort.

All chemical reactions are replication mechanics, molecular patterns propagating differentially subject to available energy gradients. That RNA can record patterns that may, under rare conditions, proliferate by catalysis does not explain how mere pattern propagation becomes beings struggling for their own existence.

Using APE, biologists contrive ways to talk about the duality of material/pseudo-material information using parallel description, a set of promulgated rules of correspondence justified by faith that life is different and therefore follows different rules. Wiener and Rosenblueth (1945: 316) defend APE by leaving the grounding question open, consistent with this justification: "Indeed, science does and should proceed from this dualistic basis. But even though the scientist behaves dualistically, his [*sic*] dualism is operational and does not necessarily imply strict dualistic metaphysics."

Biology awaits what biosemiotics could, with focused effort, provide: an explanation for how beings making functional interpretive effort emerged within nothing but physical chemistry. Addressing this challenge would be a significant contribution that biology would come to depend upon as a grounded justification for a distinction that, to date, remains unjustified.

4 APE in biosemiotics

In his article boldly titled "Biology is immature biosemiotics," Jesper Hoffmeyer touches on this challenge by saying that "for the moment we simply prefer to push back the origin question to a 'threshold zone' below which we do not find semiosis, function or agency, and above which the system indeed exhibits these properties" (2011: 41). From this passage, Hoffmeyer segues to how semiosis and genetic fixation are intertwined in the learning process called natural selection. This soft-target punch at inadequate biology employs APE by drawing a metaphoric parallel between natural selection and learning.

Here I aim to land on the point that Hoffmeyer mentions in passing: Until we have an explanation for the concrete steps at the transition from cause–effect mechanics to means–ends life, APE will remain the tolerated methodological norm in biology and biosemiotics will remain redundant, and peripheral to biology. Or, to put it positively, biologists will come to depend on biosemiotics if and only if biosemiotics can explain the concrete steps by which means–ends interpretive effort emerges within physical, cause–effect work.

Lacking such a bridge explanation, biosemioticians, perhaps to match methodology with biologists, often assume that their models are instantiated in and emergent within physiochemistry without explaining how.

Biosemiotics often assigns functional, categorical semiotic labels to biological mechanisms (e.g., Hoffmeyer's learning to natural selection, Kull's semiotics to choice [2018], and function to aesthetics [2022]) and promulgates laws of correspondence between the parallel realms of physics and function as if to set down the standards by which to model with dual-aspect black boxes and arrows.

To illustrate how APE is employed in biosemiotics, consider this declared methodology in the biosemiotics book *Semiotic agency*, here, with italics added to identify assumed APE elements, processes, and connections.

> To naturalize semiosis, we use the following principles […] A sign is what Bateson (1987 [1972]: 459) called *information*: "a difference which makes a difference" for some agent. The capacity to *detect* and *identify* the difference (that is perceived) is supported by *dedicated signaling and/or cognitive pathways* within *an agent*, which have *emerged* via evolution or ontogeny for the purpose of supporting certain functions (that make the difference). In this perspective, signs are *semiotic instruments* that are *utilized by agents* to achieve regulation of their *goal-directed activities*. Second, we recognize semiosis even in simple *agents* that *interpret* signs mechanistically […]. Third, semiosis (sign processes) can be *shared* by *higher-level agents* and their *subagents* […]. And fourth, the study of both simple and complex agents *requires a combination of mechanistic and semiotic analyses which complement each other. These two heuristics are both productive in predicting and explaining the phenomenon of agency*, but *the explanatory power of mechanistic models is higher for simple agents and decreases with increasing complexity, where a non-mechanistic approach is increasingly productive*. (Sharov and Tønnessen 2021: 14–15, my emphasis)

These are promulgated rules for parallel, dual-aspect description – instructions for drawing APE correspondences between physicality and function, which "complement each other." The rules do not explain how semiotic effort emerges from physiochemistry. Instead, they assume parallel realms.

Indeed, in a personal email (16 May 2022), Sharov wrote of "explanation of final causation on the basis of physics (efficient and formal causation) […] this kind of grounding is simply not possible and not needed." "Complementary heuristics" suffice for his purposes as they do for all APE modeling across philosophy and the life and social sciences.

To call this naturalizing semiotics or agency suggests that naturalizing is like rationalizing or moralizing – terms that imply a contrivance, a failure to meet a standard justified by relaxing the standard. Grounding semiotics would be different, explaining how beings and their functional semiotic effort emerge from a grounding in physical work. A natural, not merely naturalized semiotics would be grounded.

As in biology, biosemiotics research can be very productive in yielding descriptions, predictions, and prescriptions. There is nothing wrong with biosemioticians exploring internal and external sign relations under the APE method, but such research is little different from research in current biology.

5 Signs of life

Since biologists justify APE on the assumption that their research subjects are alive, it's striking that they disagree on a definition of life. As Zimmer (2021: 207) recounted, scientists Frances Westall and André Brack put it: "It is commonly said that there are as many definitions of life as there are people trying to define it." Astrobiologist Radu Popa declares, "This is intolerable for any science […]. You can take a science in which there are two or three definitions for one thing. But a science in which the most important object has no definition? That's absolutely unacceptable" (cited in Zimmer 2021: 208). Biophilosopher Kelly Smith says, "Any experiment conducted without a clear idea of what it is looking for ultimately settles nothing" (cited in Zimmer 2021: 208).

In philosophy, ontology is the pursuit of clarity about the nature of existence, and epistemology is the pursuit of clarity about the nature of knowledge. Epistemology is classically understood as the pursuit of justified true belief. Evolutionary epistemology is the study of knowledge as continuous with biological adaptation.

Distinguishing life would provide grounding for an ontology of epistemology, the existence of interpretive effort. However, such an explanation would be a researcher's interpretive effort. Thus, explaining the ontology of epistemology is an epistemological act. Or, to put it biosemiotically, the challenge is determining "signs of life," the semiotic challenge of explaining the ontology of semiotics. We could also describe our effort no less circularly as an interpretive effort to understand the true nature of interpretative effort or as an inescapably subjective effort to explain the objectivity of subjectivity.

There can be three primary responses to this circularity. We can throw up our hands in despair. We can handwave starting from any epistemological framework.

Or we can roll up our sleeves and pursue a minimal scientific epistemology from which to explain the ontology of interpretation.

Throwing up our hands, we could say that, given the circularity, finding the line between non-life and life is as hopeless as trying to swallow one's mouth. We can't accept any interpretation of the ontology of interpretation because it would be an interpretation. This is the mysterian response, resonant with Sharov's claim, cited above, that such "grounding is simply not possible and not needed."

Handwaving, we could start from any interpretive assumptions we favor for explaining interpretation and debate with others starting from other assumptions, with no standard for determining which interpretations are better. This is the possibilitarian response. It stimulates debate between competing theories but, as Kelly suggests, "ultimately settles nothing."

Rolling up our sleeves, we can seek a minimal scientific epistemology for explaining the ontology of epistemology – core assumptions meticulously chosen and rigorously employed to guide our research. In what follows, I'll make a few suggestions for the minimal epistemological standards by which a rigorous ontology of epistemology might best be pursued. In particular, I'll address the least rigorous aspect of APE methodology, the loose positing of categorical black boxes.

6 Imposing greater rigor on abductive categorization

APE's abstract, black-box, dual-aspect elements or modules are products of categorization or generalization. How do we come by the definitions for the categories of elements we employ in APE modeling? How do we decide whether there's a category such as beings, function, interpretation or effort, signs, agency, motivation, telos, will, or the struggle for existence? What distinguishes the scientific approach to identifying categories? By what standard do the category terms "agent" or "motivation" qualify as scientific, but the theological terms "soul" or "spirit" do not?

Plato describes the categorization challenge as "cutting nature at its proper joints," distinguishing categories of things in ways that accurately reflect reality. Taoism offers an idealization of such cutting with the allegory of a butcher so clear on where the joints are that he never has to sharpen his knife.

Folk application of APE black-boxing represents a form of pragmatic efficiency akin to Ockham's razor: assuming the fewest possible joints or categorical elements.

In contrast, with scientific categorization, the goal is to know where all of the joints are and aren't. As with any yes/no decision, the question "is there a joint?" yields true and false positives and negatives, resulting in two kinds of errors. A false positive is a false dichotomy: assuming a joint where there isn't one. A false negative is a false equivalence: assuming no joint where there is one.

How, then, to become like the Taoist butcher? By what means does one learn most efficiently where the joints are and aren't? How do we most efficiently distinguish between good and bad categorization methods? These questions are also circular in that we are attempting to cut at the joint between good and bad joint-cutting.

Categorization is the least rigorous aspect of our current scientific methods. One interpretation of the history of science is that its first breakthrough imposed greater rigor on deduction or formalism, starting perhaps as far back as Pythagoras. The second breakthrough imposed greater rigor on induction or empiricism, which we most associate with the transition from natural philosophy to science.

It would be hard to argue that science has imposed equivalent rigor on categorization, leaving researchers free to posit and reify categories of black-box components in their APE models.

By the interpretation of Peirce that I adopt here, abduction is the foundation of all interpretation, iconicity that categorizes by indifference – differences within a category that don't make a perceived difference. Abduction is a failure to distinguish – categorizing phenomena as alike or identity. Formally, it is the categorization of phenomena by common traits. It is the third inversion in Peirce's treatment of syllogisms (CP 2.623; see Table 1).

Table 1: C. S. Peirce – abduction.

Peirce's example:	**By extension:**
DEDUCTION	DEDUCTION
Rule – All the beans from this bag are white Case – These beans are from this bag Result – These beans are white	Rule – All men are mortal Case – Socrates is a man Result – Socrates is mortal
INDUCTION	INDUCTION
Case – These beans are from this bag Result – These beans are white Rule – All the beans from this bag are white	Case – Socrates is a man Result – Socrates is mortal Rule – All men are mortal
ABDUCTION	ABDUCTION
Rule – All the beans from this bag are white Result – These beans are white Case – These beans are from this bag	Rule – All men are mortal Result – Socrates is mortal Case – Socrates is a man (CP 2.623)

Abduction is how we categorize Socrates as a man because he has traits in common with man. It's how we assume that a man who leaves a room and returns is the same person due to undistinguished traits. It's how we recognize our car in a parking lot.

Abduction can be active, as in carefully deciding that a suspect is the murderer because they have more traits in common than differences. Abduction can also be as passive as failing to recognize camouflage as distinct from surroundings.

Formal abduction is the root of all set theory. In symbol-competent humans, sets of internally indistinguishable phenomena can be named and delimited. In other organisms, abduction is a product of threshold effects. For example, a bacterium does not conceptualize a delimited set termed "sugar" but will migrate in the direction of sugar or sugar-like molecules by threshold-effect interpretation. It may be inappropriate to call such threshold effects categorization. It is, nonetheless, abduction. Living beings make distinctions, presumably fewer, the further back one goes toward the origins of life.

Abduction or categorization comes so naturally to us that it gets the least attention in most treatments of logic. To the extent that it is addressed, it is often regarded, following Peirce's occasional treatment, as synonymous with the generation and selection of hypotheses, as in inference to the best explanation (Douven 2022). Again, my aim here is on Peirce's occasional treatment of it as categorization.

Induction and abduction are hypothetical since they are incomplete, unlike deduction. With induction, no matter how many men prove mortal, there remains the possibility of an immortal man. Likewise, with abduction, no matter how many traits Socrates has in common with man, there remains the possibility of an overlooked trait that differentiates him.

7 Suggestions for more rigorous abduction

Inductive and abductive hypotheses are strengthened by accretion. The more men prove mortal, the stronger the induction that man is mortal. The more traits Socrates has in common with all men, the stronger the abductive inference that he is a man.

In practice, induction and abduction are concomitant trial-and-error learning processes – refined by successive approximation. As categorical definitions change abductively, some formerly-included cases of the category are excluded as new cases are included. Conversely, the instances included can alter the abductive definition.

Whales, for example, once considered fish were by trial and error rejected from that category and inserted instead in the category mammal, thereby modifying the definition of mammal (Romero 2012). Sometimes the abductive/inductive dialectic collapses or redefines existing categories. Sometimes, it introduces new categorical distinctions. We see both processes in biological categorization.

Peirce hinted at the constructive or generative relationship between abductive and inductive hypotheses, upon which Terrence Deacon (1976) elaborated. To illustrate, Pavlov's dog came to associate bells with forthcoming food using an association between two abducted categories, undistinguished instances of both bells and food.

A windsock becomes an indicator of wind using multiple instances of seeing cloth blown at an angle by multiple instances of wind (Deacon 2012). This suggests a reading of the colloquial "putting two and two together," multiple undistinguished instances correlated with multiple undistinguished instances. Still, the "putting" is often passive and need not be additive so much as subtractive with each instance, a constraint on possibilities (e.g., of all the sounds Pavlov's dog could expect, the bells fell within a limited range; of all the directions the cloth or windsock could fall, they're tilted downwind).

The abductive challenge is to winnow essential from incidental attributes. This often happens by trial and error, as with the discovery that whales are mammals. It can also be facilitated by distinguishing a category by its earliest instances.

With evolution, incidental traits accumulate and specialize. Explaining life exemplified by humans is likely to result in incidental traits treated as essential. Linnean categorization, based on distinguishing phenotypes, was refined through cladistics, which attends to the branching points in genetic lineages.

Indeed, it is possible that *a priori*, or deductive reasoning, and a posteriori, or inductive reasoning, should be complemented by *from-the-emergence* abductive reasoning, explaining categories from their emergent origins. Thus, a rigorous treatment of interpretation would explain that categorical distinction from the very first instance of interpretation to emerge from physical chemistry which, though dynamic, is not itself interpretive. It would not simply describe or declare that interpretation emerged but would explain strictly in terms of physical work dynamics *how* interpretation emerges within nothing but physical chemistry.

Perhaps this from-the-emergence reasoning is overlooked partly in our eagerness to explain what interests us most, as with our quest to understand human consciousness. A side effect of this eagerness is the tendency to claim to have explained more than we have by two means: by smuggling what we are trying to explain into our categorizations (what Dennett [1995] calls *greedy reductionism*) and by claiming to have explained more than we have (which could be called *greedy emergentism*, though perhaps *needy emergentism* or *insight overreach* are more apt). To assume that everything is already categorically information is needy reductionism. To claim that the categories DNA or natural selection explain life is needy emergentism or insight overreach.

Confirmation bias can lead researchers into needy reductionism and needy emergentism using what I'll term *immaculate conceptions,* theories or concepts that sound plausible in immaculate isolation from alternative concepts, exceptions to our categorization rules, or cases that meet the categorical standard but are excluded from the category.

To illustrate, the biologist David Haig (2022) categorizes an interpreter as "a device that uses information in choice." While that concept may apply to living beings, it does not distinguish them from machines.

E. N. Trifonov argued that "self-reproduction with variation" is the common thread running through 123 definitions of life (Zimmer 2021: 209). However, this categorization doesn't necessarily distinguish living beings from computer viruses or catalyzed molecules. It also excludes sterile living beings or species (e.g., mules).

When defining categories, we must pay attention not just to those cases that fit the definition and category but to those that do not fit the category or the definition. With confirmation bias, we might claim that all X's are Y, but the validity of such categorization depends on the existence of not-X's that are Y's and X's that are not Y's.

Our eagerness to explain the rise of some interesting categorical trait often makes us focus on its absolute, not relative, rise. What's presented is often the product of what's prevented. For example, though we attend to our to-do list, we accomplish what's on it through self-control, "de-liberation" by which we prevent ourselves from dithering.

Some of science's greatest mysteries remained unsolved until researchers employed what I call *vice-versatility* – the versatile ability to consider a change from opposite sides, for example, either an increase in some possibilities or a decrease in other possibilities. Darwin explained speciation by attending to differential survival, not just to the organisms that exist but to those that failed to survive. Karl Popper attended to the elimination of falsified interpretations. Ludwig Boltzmann explained thermodynamics by attending to the relative unlikeliness of order compared to disorder. Claude Shannon, a founder of communication theory (commonly, by insight overreach, regarded as information theory), demonstrated that pattern replication could be measured as a relative reduction in possibilities. In explaining self-organization in terms of constraints, W. Ross Ashby (1962, 18) argued that "in the past, biologists tended to think of organization as something extra, something added to the essential variables, modern theory based on the logic of communication regards organization as a restriction or constraint." In each of these cases, a breakthrough resulted from considering the relative rise in some quality with respect to the relative fall in other qualities.

8 More rigorous abduction applied to distinguishing the category “semiotic”

Having surveyed briefly the abductive challenge of carving nature at its joints, I now focus on the fundamental joint that distinguishes semiotic from non-semiotic phenomena.

Obviously, a semiotic response is distinct from a physical response of a table when bumped, a protein altered, or a computer binary bit flipped by other binary bits. A table’s responsiveness is explained by physics alone. Semiotic responsiveness cannot be explained by physics alone. Though we might conclude that something added to physical responsiveness makes it semiotic, the reverse must be true due to the conservation of matter. Moments after death, a corpse contains all of the same matter as before death, but its capacity for semiotic responsiveness is gone, leaving only physical responsiveness.

In keeping with Ashby’s suggestion, semiotic responsiveness may be a limited subset of physical responsiveness, the difference between the passive anything-goes response to externally imposed work and proactive effort in response to external differences. If nothing is added to physics to make it semiotic – no vital force or soul breathed into it – we are compelled to seek an explanation of semiotic response as an emergent constraint within physical matter.

An emergent constraint is a dynamic, far-from-equilibrium reduction in possibilities. For an intuitive example, traffic congestion is a throughput population effect that makes some paths less likely than others. When congestion is present, a detour around it may become the path of least resistance.

The emergent constraint resulting in semiotic responsiveness would differ from traffic congestion or, more generally, self-organization. It would be a self-regenerative emergent constraint that channels energy into work that regenerates the self-same emergent constraint.

We can give this emergent constraint that distinguishes semiotic effort a new name, like selfhood, agency, and interiority. Or we can assign it an old name like soul or spirit. But naming is not explaining. A worthy challenge for biosemiotics is to explain in strictly physical terms how semiotic responsiveness emerges as a different kind of phenomenon within nothing but physical responsiveness.

Semiotic responsiveness implies a self-other relationship, selves interpreting non-self, umwelt interacting with the world. When a being’s umwelt doesn’t respond successfully to its world, the being dies. Its emergent constraint disappears. What’s left is a corpse returned to merely physical responsiveness, which, dust-to-dust, falls inexorably toward degeneration and randomness.

When beings die, we can conclude that they were somehow unfitted though we cannot pinpoint the specific trait they lacked nor the full range of traits that would have spared them. Survival is inescapably iffy, as recognized in Peirce's fallibilism. There's no escaping the possibility of ironic situations whereby seemingly maladaptive traits become adaptive in context and vice versa.

Sign interpretation isn't passive but the generation of interpretive effort, functional for the being's effort to stay alive. Thus, there can be no semiotics without effort that is functional for a being.

With APE, a being's physical organs are often treated as durable machine parts. They are not. They exist through ongoing self-regenerative effort. To illustrate, consider biologist David Haig's (2022) definition of an interpreter as a "device that uses information in choice." Haig argues that a photoelectric sensor is an interpreter, something like an eye or a living visual interpreter. Photoelectric sensors are machines designed for durability. Eyes only remain functional through ongoing self-regenerative effort. It takes effort, not just to see, but to continuously regenerate the ability to see. Beings don't persist by durability but through ongoing effort to remain beings.

From the perspective offered here, semiotics is not the study of signs but of beings in a self/other relationship with their environment as they struggle for their existence. Still, if we seek an essence of semiotics, we might ask whether any functional interpretive effort is universal to all beings. If there is, it would be a key to a robust definition of the category "life."

One interpretation of Peirce may offer hints that help us toward a robust definition of life through his concepts of tychism, synechism, and prescinding.

Tychism, Peirce's grounding in chance, is what fittedness is up against. Tychism is not just a grounding in chance and randomness at the universe's origins. Instead, it is the second law of thermodynamics, the universal, inescapable statistical tendency for order to randomize, segregations to desegregate, patterns to degrade, concentrations to diffuse, and regularities to become irregular over time. Tychism is the maximum-entropy-production constant that all organisms must outpace in their struggle for existence.

The fundamental pragmatic semiotic challenge for all living beings is outpacing the second law of thermodynamics, protecting against degeneration and regenerating what degenerates. This outpacing is more fundamental than Trifonov's "self-replication with variation" since, once degenerated, a being cannot self-replicate.

For organisms to survive in the universal context of the tychist second law of thermodynamics, they must be in the order-making business, not just self-organizing, but self-forming – Kant's formative power as distinct from mere motive power.

Synechism is Peirce's commitment to ontological continuity. It can be interpreted as suggesting that there are no discontinuities, a position that is hardly credible even in the assertion – if there were no discontinuities, there would be no beings to argue that there are no discontinuities. I take it to mean there are ontological continuities with emergent distinctions. As such, it is an antidote to dualist methodology (i.e., APE parallelism), which postulates and promulgates correspondences between separate realms without explaining their continuity. Synechism assumes one universe while avoiding reductionism. Thus, organisms are different from non-organisms but comprised of the same stuff in compliance with the same natural laws. Synechism, therefore, assumes emergence though without explaining it.

Emergence – continuity with differences, suggests that rather than assuming immutable Newtonian solids following Laplacian determinate non-emergent paths, we must think statistically about population flows and constraints. A gust of wind or water current is a population of elements interacting. Though we can model such currents as one-dimensional vectors, population flows differ from a Newtonian solid's trajectory.

Naturalism is different from Newtonian materialism. Nature includes dynamic population effects, flows, and constraints, for example, populations of molecules flowing with and against each other by paths of least resistance. I refer to this methodological distinction as *narrowing, not arrowing*.

We do well to remember that in our models, the one-dimensional arrows from zero-dimensional points A to B are abstractions. We can diagram an arrow-like trip from point A to B, but we'll take that trip by any of various paths within narrowed constraints, for example, any lane on a four-lane highway.

APE models tend to abstract down to singular paths, much as in engineering a plumbing system, a plumber can ignore the range of paths a particular molecule might take through a pipe's narrowed constraints.

From a Newtonian materialist perspective, emergence would require something from nothing, the whole being somehow greater in some quality or quantity than the sum of its parts – attributes or parts added, for example, "information" added to chemistry. From the emergentist, synechist perspective, a relative change in likely paths of least resistance can be, for lack of a better term, the *unliklification* of some pathways relative to others. When populations of elements interact, some paths become more likely than others.

Synechism suggests that, while abstract models are practical simplifications, our models should not be abstracted away from physical work. Our models should be *ergodynamic*, meaning they should explain changes in likely work. Semiotic agency is effort, most fundamentally, the physical work an organism does to outpace degeneration. It is not the passive registering of abstracted conceptual symbols in computation.

Again, failure to cut nature at its proper joints often results from treating an accidental or incidental feature as essential. This is an argument for explaining life not from today's highly evolved and specialized organisms but from the very first possible organism. Attempting to understand life by studying human cognition is like trying to understand the universal qualities of the category hair by studying porcupine quills. Yes, it is hair, but with many incidental evolved and specialized qualities. Likewise, David Chalmer's "hard problem" (2007) is the *made harder problem* since it attempts to explain human consciousness from physics, not from the emergence of beings making functional interpretive effort.

Even the enactivist implication that all beings are constantly active may be cutting at an incidental joint. Dormant plant seeds can remain viable for millennia. Given life's universal pragmatic priority of outpacing degeneration, even at the origin of life, beings must be able to protect against degeneration and repair what degenerates. Still, it may be a bridge too far for the first possible living being to self-repair constantly. Virus-like dormancy may be necessary self-protection for the first beings to emerge spontaneously from chemistry.

Prescinding is how Peirce dissected the un-dissectible: By considering attributes of a system while remembering that the attributes are not discrete modules that function independently from the system within which they are instantiated. Semiotics does not exist in isolation from life's other distinguishing features. I suggest an alternative definition of life grounded "ergodynamically" as a change in likely work (see Table 2).

Each of the four columns represents a facet of life. The four facets would have emerged together. The first column represents effort as distinct from exclusively physical work. We could call this by-ness: effort made *by* a being.

The second column represents function, utility, value, normativity, value, benefit *for* the being (i.e., for-ness). The third column represents the being itself, outpacing degeneration by protecting against degeneration and regenerating what degenerates. "Being" is a verb and a noun: a being proactively being a being. Combining the first three columns, we have beings making functional effort – effort

Table 2: Suggestion for what all living (semiotic) systems have in common.

Work…	…that works…	…to keep a chemical system working…	…in its workspace
Effort	Function	Being	Interpretation
Agency	Normativity	Viability	Semiotics
By-ness	For-ness	Being-ness	About-ness
A difference in effort…	…that makes a functional difference…	…with respect to staying alive…	…within the local environment

by the being *for* the being's benefit. The fourth column represents interpretation, fittedness, and semiotic responsiveness with respect to the being's local circumstances (i.e., about-ness).

Biosemiotics may remain a distinct research topic focused solely on interpretation in biology. However, in nature, semiotics only occurs as one facet prescinded from the other three. Without the full four-facet complement, there are no signs or information. There is no interpretation without effort, no effort without function, no function without interpretation, and none of these three prescinded features without beings, fragile in their structure, struggling to remain beings through self-protection and self-repair.

9 Conclusions

For biosemiotics and the life/social sciences beyond, the categorical essence of life is the elephant in the room. Indeed, the elephant *is* the room in that, to a large extent, life scientists continue to operate within the confines of a tacit assumption that life is different without explaining how living beings and their functional interpretive effort emerged within nothing but physiochemical work.

Functional interpretive effort is a subcategory of work. It is work (i.e., effort) that works (i.e., functions) to keep a physical system (i.e., a being) working in semiotic response to (i.e., interpreting) its workspace or environment. By this definition, Bateson is short one difference. Information is an effortful difference that makes an interpretive difference that makes a functional difference that makes a difference to the continued viability of a being struggling for its own existence.

APE plays fast and loose with these four prescinded facets of life, shifting freely among mechanics, mechanistic, and motivational explanations or focusing on one facet or another to the exclusion of others. When we treat APE as an adequate methodology, we remain like novice engineers debating which APE model is better against no clear standard for what counts as a better explanation.

Relying on APE, the life sciences, including biosemiotics, remain immature, in a stage that parallels the pre-ergodynamic stage in the investigation of heat in which researchers debated the nature of caloric. This immature stage is more advanced than that of the alchemists, who had little understanding of chemistry and posited all manner of categorical factors in their effort to turn lead into gold. Still, APE is not the culmination of life science methodology but a stage on the path to one that is more rigorous, realistic, and scientific akin to the transition from caloric theory to thermodynamics.

Here I have suggested steps toward an alternative to APE methodology, the key points of which I now summarize:

Ergodynamic, not abstract: All theories are abstractions. Still, to ground life in physics, thereby bridging the gap from non-life to life, physical work to effort, efficient cause to final cause, and physical responsiveness to semiotic responsiveness, our theories must not be abstracted away from physical work.

Emergent, not parallel: We must overcome our temptation to employ dualism, even the crypto-cartesian dualism that posits occult substances and forces like information or signs. Instead, we must explain semiotic responsiveness from its emergence as a different category of phenomena emergent within nothing but physical chemistry abiding by physical law.

Organic differentiation, not engineered assembly: Machines are assembled from purpose-built material parts. In contrast, life differentiates as zygotes differentiate through development.

A proposal for any new methodological paradigm is not of much value without an exemplar of its effectiveness. Above, I have touched on analogous methodological shifts in other and related fields.

The alternative to APE suggested here is exemplified by the work of Terrence Deacon with whom I have collaborated closely since 1998. As a lab biologist influenced by Peirce's work, Deacon has applied a from-the-emergence approach to explaining what could be termed *logogenesis*, the evolution of language (*The symbolic species*, 1997), and what could be termed *teleogenesis*, the emergence and nature of selves and effort (*Incomplete nature*, 2011). Deacon is currently drafting a book on what could be called *synergenesis*, the emergence of synergies in hierarchic transitions (distilled in Deacon 2022).

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